

UNITED STATES ARMY IN WORLD WAR II

The Technical Services

THE ORDNANCE DEPARTMENT: PROCUREMENT AND SUPPLY

by
Harry C. Thomson
and
Lida Mayo



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UNITED STATES ARMY IN WORLD WAR II

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. . to Those Who Served

Foreword

In cost and bulk, the munitions manufactured by and for the Army's Ordnance Department during World War II exceeded the output of all the other technical services of the Army combined, and in cost they rivaled that for the aircraft and ships with which the war was fought. The process of getting these munitions to fighting forces all over the world—of storing them until needed, of keeping track of them, and of keeping them in repair—was almost as complicated as their manufacture. In writing the story of these two main aspects of the Ordnance mission on the home front, the authors have produced a record of enduring value; for whatever the character of military procurement now and in the future, the problems of producing and distributing military equipment on a very large scale remain much the same.

Since private industry and civilian labor inevitably are called upon to contribute enormously to the making of munitions on any large scale, civilian as well as military readers should find much in this volume to instruct them. Perhaps its greatest lesson is the long lead time required to get munitions into full production, and therefore the need for calculating military requirements with the utmost accuracy possible. It is imperative, in this age of international tension and partial mobilization, that all of the intricacies of military production be clearly understood if the nation is to get the maximum of economy as well as security in preparations for its defense.

Washington, D. C.
22 September 1959

JAMES A. NORELL
Brig. Gen., U.S.A.
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Note on the Authors

Harry C. Thomson received his doctorate in government from Harvard University. During World War II he was a historian with the Army Air Forces, serving both as an enlisted man and as a commissioned officer. He became a member of the Ordnance Historical Branch in 1948, serving as its chief from 1952 until June 1959, when he resigned to become Assistant Editor of the *Encyclopaedia Britannica.*

Lida Mayo, a graduate of Randolph-Macon Woman's College, served as Historian with the Military Air Transport Service from 1946 to 1950, when she joined the Ordnance Historical Branch. Except for the years 1954–56, when she was Project Historian on the staff of The American University, she has continued with the Branch, becoming its chief in June 1959.

Preface

This is the second of a 3-volume series on the role of the Ordnance Department (now Ordnance Corps) in World War II. As the first volume, subtitled *Planning Munitions for War,*[1] gave emphasis to research and development, this volume deals with procurement and supply, and the third will describe Ordnance operations overseas. It is particularly important for the reader of this volume to bear in mind that the first volume includes, in addition to research and development, separate chapters on the early history of the Ordnance Department, its organizational and personnel problems during World War II, and its efforts to conserve scarce materials such as copper, steel, and aluminum. The organizational charts in the earlier volume may be of special assistance to the reader not familiar with Ordnance organization. Taken together, the three volumes deal with every major aspect of Ordnance history in World War II, and give some attention to the prewar years when the art of munitions making was sadly neglected. The authors have studiously avoided duplication of material in other volumes of the series UNITED STATES ARMY IN WORLD WAR II, particularly *The Army and Economic Mobilization* by R. Elberton Smith.

In his preface to Charles Ffoulkes' little classic, *The Gun-Founders of England,* Lord Cottesloe observed, on the eve of World War II, "In all that has been written about war, but little mention has been made of the making of weapons; it is their use which is dramatic and tragic and commands public attention." The mystery of such important matters as the invention of gunpowder in the 13th century and its employment in crude firearms in the 14th century has never been properly unraveled; nor has the method by which medieval chain mail was manufactured in quantity ever been satisfactorily explained. Neglect of the armorer's art by historians has been traditional in this country as well as in England, owing in part, no doubt, to the reluctance of scholars to explore the sooty mysteries of forge and furnace.

After World War I, this reluctance was reinforced by a strong desire to emphasize the pursuits of peace rather than the ways of war and to write new textbooks giving less space to battles and political campaigns and more to social, economic, and cultural history. Most professional historians of the 1920's and 1930's systematically avoided the study of both warfare and munitions manufacture, while a number of journalistic writers turned out lurid accounts

[1] Constance McLaughton Green, Harry C. Thomson, and Peter C. Roots, *The Ordnance Department: Planning Munitions for War,* UNITED STATES ARMY IN WORLD WAR II (Washington, 1955).

of the evil traffic in arms, labeling its practitioners "Merchants of Death." During World War II the life-and-death importance of arms production swept away part of the earlier aversion to the subject, and some of the newly aroused interest in munitions carried over into the postwar years. But it is still true that, in proportion to its significance, remarkably little substantial material has been published on the manufacture of munitions. This volume is a modest effort to redress the balance.

With storage, issue, and maintenance—subjects not mentioned in Lord Cottesloe's comment but nevertheless implied in it—the situation has been much the same. If anything, these topics have appeared less appealing and have been less written about. Warehouses, pipelines, inventories, parts catalogs —there is nothing glamorous or exciting about these subjects unless an investigator uncovers fraud or waste. Yet even the most casual student of military affairs recognizes that these humdrum activities are an essential link in the long chain of supply. They may not win wars, but their neglect or mismanagement may bring on military disaster.

A word of explanation is needed for the preponderant emphasis on the early years, 1939–43, in the chapters devoted to procurement (I to XV), and on the later years in the Field Service chapters. This emphasis is considered justified for the procurement chapters because the early years saw the emergence of many new problems and led to pioneering efforts to work out solutions. "If you do any research on procurement," Brig. Gen. John K. Christmas once advised Industrial College students, "don't look at procurement as it was in 1944. Anybody could do it in 1944. . . . But go back and look at 1940–41, and so on, if you want to really do some research on procurement." [2] This injunction has been followed and has been found to fit the facts of life on the procurement front. With Field Service the opposite has been true. Though due attention has been given to the early formative years when the Army, swollen by selective service, was training with broomstick rifles and stovepipe cannon, the big job for field service came in the latter half of the war when factories were pouring out equipment in vast quantities and troops were being deployed around the world. Problems in the management of stocks and maintenance of equipment became critical during the 1943–45 period just as pressure on the procurement front eased off.

Another distinction between the two parts of the volume should be noted. As the Industrial Service was organized mainly along product lines—small arms, artillery, combat vehicles, and ammunition—the procurement chapters follow, with obvious exceptions, the same pattern. The Field Service organization, mainly along functional lines, is reflected in the supply chapters on such topics as storage, stock control, and maintenance. Co-ordination of the two has proved as difficult in the writing as it was in actual operation during the war.

Of the procurement chapters all except Chapter VIII were written by Dr. Harry C. Thomson; the Field Service chapters (XVI to XXII) and the In-

[2] Lecture, Brig Gen John K. Christmas, Procurement Organization, Policies and Problems of the Department of the Army, 2 Nov 48, ICAF, L49-36, OHF.

troduction are the work of Lida Mayo. Both authors were ably supported by Mrs. Irene House, whose many services as research assistant were invaluable and who wrote most of Chapter VIII on small arms. The entire manuscript was typed and retyped with great skill and patience by Mrs. Feril Cummings.

In the Office of the Chief of Military History, Dr. Stetson Conn, Chief Historian, and Mr. Joseph R. Friedman, Editor in Chief of the World War II series, gave the utmost assistance in all aspects of the volume's preparation. Editing of the manuscript was performed by Carl Brinton Schultz, senior editor, most ably assisted by Mrs. Helen Whittington, copy editor. Miss Margaret E. Tackley chose the photographs.

Washington, D. C.
22 September 1959

HARRY C. THOMSON

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All illustrations are from the files of the Department of Defense except for the cartoon by Bill Mauldin on page 298 and the photographs from the American Ordnance Association on pages 82, 179, and 441.

THE ORDNANCE DEPARTMENT: PROCUREMENT AND SUPPLY

CHAPTER I

Introduction

"Nobody can see through this curtain of battle smoke that enshrouds the earth today," cried a member of the U.S. House of Representatives on 10 May 1940, the morning Hitler invaded the Low Countries. As the early news bulletins came over the radio, the first reaction in America was shock. On succeeding days, as news reports described the full weight of the offensive—the great thunder and roar of tanks, artillery, and dive bombers crushing Luxembourg, Belgium, and the Netherlands, and rolling toward France and the English Channel—shock became alarm. Another Representative expressed the general feeling when he shouted, "Hell is out of bounds!" [1]

Speculations that would have seemed fantastic a few months before suddenly became horrifying possibilities: that Hitler would quickly defeat Britain and France; that Japan would move to seize the Netherlands East Indies and Malaya; and that the United States would soon stand alone, virtually isolated in a world of hostile dictatorships, "the last great Democracy on earth."[2] How well would the United States be able to defend itself if attacked? What weapons did it have?

Congress had the answer as of 1 May 1940, submitted by the War Department at hearings on the military appropriations bill for Fiscal Year 1941. When the figures came out in late May, on the floor of Congress and in the published hearings, they caused an uproar. There were not enough effective antiaircraft guns to defend a single large American city. There were coast-defense guns for most large coastal cities but some of them had not been fired for twenty years, and all could be bombed out of existence by carrier-based airplanes. As for field artillery, there were about 5,000 French 75's left over from World War I, but nearly all of them were mounted on big wooden wheels with steel tires made to be drawn by mules or horses. Such guns would be shaken to pieces if towed by a truck or tractor at high speed over rough ground; furthermore, they did not have sufficient traverse or elevation to be fully effective. Only 141 had been modernized with improved carriages and pneumatic tires. The 105-mm. howitzer, a companion piece to the 75-mm. gun as primary divisional artillery, was just going into production. There were none on hand, and it would take fourteen to sixteen months to produce the 48 for which funds had been provided. There were only four modernized

[1] (1) *Congressional Record*, vol. 86, pt. 6, 76th Cong., 3d sess., pp. 5916, 6560; (2) *Time*, May 27, 1940, pp. 17–18.

[2] Walter Lippmann quoted in *Time*, May 20, 1940, p. 15. By 27 May a Gallup poll showed that U.S. confidence in an Allied victory had dropped from 82 percent to 55 percent.

155-mm. guns, and no modern 8-inch howitzers.[3]

And what of the ability of the U.S. Army to wage tank warfare, so brilliantly employed by the Germans? Senator Henry Cabot Lodge, just returned from maneuvers in Louisiana, reported to the Senate: "I have recently seen all the tanks in the United States, about 400 in number, or about one finger of the fanlike German advance about which we have read, or about the number destroyed in two days of fighting in the current European War. The Germans have a rough total of 3,000." Furthermore, almost all American tanks were of the light type, weighing only 10 or 12 tons. Little was authoritatively known about German tanks; some were said to be 80-ton monsters. The Army believed that 37-mm. antitank guns would be effective against them. But the United States had only 218 guns of this type.[4]

The brightest spot in the dark picture was the small arms situation. There were enough machine guns; and there were some two and a half million rifles. About 35,000 of the rifles were new Garand semiautomatics, and the number was increasing steadily; 4,000 a month were being turned out at Springfield Armory. The new rapid-firing rifle had received high praise from no less a personage than Vice President John N. Garner, who had used it in deer hunting.[5]

All types of weapons needed ammunition in unprecedented quantities to wage blitzkrieg warfare. The figures for ammunition on hand were as discouraging as those for artillery. Congress was told that there were only 46,000 rounds for 37-mm. antiaircraft guns, 75,000 for 37-mm. tank and antitank guns, about 17 million of .30-caliber armor-piercing ammunition, and about 25 million of .50-caliber ball ammunition. The sudden, crucial importance of the bomber threw a glaring light on the pitifully small stock of bombs. There were only 11,928 bombs of the 500-lb. size and only 4,336 of the 1,000-lb. type.[6]

Alarmed and angry, Congress, the press, and the public demanded to know the reason for the low state of the nation's defenses. Since 1933 there had been mounting appropriations for defense, the largest peacetime appropriations for military purposes in the history of the United States. Where had the money gone? When President Roosevelt stood before a joint session of Congress on 16 May 1940 to ask for over a billion dollars more, his program was almost unanimously approved by the lawmakers and the press. But some members of Congress were demanding to know whether new appropriations would "go down the same rat hole into which we have poured $7,000,000,000 . . . during the last 6 years." [7]

The Army's answer was that about three-fourths of the $3,400,000,000 appropriated for the Army had gone for such things as pay, subsistence, and travel expenses,—"merely a case of the American standard of living applied to the mainte-

[3] *Hearings Before the Subcommittee of the Senate Committee on Appropriations* on H.R. 9209, *Military Establishment Appropriation Bill for 1941*, 76th Cong., 3d sess., pp. 221–24. (Hereafter Congressional Hearings on Army appropriation bills will be cited as *WDAB*, S. or H.R.)

[4] (1) *Congressional Record*, vol. 86, pt. 6, 76th Cong., 3d sess., pp. 6130–39, 6877; (2) *WDAB*, S., 76th Cong., 3d sess., p. 223.

[5] Maj Gen Charles M. Wesson's 11 O'Clock Conf Min, 1 Apr 40, OHF. (Hereafter Minutes of the Wesson Conferences are cited as Min, Wesson Confs.)

[6] *WDAB*, S., 76th Cong., 3d sess., p. 422.

[7] *Congressional Record*, vol. 86, pt. 6, 76th Cong., 3d sess., pp. 6163, 6776, 6830–31. See also critical comments by Arthur Krock in The New York *Times*, May 16, 1940, p. 22.



SENATOR HENRY CABOT LODGE ABOARD MEDIUM TANK M2 *of the 67th Armored Regiment. Officer in left foreground is Lt. Col. Omar N. Bradley. (Photograph taken May 1940.)*

nance of a volunteer army scattered over a tremendous number of small posts." [8] Some of the money, a small proportion, had gone into munitions, but weapons were not yet coming off the production lines, for they could not readily be obtained from commercial sources, as could food and uniforms, and were hard to manufacture. A year earlier General Malin Craig, then Chief of Staff, had stressed the inexorable demands of time in weapons manufacture: "the sums appropriated this last year will not be fully transformed into military power for two years." [9] Besides, as one Senator pointed out in defense of the War Department, America had not been "under the same strain, nor in the same sphere as the warring nations of Europe. We prepared ourselves for national defense and not to invade Belgium and Holland." [10]

Yet nothing could quiet the outcries over "popgun defense," not even the President's steady, reassuring voice telling the country over the radio in a fireside chat that the United States had "on hand or on order" 792 tanks, 744 antitank guns, 741 modernized 75's, and 2,000 antiaircraft guns. The press was quick to point out that most of the tanks were light rather than medium or heavy, that more than half the antiaircraft guns were .50-caliber machine guns, good only against low-flying aircraft, and,

[8] Testimony of Gen. George C. Marshall, CofS, May 17, 1940, in *WDAB,* S., 76th Cong., 3d sess., p. 429.

[9] Gen. Malin Craig, "Our Present Military Position," (extracts from final report to SW, 30 Jun 39), *Army Ordnance,* (now *Ordnance*), XX, No. 116 (September–October 1939), 89.

[10] *Congressional Record,* vol. 86, pt. 6, 76th Cong., 3d sess., p. 6165.

most important of all, that only a small percentage of all weapons were actually on hand. Complete delivery of the weapons "on order" could not be expected before June 1941.

At the current rate of delivery, the $348,228,998 just appropriated for ordnance could not be translated into antiaircraft guns, tanks, field artillery, powder, and shells until June 1942. Recalled to Senate hearings, General Marshall gave a more optimistic (and prophetic) date; he thought the nation could be ready for war by December 1941.[11] "I am terribly disappointed in the attitude of the Army," said one Senator. "Their ambition is to get ready in a period of 18 or 24 months, when we are living in a period of wars being settled in 30 days." [12]

The agency responsible for developing, procuring, and distributing the Army's weapons and ammunition was the Ordnance Department. One of the supply services of the War Department, Ordnance consisted of a headquarters staff in Washington and numerous field installations, including manufacturing arsenals, storage depots, and procurement district offices in major cities.[13] It was headed by a major general who reported on procurement matters to the civilian Assistant Secretary of War (later Under Secretary) and on military matters to the Chief of Staff through G–4. The line between military and procurement matters was not always distinct. But as a general rule decisions as to types and quantities of weapons needed for each unit of the Army were looked upon as military matters, while decisions as to contracts, financing, and production schedules were regarded as procurement matters. As a supply service (later technical service) the Ordnance Department had little authority for independent action except in the execution of directives from the Assistant Secretary or the Chief of Staff. Ordnance might advise and suggest on the development of new weapons, but the final decision was made by the Chief of Staff on the basis of recommendations of the using arms—the Infantry, the Coast and Field Artillery, the Air Corps, and the Cavalry or Armored Force.[14]

How good a job would it do in this crisis? Some commentators had doubts. The Chicago *Tribune* denounced "Army and Navy bureaucrats." *Time,* contending that most generals were still thinking in terms of horse warfare, made the point that money was not the only cure for unpreparedness and that brains were needed as well as weapons. Others argued that if the nation was unprepared the fault lay rather in the apathy of the public than in the attitude of the Army or the caliber of the professional officer. Even so severe a critic as Senator Lodge had been impressed by the officers who had testified at committee hearings on the appropriations bill.[15]

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[11] (1) Editorial, "Editors Approve President's Defense Plan; Score 'Fireside' Talk," *Army and Navy Journal,* LXXVII, 40, June 1, 1940; (2) *Time,* May 27, 1940, p. 14, and June 3, 1940, p. 17.

[12] *WDAB,* S., 76th Cong., 3d sess., p. 191.

[13] The other supply arms and services in 1940 were the Chemical Warfare Service, Corps of Engineers, Medical Department, Quartermaster Corps, and Signal Corps.

[14] Constance McLaughlin Green, Harry C. Thomson, and Peter C. Roots, *The Ordnance Department: Planning Munitions for War,* UNITED STATES ARMY IN WORLD WAR II (Washington, 1955), ch. IV (hereafter cited as Green, Thomson, and Roots, *Planning Munitions for War*).

[15] (1) *WDAB,* S., 76th Cong., 3d sess., p. 226; (2) *Congressional Record,* vol. 86, pt. 6, 76th Cong., 3d sess., p. 5943; (3) *Time,* June 3, 1940, p. 14.

One of these was Maj. Gen. Charles M. Wesson, Chief of Ordnance. Another was Brig. Gen. Charles T. Harris, Jr., who, as the Chief of the Ordnance Department's Industrial Service, was the man in charge of procuring the weapons and ammunition. A stocky, plain-spoken, hard-driving officer, he was, in the opinion of one high-ranking Army official, "the dynamo of Ordnance." His years of experience in the Office of the Assistant Secretary of War—the Army's agency for industrial planning—had given him an excellent grasp of the first and most important rearmament task, which was to put industry to work. Just as nobody expected to fight a war with the small Regular Army, nobody expected the six Ordnance arsenals to turn out more than a small portion of the munitions that would be needed, perhaps 5 percent. After years of neglect, they were at last being renovated. But to one Senator, who had recently inspected Ordnance installations, the arsenals "looked like . . . a plant that had been abandoned for 20 years, and then a bunch of men were feverishly trying to get them back into shape to start production." [16] They were valuable mainly as centers of technical knowledge where the art of design was kept alive and production was maintained on a laboratory basis.

For the past eighteen years the Office of the Assistant Secretary of War had been planning a training program for industry that was comparable to the peacetime training of the Reserves, and Ordnance had the lion's share. The most fruitful part of the early program for Ordnance wartime expansion consisted of small orders given to qualified manufacturers to educate them in the intricacies of munitions manufacture. Under the Fiscal Year 1939 program, educational orders had been placed for semiautomatic rifles, recoil mechanisms for the 3-inch antiaircraft gun, and 75-mm. shells;[17] and by the spring of 1940 the results were beginning to come in. In March General Harris was able to bring a shell made by the S. A. Woods Company to the daily Ordnance conference in General Wesson's office, where it was passed around and examined with much interest.[18] Advance planning enabled Ordnance production to get off to a fast start before tool and materials shortages and low priorities put a brake on the program.

In the old Munitions Building on Washington's Constitution Avenue, a World War I temporary structure where all the supply services were housed, General Harris and Brig. Gen. Earl McFarland, chief of Ordnance's Military Service, met with General Wesson every morning to hear reports of staff officers and discuss Ordnance policy. Just as the Industrial Service was the point of contact with industry, under the Office of the Assistant Secretary of War, the Military Service was the point of contact with the Chief of Staff and the using arms and services. This contact was of great importance, for Ordnance received its guidance and approval on matters of weapons development from the using arms.

At the time the Germans invaded the Low Countries, the storage, distribution, and maintenance duties of Ordnance were delegated to an office under General McFarland that was designated Field Service and was headed by Col. James K. Crain. The following year Field Service was raised to the same level as Industrial Service, and

[16] *WDAB*, S., 76th Cong., 3d sess., p. 34.

[17] (1) *WDAB*, S., 76th Cong., 3d sess., pp. 130–31 and 141–46; (2) Col. Harry K. Rutherford, "Industry's Manual of Arms: A Progress Report on the Educational Orders Program," *Army Ordnance*, XX, No. 120 (June–July 1940), 371.

[18] Min, Wesson Confs., 21 Mar 40.



MAJ. GEN. JAMES K. CRAIN, *Chief of Ordnance Department's Field Service. (Photograph taken October 1944.)*

Colonel Crain was soon to become a brigadier general.[19] A slender, thoughtful man, a few years older than General Harris, Colonel Crain looked more like a college professor than an Army officer. He had had long service in the field, beginning with his assignment as Chief Ordnance Officer of the Rainbow Division in World War I,[20] and had recently engineered an innovation in field maintenance organization by grouping Ordnance companies into an Ordnance battalion. The battalion was tried for the first time in the spring 1940 maneuvers, and Colonel Crain, on the scene as Corps Ordnance Officer, saw that it was successful.[21]

Though after the blitzkrieg the maneuvers that spring seemed to the press "more unreal than most such playing at soldiers," and against the background of Europe's total war "the U.S. Army looked like a few nice boys with BB guns," [22] yet there were presages of the World War II Army. Gone were the khaki breeches and wrapped puttees, replaced by loose trousers; almost entirely departed were the horse and mule. For the first time in history the Army was equipped with enough motor transportation to carry weapons and men, food, and ammunition; and the star of the Air Corps was rising.

The coming of age of air power had a definite impact on the Ordnance Department. Bomb cases and fuzes formed a large part of the educational orders under the Fiscal Year 1940 program;[23] and, since industry had cut down the time of making bomb bodies to six months, quick results could be expected from production orders.[24] Prospects for new and more powerful bomb fillings were being explored. In mid-January 1940 Dr. Lyman J. Briggs of the Bureau of Standards had called on General Wesson about obtaining three thousand dollars "for the purpose of splitting the uranium atom." It seemed to Ordnance that the development had "possibilities from an explosive viewpoint." [25]

[19] For the organization and the research and development activities of the Ordnance Department, see Green, Thomson, and Roots, *Planning Munitions for War.*

[20] "New Ordnance Strength," *Army Ordnance,* XXI, No. 123 (November–December 1940), 214–15.

[21] (1) Min, Wesson Confs, 3 Apr. 40; (2) Capt. Joseph M. Colby [Comdr, Ord Bn, Fourth Army Corps], "The New Ordnance Battalion: Maintenance and Supply in the Streamlined Division," *Army Ordnance,* XXI, No. 123 (November–December 1940), 208–13.

[22] *Time,* May 27, 1940, p. 19.

[23] Rutherford, "Industry's Manual of Arms," *Army Ordnance,* XX, No. 120 (June–July 1940), 370.

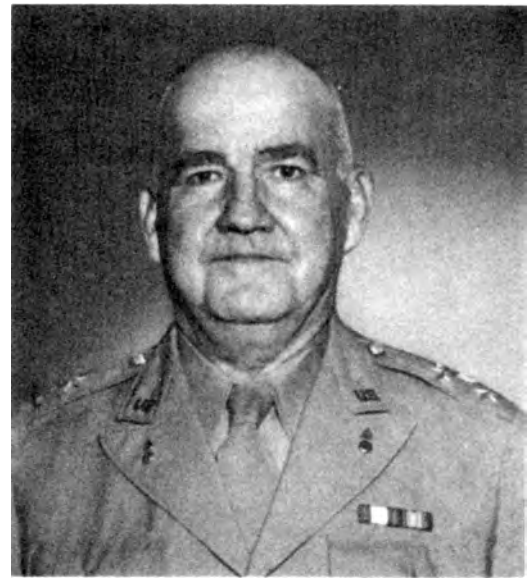
[24] *WDAB,* S., 76th Cong., 3d sess., p. 42.

[25] Min, Wesson Confs, 15 Jan 40. For a detailed account of Ordnance participation in early atomic bomb work, see Arthur Adelman, Fission Explosives, 30 Jun 44, OHF.

A few months later Mr. Lester P. Barlow, an employee of the Glenn L. Martin aircraft factory, submitted to the Senate Committee on Military Affairs a bomb filled with liquid oxygen. Called "glmite" in honor of Mr. Martin, the explosive was said to give off violent vibrations of the air waves that would kill every living thing within a radius of a thousand yards. Senator Gerald P. Nye was so impressed that he called in reporters to watch while minutes of the committee meeting were burned —"so great was the military secrecy of the subject! . . . an explosive so deadly it might even outlaw war!!!" [26]

Tests of the Barlow bomb took up a good deal of the time of Ordnance planners in April and May, extending down into the most anxious weeks in May. When the newspapers announced that goats would be tethered at varying distances from the bomb to determine its lethal effects, Congress and the War Department were deluged with letters of protest from humane societies and private citizens.[27] All the concern turned out to be wasted. At the first test, the bomb leaked and did not go off; at the second, held at Aberdeen Proving Ground in late May, the explosion occurred, but the goats, unharmed, continued to nibble the Maryland grass.[28]

In a few days' time, such matters as cruelty to goats became trivial. On 3 June the British were driven off the Continent at Dunkerque. On 8 June the Ordnance Department received instructions to load twelve Thompson submachine guns on the Atlantic Clipper scheduled to leave for Europe the next day; the guns were for protection of the American Embassy in Paris. But it was already too late; the order was canceled by the President almost as soon as given.[29] Paris surrendered on 14 June.



MAJ. GEN. CHARLES T. HARRIS, JR., *Chief of the Ordnance Department's Industrial Service, 1939–42.*

The fall of France marked the real beginning of America's rearmament. Once the tremendous Munitions Program of 30 June 1940 became effective, dwarfing all previous programs, there was an unheard-of expansion in Ordnance operations. Factories had to be converted into armories; ammunition plants, magazines, and depots built; huge stocks of weapons and ammunition distributed. And there was never enough time. It took an inexorable number of months to build a powder plant, make a tank, or fill a requisition, in spite of the

[26] Editorial, *Army Ordnance,* XXI, No. 121 (July–August 1940), 45.

[27] Min, Wesson Confs, 6, 11, 12 and 19 Apr; 2 and 13 May 40.

[28] (1) Editorial, *Army Ordnance,* XXI, No. 121 (July–August 1940), 45; (2) *Time,* May 27, 1940, p. 21.

[29] Min, Wesson Confs, 10 Jun 40.

most strenuous efforts of hard-pressed men to speed up the machinery of supply. At Ordnance conferences in the old Munitions Building and later in the new Pentagon, there was always present the haunting specter of Time.

CHAPTER II

Procurement Planning

Planning for military preparedness in the United States before World War II differed somewhat from planning by European military establishments. The differences stemmed largely from two factors: lack of a munitions industry in this country comparable to those of the major European nations, and American emphasis on maintenance of a small Regular Army backed by a modest reserve of war supplies. War Department planners had for many years assumed that, in event of war, the United States would have time to mobilize its reserves both of manpower and of industrial production, and would not need to maintain either a large standing army or large stores of munitions. Quantities of matériel left over from World War I were kept in storage during the 1920's and 1930's, but ammunition gradually deteriorated and weapons became outmoded. With each passing year, therefore, the Ordnance Department gave more attention to development of plans for speedy conversion of private industry to new munitions production in time of war. Ordnance procurement plans provided essential background for the vast rearmament effort launched in 1940.[1]

In spite of the injunction of the National Defense Act of 1920 to plan in advance for military supply, the War Department found the climate of opinion in the United States during the 1920's and 1930's not at all favorable to such planning.[2] The Planning Branch in the Office of the Assistant Secretary of War, headed in the middle 1930's by Col. Charles T. Harris, Jr., provided official encouragement for procurement planning, but its activities were strictly limited. During the years when hopes for peace were high, and military budgets low, this agency managed to keep alive the system of district procurement offices within the supply services and to promote arrangements with industry for

[1] (1) Lt. Col. Gladeon M. Barnes, "Procurement Planning," *Army Ordnance,* XVIII, No. 103 (July–August 1937), 22–23; (2) Maj. Gen. Charles M. Wesson, "Fundamentals of Preparedness," *Army Ordnance,* XIX, No. 114 (May–June 1939), 329–32; (3) Col. James H. Burns, "Production is Preparedness," *Army Ordnance,* XX, No. 115 (July–August 1939), 9–11; (4) Capt. Paul D. Olejar, Procurement Planning for War—Ordnance, May 44, a monograph prepared in the Ordnance Historical Branch, OCO. For a broad survey of the subject from the Army level, see R. Elberton Smith, *The Army and Economic Mobilization,* UNITED STATES ARMY IN WORLD WAR II (Washington, 1959), Chapters II–IV. A comparable Navy volume is Robert H. Connery, *The Navy and the Industrial Mobilization* (Princeton: Princeton University Press, 1951). An interesting essay by Troyer S. Anderson, The Influence of Military Production and Supply Upon History, may be found in OCMH files.

[2] The effect of public opinion on the War Department is discussed in chapter II of Green, Thomson, and Roots, *Planning Munitions for War,* and in Mark S. Watson, *Chief of Staff: Prewar Plans and Preparations* UNITED STATES ARMY IN WORLD WAR II (Washington, 1950), ch. VI (hereafter cited as Watson, *Chief of Staff*). See also summary of testimony before the Special Comm., *Investigating the National Defense Program,* S. Rpt No. 440, pt. 4, 80th Cong., 2d sess., 28 Apr 48, p. 292ff.

converting to war production.[3] By the spring of 1940 a change of popular sentiment was taking place; the American people were demanding more adequate national defense, but they still found the thought of planning for another war extremely distasteful.

The neutrality legislation of the 1930's had reflected the public's mood by forbidding shipment of American arms to other nations. Though the ban was altered in November 1939 to permit warring nations to purchase munitions in this country, all transactions had to be on a cash-and-carry basis. Under these circumstances, the British and French purchasing commissions made few contracts for munitions before June 1940, preferring to shop around for more favorable prices and to use the United States as a source of aircraft, machine tools, and scarce raw materials.[4] It was only after the disastrous defeats of May and June 1940 that the British plunged into an "arms at any price" buying campaign. Meanwhile the build-up of munitions for the U.S. Army was proceeding cautiously but picking up speed. Using a financial yardstick, General Wesson summed it up in the fall of 1939 as follows:

> In the fiscal year 1938 approximately $25,000,000 was expended for the procurement of Ordnance material. In the fiscal year 1939 approximately $50,000,000 has been and is being expended for like purposes. In the fiscal year 1940 a total of approximately $150,000,000 has been made available. . . .[5]

The depression of the 1930's had a very real, though indirect, influence on procurement planning. Since most industries were operating far below their normal capacity during the depression, Army planners tended to look upon the unused portion of the nation's industrial plant as an immediately available reserve for war production.[6] Unused industrial capacity was, of course, far more readily available for Quartermaster items, which were largely commercial in nature, than for Ordnance items. But the existence of idle factories, tools, and manpower throughout nearly the whole decade of the 1930's served to condition all planning for war procurement. It placed primary emphasis on utilization of existing capacity, rather than on building additional plants, and tended to minimize estimates of the probable impact on the civilian economy of a war production program. It gave rise to the belief, still widely held in 1940, that the capacity of American industry was great enough to support both a war economy and a peace economy, or, to employ the language popular at the time, to produce "both guns and butter." [7]

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[3] (1) Testimony of Brig. Gen. Charles T. Harris, Jr., in *WDAB,* S., 76th Cong., 3d sess., pp. 129 ff; (2) Ltr, CofOrd to ASW, 20 Sep 39, sub: Readiness of the Ord Dept. . . , OO 381/27800 ASW. For a critical evaluation of the War Department's procurement planning, see Harry B. Yoshpe, "Economic Mobilization Between the Two World Wars," *Military Affairs,* Winter 1951, pp. 199–204, and Summer 1952, pp. 71–83.

[4] For an account of these purchases, see (1) Richard M. Leighton and Robert W. Coakley, *Global Logistics and Strategy, 1940–1943,* UNITED STATES ARMY IN WORLD WAR II (Washington, 1955), ch. I; (2) Watson Pierce, Foreign Purchasing Competition Before the Lend-Lease Act, ICAF Research Project RP No. 28, July 1946. By 28 December 1940 British orders for machine tools, explosives, propellants, ammunition, tanks, and other ordnance equipment totaled nearly $800,000,000. See also Lt Col John N. Lyle, Historical Review of Lend Lease Activities, Small Arms and Small Arms Ammunition, 17 Jul 45, OHF.

[5] Ltr, CofOrd to ASW, 20 Sep 39, sub: Readiness of the Ord Dept to Meet the Requirements of a Major Emergency, OO 381/27800 ASW.

[6] Lecture, Maj Ray M. Hare, The Allocations Division, OASW, 8 Jan 40, ICAF. See also History, Rochester Ordnance District, I, p. 15.

[7] For discussion of this point from the level of the National Defense Advisory Commission, see Civilian Production Administration, *Industrial*

Ordnance devoted far more attention to procurement planning during the interwar years than did any of the other Army supply services. In the early 1920's Ordnance officers took a leading part in the establishment of the Army Industrial College, and throughout the interwar years they held key positions in the Planning Branch of the Office of Assistant Secretary of War.[8] Through its many procurement district offices Ordnance kept officially in touch with industry in all parts of the nation while the Army Ordnance Association, on a semiofficial level, promoted public interest in industrial preparedness. In fiscal year 1939, Ordnance Department procurement planning (including educational orders) accounted for about $8,000,000 of the $9,275,300 allocated for all War Department (including Air Corps) procurement planning for that year. In the early months of 1940 Ordnance had 231 officers and civilians engaged in procurement planning activities compared to only 264 for all the other supply services combined (including the Air Corps).[9] That Ordnance defense production got off to a fast start in 1940–41 was due in large measure to this prewar planning.[10]

Plans for New Facilities

Because of the specialized nature of its products, the Ordnance Department was fully aware of the need for scores of new facilities in time of war.[11] For such products as smokeless powder,[12] TNT, ammonia, and small arms ammunition, and also for loading artillery ammunition, there were no existing plants that could be readily converted. Furthermore, because powder and ammunition plants offered none of the usual attractions for private capital, it was recognized that they would have to be built at government expense if they were to be built at all. Working on these assumptions during the interwar years, Ordnance engineers, co-operating with the nation's small peacetime explosives industry and using the technical developments of Picatinny and Frankford Arsenals, drew up plans and specifications for typical plants to be built in time of need. In 1937 they established an office in Wilmington, Delaware, to carry on this work, and in 1938 Congress appropriated funds for the purchase of some of the highly specialized machinery required for the production of

Mobilization for War, History of the War Production Board and Predecessor Agencies, 1940–1945 (Washington, 1947), pp. 57–58, and p. 185.

[8] The importance of the Ordnance planning effort in the broad Army-wide picture is revealed in Smith, *Army and Economic Mobilization,* Chapters II–IV. The library of the Industrial College of the Armed Forces has several lectures given by Ordnance officers during 1940 and earlier years on the work of the Planning Branch.

[9] *WDAB,* 1941, H.R., 76th Cong., 3d sess., p. 98.

[10] See remarks by Lt. Gen. Brehon Somervell praising Ordnance as "preeminent" in this area, Rpt of Conf of Ord Dist Chiefs, Detroit, 22 Apr 44, p. 2, OHF. See also the report by Luther Gulick and his associates on the Cincinnati Field Survey, Apr 42, p. 20, ASF Contl Div files.

[11] (1) WD Ann Rpt, Report of the Chief of Ordnance, 1938, p. 9. (Hereafter, regardless of variations of title, these reports are cited as Ann Rpt CofOrd); (2) Memo, Col Lucian D. Booth, Ammo Div, for Gen Harris, 3 Jan 39, sub: Gen Data . . . for Ammo in an Emergency, OHF; (3) Lecture, Maj Gen Charles M. Wesson, The Ordnance Department, 9 May 41, ICAF; (4) Memo, CofOrd for ASW, 6 May 40, sub: Additional Facilities Required. . . , OO 381/35763 ASW; (5) Rpt of Comm. headed by Col Rutherford for ASW, 24 Jun 40, sub: Proposed WD Program for Increasing Productive Capacity for Munitions, Maj Gen James H. Burns's personal file; (6) Notes on conversation with Col Leo Dillon, assistant executive officer to Gen Burns, no date, in Troyer Anderson's notes, folder 4, OCMH.

[12] "Smokeless powder" is used throughout this volume because of its wide currency, not because it was an accurately descriptive term. "Propellant" was generally preferred by specialists in this area.

powder and small arms and for the operation of loading plants. By the summer of 1940, thanks largely to the efforts of General Harris, Ordnance had a fairly clear idea as to the type of new facilities it would need to produce smokeless powder, explosives, ammonia, and TNT.[13] These plans and reserve machinery, General Wesson told the Truman Committee in April 1941, proved to be of "untold value" in promptly starting the new facilities program.[14]

In the summer of 1940 the Munitions Program of 30 June opened a new era in procurement planning. It called for immediate procurement of equipment for 1,200,000 ground troops, procurement of important long-lead-time items for a ground force of 2,000,000, creation of productive capacity for eventually supplying a much larger force on combat status, and production of 18,000 airplanes. Approval of this plan, formulated in large part by an Ordnance officer, Col. James H. Burns, was a big step forward along the road toward effective industrial mobilization.[15] It made a sharp break with all previous plans to supply equipment for small Army increments, for it established broad planning goals far in advance of any formal action to increase the strength of the Army. It cleared the way for creation of munitions plants for a big military effort and left to the future the tedious task of refining and adjusting its parts. But Ordnance planners found that there were still many unknown factors in the equation—new weapons, tables of equipment, estimated rates of consumption, speed of mobilization, timetable for overseas deployment, and, most important, how much money would be available.

Although Ordnance maintained six manufacturing arsenals in time of peace, they were not intended for large-scale production in time of war.[16] It was estimated that all the arsenals combined would never be able to produce more than about 5 percent of the Army's requirements for war. In the initial stages of an emergency, while indus-

[13] Memo, CofOrd for Col Burns, OASW, 1 Mar 40, sub: Ord War Construction Rpt, OO 381/33041 ASW. The inclosure to this memo tabulated 29 proposed loading and powder plants, with tentative locations indicated. See also list of proposed new plants in Munitions Program of 30 June 1940, ASF Contl Div dr G43; Dir, High Explosives Manufacturing Plants, 20 Sep 39, by Lt Col Alfred B. Quinton, Jr., approved by Col Booth and Brig Gen Harris, OHF; and Dir, War Plans for Loading Ammunition, 21 Mar 40, by Brig Gen Harris, OHF. On the role of General Harris, see Ltr, Louis Johnson to Harry C. Thomson, 14 Oct 52, OHF. The New York *Times* on 2 January 1941 ran a front-page article on the need for powder plants and on Ordnance plans for their construction.

[14] (1) Statement of Gen Wesson . . . before the Spec S. Comm. *Investigating the National Defense Program,* 77th Cong., 1st sess., *Hearings* on S. Res. 71, *Investigation of the National Defense Program,* Apr 41. (These hearings, which extended from 1 March 1941 through 11 June 1948, from the 77th through the 80th Congresses, will hereafter be cited as Truman or Mead Comm., *Hearings* according to date. The successive chairmen of this committee were Harry S. Truman, James M. Mead, and Owen Brewster). A copy of Gen Wesson's statement is in OHF; (2) Interv with Maj Gen Charles T. Harris, Jr., and Brig Gen Burton O. Lewis, 13 Jan 53; (3) Min, Wesson Confs, 20 Jun 40. On the development of plans and purchase of machinery, see also (4) Small Arms Ammunition, A History of an Industry, 1918–1944, vol. I, ch. 4, prepared by Ammo Br, SA Div, OCO (hereafter cited as SAA); and (5) Ord Monograph No. 4, Ammunition, 1 July 1940–31 August 1945, by Maj Berkeley R. Lewis and Lt C. B. Rosa; 31 Dec 45, p. 6, OHF.

[15] (1) Munitions Program of 30 June 1940 (corrected as of 24 July), in ASF Contl Div files, dr G43. For the important role played by Col. (later Maj. Gen.) James H. Burns in developing this program, see (2) Watson, *Chief of Staff,* pp. 172–182, and (3) Smith, *Army and Economic Mobilization,* Chapter VI. (4) See also Ltr, Johnson to Thomson, 14 Oct 52, OHF.

[16] For names, locations, and wartime activities of the arsenals, see Green, Thomson, and Roots, *Planning Munitions for War,* pp. 6–7. A detailed history of each arsenal may be found in OHF.

try built new plants, the arsenals were to produce certain types of urgently needed munitions; but, with a few exceptions, their major wartime role was to serve as sources of production techniques, as development centers, and as training grounds for Ordnance production personnel, inspectors, and key men from industrial plants. The main burden of war production would fall on private industry and on new government-owned, contractor-operated (GOCO) plants built for the purpose.[17]

Plans for Decentralized Procurement

In terms of organization, the foremost principle of Ordnance procurement planning in the summer of 1940 was decentralization through the six manufacturing arsenals and the thirteen district offices.[18] Ever since World War I, Ordnance procurement plans had provided that, with certain exceptions, contracts for war matériel would be placed by the arsenals or the district offices, each of which was familiar with industries capable of producing the required munitions. Over-all direction of the program in wartime was to be exercised from Washington by the Chief of the Industrial Service, General Harris, but the day-by-day work of negotiating and administering contracts was to be carried on in the districts.[19]

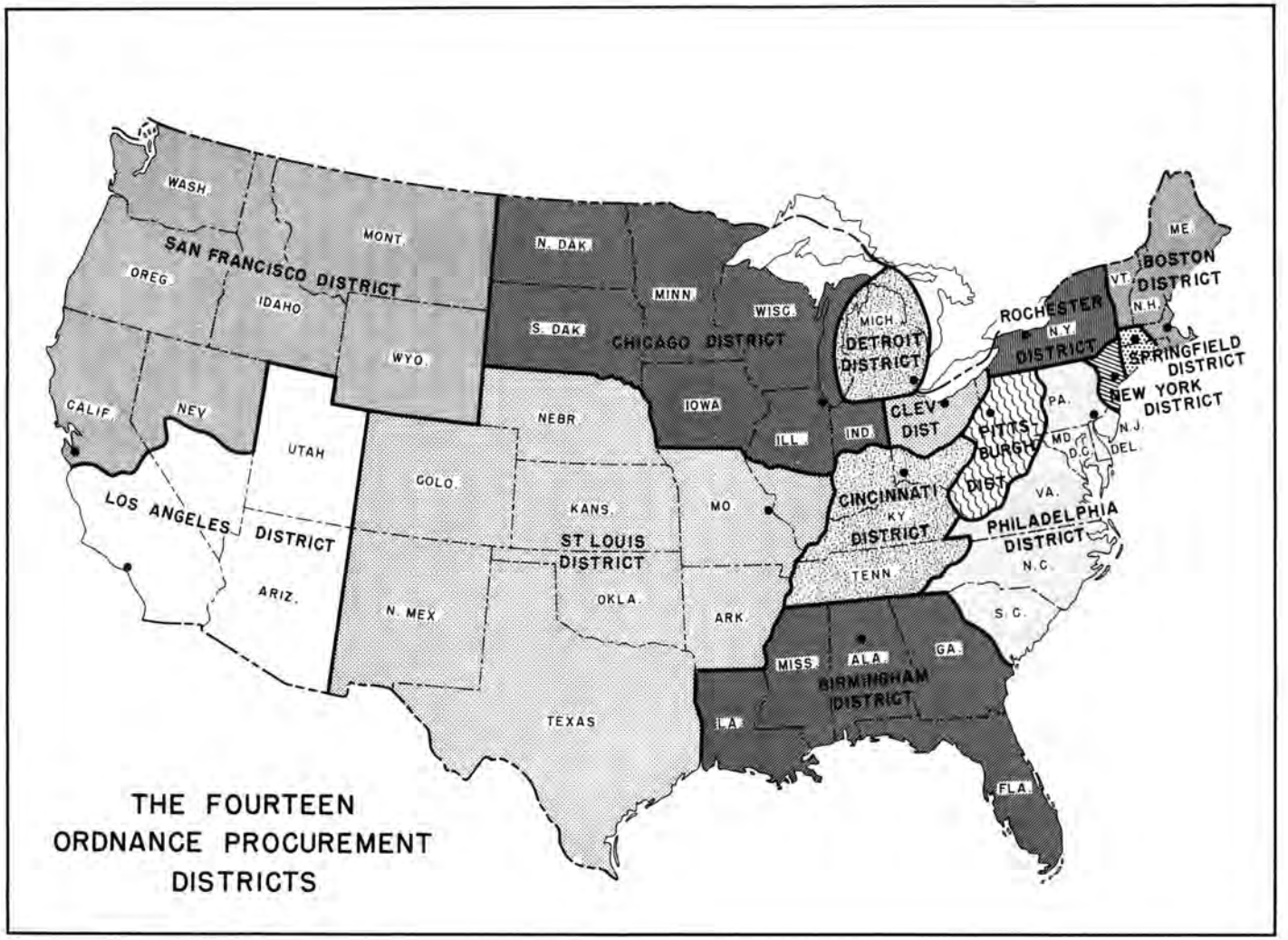
The districts had a combination of civilian and military leadership. Each district had as its chief (until 1942) a prominent local businessman, usually a Reserve officer, who devoted part of his time to district affairs. To each district a regular Ordnance officer was assigned on a full-time basis as assistant chief or executive officer. Most of the districts also had advisory boards made up of prominent business leaders who were sympathetic, at least in theory, with the Ordnance Department's preparedness plans. There was an element of "window dressing" about these boards but there was some real substance, too. The New York district, for example, numbered among its board members in the 1939–41 period such prominent figures as Patrick E. Crowley, president of the New York Central Lines; James A. Farrell of the United States Steel Corporation; Maj. Gen. James G. Harbord (Ret.), chairman of the board of directors of the Radio Corporation of America; Robert P. Lamont, former Secretary of Commerce; and Owen D. Young, chairman of the board of the General Electric Company. The Cleveland district probably reflected the experience of other districts when it reported that the names of highly respected industrialists on its advisory board helped to unlock industrial doors.

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[17] (1) Lectures, Maj Gen Charles M. Wesson, Ordnance Department Procurement, and The Ordnance Department, 15 Jan 40 and 9 May 41 respectively, ICAF. (2) See also Memo, CofOrd for Planning Br, OASW, 8 Sep 39, sub: Measures . . . in Event of War. . . , OO 381/27496 Misc.

[18] The origins and early history of the arsenals and district offices are treated in Green, Thomson, and Roots, *Planning Munitions for War,* Chapter I. In 1940 the district offices were in the following cities: Birmingham, Boston, Chicago, Cincinnati, Cleveland, Detroit, Hartford (redesignated Springfield in May 1942), New York, Philadelphia, Pittsburgh, Rochester, St. Louis, and San Francisco.

[19] For detailed description of the organization of the Industrial Service, and its relation to the districts, see Green, Thomson, and Roots, *Planning Munitions for War,* Chapters II and IV. The mechanics of Ordnance procurement, and many references to specific procurement planning directives, are described in History of the Industrial Service, District Administrative Branch, vol. 101, OHF. See also Dir for Procurement . . . for FY 1940. . . , 1 May 39, OHF; Cir 18, The Mission of the New York Ord Dist, 29 Oct 35, in History of New York Ordnance District, I, pt. 1, app. C.



THE FOURTEEN ORDNANCE PROCUREMENT DISTRICTS

In the early stages of an emergency, while the districts built up their staffs and established operating procedures, the arsenals were to let contracts for the more complicated types of matériel and were to aid the districts by providing blueprints, specifications, and technical guidance to manufacturers.[20] Up to July 1940, the districts had no authority to award contracts. During the preceding eighteen months they had handled some of the preliminary work for educational orders and production studies.[21] They had been given increasing responsibility for inspecting finished products, but they had had no authority to place orders with industry. The grant of that authority to the districts was nevertheless an integral part of the Ordnance plan, and to lend realism to such planning each district was requested in December 1939 to submit its recommendations covering the first twenty contracts it expected to place in time of war. The reports sent in by the districts showed names of plants, items to be produced, types of contracts to be used, and the reasons for selecting each plant.[22] The Chicago district, to cite one example, planned to place orders with Elgin National Watch Company for time fuzes, with Allis-Chalmers Manufacturing Company for machining 75-mm. shells, with Bucyrus-Erie Company for 3-inch AA gun mounts, with Stewart-Warner Corporation for metallic belt links, and so on through the list.[23]

The Industrial Service in mid-July 1940 described in some detail the specific procurement procedures to be followed by the arsenals and districts. To use the district procurement system and at the same time retain competitive bidding to the maximum extent, Ordnance proposed to divide the requirement for each item among districts that had facilities allocated for production of that item.[24] When district offices received these assignments they would request facilities allocated to them to submit bids. The bids from all districts would then be reported to the Ordnance office in Washington. That office would compare the bids with each other and with known costs of manufacture at arsenals and would make awards to facilities that offered the best assurance of producing on schedule and at a fair price. Rigid acceptance inspection by the district offices, coupled with periodic interchangeability tests, would assure uniformity of product. In analyzing the plan the Chief of Ordnance wrote:

> It will be observed that this plan, in effect, provides for nation-wide competition among allocated facilities, with contract negotiations carried on in the geographic territories of the several Ordnance Districts. Assurance of the timely production of munitions through use of the district system cannot be obtained in any other manner, and it is considered that

[20] (1) Ann Rpt CofOrd FY 1938, p. 8; (2) Hist, Ind Serv, Dist Admin Br, sec. B, vol. 101; (3) Harry B. Yoshpe, Plans for Industrial Mobilization, 1920–39, ICAF Research Project RP No. 28, Nov 45, p. 78. For the experience of the Quartermaster Corps wherein current procurement and procurement planning were not closely tied together, see Thomas M. Pitkin and Herbert R. Rifkind, Procurement Planning in the Quartermaster Corps 1920–40, QMC Historical Studies No. 1, Mar 43, pp. 121–28.

[21] Discussed below, pp. 19–21. For a detailed record of one district's activities, see the bound volumes of monthly reports of the Cincinnati Ordnance District for 1940 and 1941, OHF.

[22] Ltr, CofOrd for all districts, 14 Dec 39, sub: Negotiation of Wartime Contracts, OO 381/-30303 San Francisco. Replies from the districts are also in this file.

[23] Ltr, Chicago Ord Dist to CofOrd, 21 Dec 39, sub: Negotiation of War-time Contracts, OO 381/3062, copy in OHF.

[24] Allocated facilities were those assigned in War Department plans for use of a specific procurement agency. See below, p. 19.

the plan will bring forth the best facilities producing at the lowest cost, consistent with the desired distribution of the load.[25]

It was estimated that in meeting requirements of the Munitions Program of 30 June the districts would place approximately four hundred prime contracts, utilizing some eight thousand facilities. For that part of the procurement load assigned to the arsenals, competitive bidding among allocated facilities or any other facilities with suitable production experience, and the signing of fixed-price contracts, were to be the rule. Arsenal commanders had authority to close contracts involving less than $50,000 without referring them to Washington for approval, but larger contracts had to have the approval of the Chief of Ordnance, the Assistant Secretary of War, and Commissioner William S. Knudsen of the Advisory Commission to the Council of National Defense (usually referred to as NDAC).[26]

Each district office was to administer its own contracts and also all contracts with industries within its borders placed by the arsenals. Administration of contracts included, among other things, helping contractors solve production problems, making periodic reports to the Chief of Ordnance on the status of production, inspecting finished products, and paying for the goods delivered. By means of production reports from the districts and the arsenals the Chief of Ordnance planned to exercise close control over the flow of components to final assembly points and loading plants, and to bring pressure to bear upon contractors who failed to meet their production schedules.

Contract Forms and Legal Restrictions

By the summer of 1940 the Assistant Secretary of War had approved six standard contract forms for use in a national emergency.[27] These had been drafted to prevent recurrence of the confusion of World War I when purchasing agencies of the War Department evolved and used over four hundred different and troublesome contract forms. Ordnance expected that the most important of the approved contracts would be Standard Form No. 32, a fixed-price supply contract to be used under the system of competitive bidding. It was thought that this type of contract would account for 95 percent of all awards by the district offices. But, because of the difficulty of estimating costs of war equipment that manufacturers had never before produced, other types of contracts, such as the cost-plus-fixed-fee (CPFF), which allowed greater flexibility in pricing, were also considered.

In January 1940 the Ordnance Department regarded the legal restrictions on peacetime procurement as a major factor that would retard the award of Ordnance contracts in time of emergency. It cited the law requiring public advance advertising and award to the lowest responsible bidder, and other legislation affecting hours, wages, and profits. In January 1940, General Wesson stated that because of this legislation, with which many manufactur-

[25] Memo, CofOrd, for ASW, 19 Jul 40, OO 381/1335 ASW. The Ordnance plan was officially approved by the Secretary of War in a memo for NDAC, 23 Jul 40, OO 334.9/26. The plans of all the supply services are summarized in Ann Rpt USW FY 41, and in Ann Rpt P and C Br, OUSW, FY 41.

[26] Memo, ASW for CofOrd, 10 Jun 40, sub: Approval of Important Purchases. . . , OHF.

[27] For copies of these forms see Ind College Spec Text No. 98, War Department Procurement Planning, ch. 8, prepared in 1940 by Extension Course Div ICAF. See also Yoshpe, *op. cit.*, pp. 50–53, and Lt. Col. John P. Dinsmore, "War Contracts," *Army Ordnance*, XX, No. 119 (March–April 1940), 317–21.

ers were not familiar, it took about ninety days to advertise for bids, examine the bids, and make an award. He went on to say that this procurement cycle could be cut from ninety to thirty days for essential items in an emergency only if the industrial mobilization plan were put in effect, legal restrictions removed, and Ordnance permitted to negotiate directly with selected facilities.[28]

Surveys of Industry

In the summer of 1940 each district office had on file hundreds of reports of industrial surveys made during the preceding years and kept as nearly up-to-date as possible with the handful of officers and civilian engineers available for the job. These surveys, made under the broad supervision of Louis Johnson, Assistant Secretary of War, covered major industrial plants within each district that might be converted to munitions production in time of war. For each plant the survey recorded the firm's normal product, its productive capacity, floor space, and major items of equipment. It also gave information on the firm's financial standing and resources, transportation facilities, availability of skilled workers, and, most important, the type and quantity of Ordnance matériel the company might produce in an emergency. Above all, Ordnance was interested in firms with good management and strong engineering departments. "It was not just the machines and floor space that counted," observed Brig. Gen. Burton O. Lewis, a leader in Ordnance procurement planning. "Of even greater importance were the men—the skilled workers, the production engineers, the executives who understood the secret of high-quality mass production." [29] In most cases, after the survey



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was complete, Ordnance and the company signed an informal agreement known as an "accepted schedule of production" showing specifically what the company was prepared to produce.[30] Accepted schedules of production were "all important," General Wesson told Industrial College students early in 1940. "They are part of our war reserve. They are as vital as the material in our storehouses." [31]

[28] Lecture, Wesson, Ordnance Department Procurement, p. 10. See also Memo, Brig Gen Harris, Actg CofOrd, for ASW, 15 May 40, sub: Measures to Expedite Proc, OO 400.12/5908.

[29] Interv with Brig Gen Burton O. Lewis, 29 Apr 52. The same view was expressed by many other Ordnance officers in interviews with the author.

[30] For discussion of this topic, see testimony of Brig Gen Harris, *WDAB,* S., 76th Cong., 3d sess., p. 239ff. See also Smith, *Army and Economic Mobilization,* ch. III.

[31] Lecture, Wesson, Ordnance Department Procurement.

Before 1940 the process of making industrial surveys was slow, hampered by lack of interest on the part of some manufacturers and by lack of personnel in the district offices. It was also hampered by the fact that not all Ordnance district officers had sufficient manufacturing background and engineering knowledge to do a good surveying job. But during the first six months of 1940 the tempo of survey work increased markedly, stimulated by a procurement planning conference called by Louis Johnson in October 1939. The Pittsburgh District made more than two hundred surveys during the first half of 1940 as compared with only thirty-nine during the preceding six months, and the cumulative total for the District in July 1940 rose to five hundred.[32]

By 1940 the purpose of industrial surveys had generally ceased to be discovery of firms that could turn out complete items of Ordnance matériel ready for storage or issue. The search was for several firms, each of which might manufacture one or more components or perform one or more steps in the whole process of manufacture. Further, surveying officials were looking for plants that could do the job by using equipment already on hand and with workers already trained in similar processes.

The search for plants that could undertake Ordnance production with existing equipment was dictated largely by the anticipated shortage of machine tools. Ordnance planners were aware that the nation's small machine-tool industry would be swamped in time of war; they realized that every possible step should be taken to utilize existing machines rather than count on extensive retooling. The dearth of machine tools in the South was spectacularly revealed in the fall of 1939 when the Birmingham District office reported that, of eighteen contractors approached, not one had the tools needed to begin production on any type of matériel contemplated for production in that District.[33] The educational orders program revealed that lack of machine tools was also a problem for industries in the North. In January 1940, for example, the Philadelphia District reported that bids on educational orders "indicate a larger deficiency of machine tools than was anticipated six months ago." [34]

Planning for an adequate supply of gages —those essential measuring and checking devices needed to assure precision manufacture—was an altogether different story. Profiting from the experience of World War I, the Ordnance Department during the 1920's and 1930's took a number of important steps to assure an adequate supply of gages for a future emergency. More than half a million World War I gages were collected, checked for accuracy, and put in storage. During the 1930's nine district gage laboratories were established at universities to provide gage-checking services to manufacturers and to train personnel for gage-surveillance duties, and gage laboratories were established at all the arsenals. Beginning in 1938 Ordnance made a concerted effort to design gages for all items for which it was reasonably sure that production would be required. Gages on hand at the arsenals were brought up to date, and new gages were procured for

[32] History, Pittsburgh Ordnance District, I, pt. 3, p. 382. For similar data, see History, Detroit Ordnance District, I, p. D–3.

[33] History, Birmingham Ordnance District, I, pt. 1, pp. 285–90.

[34] Monthly Progress Rpt, Phila Ord Dist, Jan 40. See also History, New York Ordnance District, I, pt. 2, pp. 75–76.

standard items. In July 1940 Ordnance allotted approximately $2,500,000 for gage procurement in advance of actual production of weapons or ammunition. At the same time, steps were taken, in cooperation with other government agencies and private industry, leading to allotment by the War Department of $4,000,000 to expand productive capacity of the gage industry.[35] So effective were these preparatory measures that the gage problem, which proved so serious in World War I, was scarcely a problem at all in World War II.

Closely related to industrial surveys was the system by which a certain percentage of a plant's capacity was allocated by the Army and Navy Munitions Board for the exclusive wartime use of one or possibly several supply services.[36] Originally adopted to guard against recurrence of the confusion and interagency competition that had marked the procurement process in 1917, the allocation system was designed also to forewarn industry of the tasks it would be called upon to perform in time of war, to promote mutual understanding between industry and procurement officers, and to serve as a basis on which to plan war production. The supply services furnished allocated facilities with drawings, specifications, descriptions of manufacture, and in some cases samples of the critical items they were scheduled to produce, and encouraged them to study means of converting their plants to munitions production.[37]

Educational Orders and Production Studies

Perhaps the most radical departure from conventional practice, and the most highly publicized feature of Ordnance prewar procurement plans, were the educational orders. Approved by Congress in 1938, after years of urging by procurement officers and the Army Ordnance Association, the Educational Orders Act permitted placement of orders with allocated facilities for small quantities of hard-to-manufacture items. The purpose was to give selected manufacturers experience in producing munitions and to procure essential tools and manufacturing aids. Other supply services participated in the program to some extent, but the bulk of the educational orders were for Ordnance matériel.[38]

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[35] (1) History, Gage Section and Gage Facilities Section, OCO, I, pt. 1; (2) Memo, ASW for Donald Nelson, 21 Sep 40, sub: Project for Expansion of Productive Capacity for Gages, copy in OHF.

[36] The next chapter discusses the allocation system more fully.

[37] For a detailed description of the allocation system, see Yoshpe, *op. cit.*, pp. 22–26. See also Maj Gen Charles M. Wesson, "Arms for the Army," *Army Ordnance,* XIX, No. 112 (January–February 1939), 209; Maj Scott B. Ritchie, "The Allocations System," *Army Ordnance,* XVIII, No. 104 (September–October 1937), 77–83. The district histories, particularly that of the Pittsburgh District, describe the allocations procedure in detail. The names of all allocated plants, and the service or services to which they were allocated, appear in Alphabetical Directory of Industrial Allocations, May 1940, issued by ANMB. The most recent review of the allocation system appears in Smith, *Army and Economic Mobilization,* Chapter III.

[38] See Chapter III of Green, Thomson, and Roots, *Planning Munitions for War,* for a summary of the program before 1940. *The Annual Report of the Secretary of War to the President, 1939* (Washington, 1939) (hereafter cited as Ann Rpt SW, 1939), pp. 16–17, describes the over-all program as does Smith, *Army and Economic Mobilization,* ch. III. The histories of the Ordnance districts report on the details of its administration. Many pertinent documents are in OHF. See also testimony of Brig. Gen. Harris and Col Rutherford, *WDAB,* S., 76th Cong., 3d sess., p. 129ff; Col. Harry K. Rutherford, "Educational Orders," *Army Ordnance,* XX, No. 117 (November–December 1939), 162–66; and Benedict

After a rather cautious start in fiscal year 1939, when Ordnance awards went to only four companies, the program leaped ahead in fiscal 1940 with more than eighty educational awards. As orders for a wide range of items went to manufacturers in all parts of the country, the district offices and arsenals plunged into the task of sharing with industry their knowledge of production methods peculiar to munitions making. The invitations to bid for educational orders were issued by the arsenals and the contracts were let from the Office of the Chief of Ordnance, after approval by the Secretary of War and the President, as required by law. Selection of firms to receive invitations to bid, negotiation of contract details, and inspection and acceptance of finished matériel were all managed by the district offices. The entire process was thus an educational experience for the Ordnance Department as well as for the manufacturers. But, just as the program was getting well under way in the summer of 1940, it was suddenly halted. Because of the swift German victories in western Europe and the huge appropriations for military supplies voted by Congress, educational orders gave way to production orders. Ordnance placed its last educational order in July 1940 while the British Army was recovering from its evacuation of Dunkerque.[39]

The prevailing opinion in the Ordnance Department and among contractors holding educational orders was that the program, in spite of being too limited in scope and too brief in duration, proved its value as a means of industrial preparedness.[40] The Winchester Repeating Arms Company estimated that its educational order for the M1 rifle saved a full year's time in getting into quantity production.[41] Not all companies with educational orders completed them successfully, nor were all holders of educational contracts later given production orders for exactly the same product. But in April 1941 Ordnance reported that about half had received production orders for the same or similar items.[42] All told, the educational orders had spread the "know how" of specialized ordnance manufacture to some eighty-two companies, made available to them at least a minimum of special tools and other manufacturing aids, and, by familiarizing them with Ordnance inspection methods, probably cut down rejections on later production orders.[43]

While Ordnance was launching its educational orders experiment it also entered

Crowell, *et al.*, "The Crowell Board Report on Educational Orders for Peacetime Munitions Production," *Army Ordnance,* XX, No. 117 (November–December 1939), 167–70.

[39] Min of conf in Gen Wesson's office, 1 Apr 41, relative to S. Res. 71, OHF. See also Memo, Lt Col Hugh C. Minton for Mr. Julius H. Amberg, 4 Apr 41, sub: Educational Orders, OHF.

[40] (1) Replies to questions submitted to Maj Gen C. T. Harris. . . , 28 Feb 45, OHF, pp. 3–4; (2) *WDAB,* 1942, H.R., 77th Cong., 1st sess., p. 27; (3) Yoshpe, *op. cit.*, p. 37; (4) Histories of Ord Districts; (5) Testimony of Rutherford, 27 Feb 40, *WDAB,* 1941 H.R., 76th Cong., 3d sess., p. 108, *passim;* (6) *WDAB,* 1941, S., 76th Cong., 3d sess., p. 200. See also the statement by Secretary of War Robert P. Patterson that educational orders were of "immeasurable value," *Army Ordnance,* XXII, No. 131 (March–April 1942), 729–30.

[41] History, Rochester Ordnance District, I, p. 50. Similar testimony may be found in the histories of other districts and in the Report of the Under Secretary of War, 30 June 1941.

[42] Memo, Minton for Amberg, 4 Apr 41, sub: Educational Orders.

[43] (1) Statement of Maj Gen Charles M. Wesson, Truman Comm. *Hearings,* Apr 41, copy in OHF. (2) Statement of Wesson, *WDAB,* H.R., 77th Cong., 1st sess., p. 527, and statement by Maj Gen Harry K. Rutherford, p. 229.

into nearly one hundred contracts for production studies to determine the techniques and equipment needed for quantity production of items of ordnance.[44] Congress authorized the War Department to purchase such studies in 1939. In the spring of 1940 General Wesson told a Congressional committee that funds for 420 additional studies should be appropriated as he considered such studies to be "of paramount importance to national defense." [45] Averaging about $5,000 each, these studies had the advantage of being much cheaper than either educational orders or production orders, but they were of far less value. Their usefulness depended in large measure on the strength of the contracting company's engineering staff and on the seriousness with which it tackled the study. In the final analysis, only production orders under wartime conditions could provide the proof of the pudding. That proof was not slow in coming, for in some cases contracts for production studies were replaced, even before they were signed, by production orders.[46]

During the year ending 30 June 1940 the Ordnance Department awarded 1,450 contracts to industry for approximately $83,000,000 worth of weapons, ammunition, and new machinery, and it allocated a nearly equal sum to the arsenals for production and modernization.[47] Plans called for completion of this 1940 program within two years, with 95 percent of it completed by December 1941. "In general," observed General Wesson, "it takes approximately one year to place orders and to get production started, and a second year to finish any reasonable program." [48] Beyond the 1940 program, provision had been made for a tremendous increase in production when funds for fiscal year 1941 became available.

Conclusion

Such, in broad outline, was the nature of Ordnance procurement planning in the summer of 1940. It was fundamentally sound, in terms of the political and economic atmosphere of the time. Its most serious weakness lay in the limitations on its application and development. The value of plant surveys made in the late 1930's was demonstrated time and again during the defense period and was recognized by the Office of Production Management (OPM) in the spring of 1941 when it declared that they "have been found adequate for the purpose of OPM's defense contract service and will not be duplicated." [49] But Ordnance and the other supply services never had enough money or enough manpower to carry on a fully adequate program of industrial surveys. Similarly, the educational orders program, although soundly con-

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[44] Memo, Lt Col Quinton for Maj Hugh B. Hester, OASW, 5 Aug 40, sub: Production Studies, OO 381/2210 ASW. See also testimony of Col Harry K. Rutherford in *WDAB,* H.R., 76th Cong., 3d sess., 27 Feb 40, pp. 100ff, and "Production Studies," and editorial in *Army Ordnance,* XX, No. 120 (June–July 1940), 396. The History of the Pittsburgh Ordnance District, I, Part 3, Chapter 4, describes that District's experience with production studies in detail.

[45] *WDAB,* 1941, H.R., 76th Cong, 3d sess., 12 Mar 40, pp. 558 and 601.

[46] History, Pittsburgh Ordnance District, I, pt. 3, p. 416. This reference also gives evidence of the usefulness of the production studies which were completed.

[47] Analysis of FY 1940 Ord Dept Contracts, Asst Chief of Ind Serv (Prod), OHF.

[48] Speech by Maj Gen Charles M. Wesson in Pittsburgh, 3 May 40, OHF. For a review of the contracts in force in the spring of 1940, see testimony of Wesson, *WDAB,* H.R., 76th Cong, 3d sess, pp. 555–56.

[49] Proc Plng Bull, 1 Apr 41, cited in Hist, Pittsburgh Ord Dist, I, pt. 3, p. 385. See also statement by Secretary Patterson in praise of these surveys before Select Comm., *Investigating National Defense Migration,* 23 Dec 41.

ceived and effectively administered, was started so late and was allotted so little money that its full value was never realized. The system of plant allocations formed the basis for a fruitful exchange of information between Ordnance and industry during the interwar years, and, when the emergency came, the allocation plans provided most useful guidance for placing Ordnance contracts. But the allocation plans were only a first step toward industrial preparedness. Their effectiveness depended upon their being backed up by the district system, the arsenals, and a competent managerial staff in Washington.

Maintenance of the six manufacturing arsenals as the "Regular Army of production" throughout the interwar years was one of the most important Ordnance contributions to the cause of industrial preparedness. But it must also be remembered that, because of lack of funds, the equipment of the arsenals was not kept up-to-date. Although some progress toward modernizing arsenal equipment was made in the late 1930's, particularly at Frankford, by 1939 some 80 percent of the machine tools in the arsenals were eighteen or more years old, and some of them antedated the Civil War.[50] With such equipment the arsenals were not able to keep abreast of the latest developments in manufacturing techniques, nor were they fully prepared in 1940 to serve as model factories to be copied by private industries about to convert to munitions making.

Without the district offices, with their continual and friendly liaison with industrial leaders, the paper plans for war procurement would have been far less valuable than they actually proved to be. But the fact that no annual meeting of the district chiefs was held between 1931 and 1935 because of lack of funds is eloquent testimony to the limitations on district activity during those years. So is the fact that before 1939 the employees on duty in the average district office could be counted on the fingers of one hand. It is no doubt true, as General Harris asserted, that there was never a time in the 1938–40 period when he could not gain a sympathetic hearing from the president of any leading corporation in the United States to discuss procurement plans. In some degree the same was true of the district chiefs who were themselves prominent industrialists and were supported by advisory committees composed of industrial leaders. But most businessmen were reluctant to undertake detailed planning for an unforeseeable future. They were willing to go just so far, and no farther. As a result, within the limited budgets of the peacetime years the districts did a great deal of valuable work, but in 1940 much still remained to be done before a major program of munitions production could be launched.

In one respect a great advance was made in Ordnance procurement planning between the fall of 1939 and the fall of 1940. More and more people, both in and out of the Army, began to take such planning seriously for the first time. Before

[50] Three significant magazine articles on this subject appeared in 1939. "The Arsenals in Action" in *American Machinist,* vol. 83, (February 8, 1939), pp. 48aff., reported the findings of a study of arsenal machines made by the magazine staff. Maj. Gen. Charles M. Wesson, in "Adequate National Defense Requires Modernized Arsenals," *Machinery,* vol. 45 (July 1939), pp. 735ff., declared that a great proportion of arsenal machinery was obsolete. The same facts were presented by General Wesson in *Army Ordnance,* XIX, No. 114 (May–June 1939), 331, and in *WDAB,* 1941, H.R., 77th Cong., 1st sess., pp. 596–97. The official histories of the arsenals provide some data on new machinery purchased in 1939–40, as does Memo, CofOrd for Col Wade H. Haislip, 28 Jan 39, OO 111.6954, copy in OHF.

1939, when the prospects of American involvement in war seemed remote, only a few people took procurement planning seriously. Among these, it should be noted, were the members of the Army Ordnance Association, who worked throughout the interwar years to promote the cause of industrial preparedness for national defense. Established in 1919, the AOA immediately gained recognition in both industry and government when it elected as its first president Benedict Crowell, director of munitions in World War I. At the annual dinners held by AOA posts in major cities the most important leaders of American industry were brought together to consider industry's role in national defense. The bimonthly magazine, *Army Ordnance,* brought to all members of the association articles on new developments in ordnance engineering along with news and comment on industrial preparedness.

In the late 1930's Louis Johnson made countless speeches in all parts of the country urging the need for industrial preparedness, but the response was generally apathetic, and frequently hostile.[51] Then, in the spring of 1940, the swift German victories aroused public interest in rearmament of the United States and in plans for national defense. Instead of being denounced for making war plans, military men were now criticized for not having made better plans. With the launching of the munitions program in the late summer of 1940 a new attitude prevailed in the Army and among businessmen. The change did not come overnight, nor was it complete before Pearl Harbor, but it had a steady growth. It gave to all considerations of procurement plans a sense of reality and urgency they had never had before. It not only freed the procurement planners of the psychological handicap under which they had labored for two decades but it also brought forth the money needed to transform blueprints into weapons.[52]

[51] Ann Rpt of ASW, 30 Jun 38, in *Ann Rpt SW, 1938,* pp. 19–20. See editorial in *Saturday Evening Post,* vol. 211, No. 22 (November 26, 1938), attacking the Industrial Mobilization Plan as "articles of war-time dictatorship." The broad background of these events is described in Smith, *Army and Economic Mobilization,* Chapter V.

[52] For comment on this matter as viewed from the highest level in the War Department, see *Ann Rpt SW, 1941,* pp. 2–3.

CHAPTER III

Launching the Defense Program, 1940–41

Appropriations for preparedness in the early months of 1940 indicated a growing awareness of the dangers threatening the nation, but they fell far short of financing a long-range military program for the United States. Because of the cumbersome machinery used in making military appropriations, and the uncertainty among advocates of preparedness as to how far and how fast the nation should go in the directions of rearmament, the money to finance the munitions program did not come all at once but in varying amounts at irregular intervals. After the startling German successes in May and June, Congress acted quickly to make more funds available. Following the $436,000,000 approved for Ordnance in June 1940, there came a supplemental grant of $1,442,000,000 in September. Six months later $913,000,000 was appropriated for Ordnance expenditures under lend-lease, followed by $1,339,000,000 for general purposes in June, and nearly $3,000,000,000 in August 1941.[1] These funds strengthened the rearmament effort, but each appropriation also called for a revision of plans and objectives, thus making it difficult for the General Staff to provide Ordnance with a firm long-range statement of procurement goals.[2]

Procurement Objectives

As a first step toward providing detailed procurement objectives for the supply services, the General Staff issued an Expenditure Program in August 1940. Designed as a master shopping list for Army procurement, this document showed requirements for the Protective Mobilization Plan (PMP) force of 1,200,000 men and for the augmented force of 2,000,000 men, the

[1] Ordnance appropriations during the defense period are discussed in Green, Thomson, and Roots, *Planning Munitions for War,* Chapter III. See also Incl to Memo of Harris for USW, 9 Sep 41, sub: Comments on Study. . ., OHF. For a brief summary of other measures adopted during 1940 and early 1941, see testimony of the Secretary of War and the Under Secretary before the Truman Committee, 15 April 1941, pt. 1.

[2] The history of industrial mobilization during the defense period, written from the vantage point of higher civilian or military levels, may be found in several published works, notably Bureau of the Budget, Committee on Records of War Administration, *The United States at War,* (Washington, 1946); Watson, *Chief of Staff;* and Smith, *Army and Economic Mobilization.* Among the many unpublished manuscripts dealing with this period, two are particularly worthy of mention: Troyer S. Anderson, Office of the Under Secretary of War, 1914–41, and History of the ASF Purchases Division, both in OCMH files. The annual reports of the Under Secretary of War for 1940 and 1941 are valuable, as is the annual report of the Purchase and Control Branch, OUSW, 1941.

TABLE 1—SELECTED ITEMS FROM TIME OBJECTIVE, AUGUST 1940

Item	On Hand July 1940	Initial Equipment for PMP	Initial Equipment for 2,000,000 men
Light tanks	46	1400 (30 Jun 41)	2548 (31 Dec 41)
Medium tanks	18	675 (31 Dec 41)	1763 (Jul 42)
Heavy tanks	0	0	324 (Apr 42)
37-mm. antitank guns	228	2116 (30 Sep 41)	3748 (31 Dec 41)
75-mm. howitzers (field)	59	384 (31 Dec 41)	696 (30 Jun 42)
3-inch or 90-mm. AA guns	400	849 (31 Dec 41)	1629 (30 Jun 42)
AA Directors	162	279 (31 Dec 41)	474 (30 Jun 42)
105-mm. howitzers (hi-speed)	14	1404 (31 Dec 41)	2100 (30 Jun 42)
155-mm. howitzers (hi-speed)	683	1013 (31 Dec 41)	1541 (30 Jun 42)
Submachine guns .45-cal.	260	6029 (30 Jun 41)	7635 (31 Dec 41)
155-mm. guns (hi-speed)	144	519 (31 Dec 41)	519 (31 Dec 41)
Rifles .30-cal. M1	46,078	215, 045(30 Jun 41)	341,199 (31 Dec 41)
Steel helmets	952,683	1,289,739 (30 Jun 41)	2,108,056 (31 Dec 41)

unit cost of each item, the stocks on hand, the resultant shortages, and the approved expenditures. The Expenditure Program showed how much money was to be spent for each type of equipment, but it did not establish any delivery schedules or even broad time objectives for procurement. To fill this gap, G–4 issued separately in August a statement of time objectives that served as a target for production planners.[3] The "all-important present objective" was to provide at the earliest possible date initial equipment for the PMP force and sufficient monthly production to maintain this force in combat. (*Table 1*) For small arms, combat vehicles, tractors, and miscellaneous fire control equipment, the target date for equipping the PMP force was 30 June 1941, and for the 2,000,000-man force it was 31 December 1941. For antiaircraft and field artillery, the corresponding deadlines were six months later —31 December 1941 for the PMP and 30 June 1942 for the larger force. Production of ammunition was to reach by 30 September 1941 the estimated expenditure rate of the 2,000,000-man force.

Many of the items listed in the Time Objective were approaching obsolescence. All during the 1920's and 1930's Ordnance had been hampered in its development of new and improved matériel by lack of money. Ordnance did not have a free hand either to develop or to procure the materiel it considered most desirable. It worked within the framework of Army command as a service agency bound to meet, as best it could, the wishes of the using troops. With the approach of war, co-ordination between Ordnance and the using arms became closer. It was expressed in the approval of new items by the Ordnance Technical Committee on which the using arms were represented. But it was never without its rough spots.[4]

Placing the First Orders

Even before the Expenditure Program and the Time Objective were issued, re-

[3] Time Objective for Rqmts, approved 26 Aug 40, in G–4 file 31773, and in OHF.

[4] See Green, Thomson, and Roots, *Planning Munitions for War*, p. XXIX, and ch. VII.

quirements for Ordnance items financed by the $436 million that became available in July 1940 were sufficiently clear to permit placing some orders with the arsenals and private industry. Placing these and later orders was a large and complicated task, not only because Ordnance was responsible for about 1,200 principal articles, involving some 250,000 components, but also because each order had to be drawn up for specific quantities of munitions to be delivered according to a definite time schedule. Manufacturers could not accurately estimate unit production costs unless they knew the quantities to be produced, for unit costs normally declined as volume rose. Prospective bidders also required blueprints and specifications before they could calculate probable costs on items they had never before produced. The entire program required careful balancing so that adequate supplies of each component would arrive in proper time at the assembly points. Pervading the whole atmosphere was the demand for speed in signing contracts and starting production, for the dramatic German victories of May and June had shocked the American people and pointed up the urgent need for a stronger national defense.[5]

Because of its extensive advance planning, the Ordnance Department was ready to act quickly when funds became available on 1 July 1940. Unlike 1917, when the lack of designs and specifications held up production for many months, 1940 found the Ordnance Department with production drawings of most items ready for immediate issue to manufacturers. The only delay was with items still undergoing test and development and not yet standardized, such as the new medium tank.[6] On the administrative level there were delays caused by legal restrictions and red tape. Procurement officers frequently spoke of the need to "take the law into their own hands" to get quick action. Only gradually were the time-consuming procedures of the years of peace replaced by more expeditious means of conducting business.[7]

In dividing orders between the arsenals and private industry, the policy was to give industry as much work as possible, and thus share with it the knowledge of production methods gained by the arsenals, and at the same time to avoid overloading the arsenals with straight production orders at the cost of curtailing their development activities. To private industry went orders for articles previously produced in quantity at the arsenals, items for which production methods had been worked out; the arsenals were given orders for items not yet produced in quantity.[8] The assignment

[5] Memo of USW for CofOrd, 19 Sep 40, sub: Priorities and Scheduling, OO 400.12/476. For a description of procurement policy and citation of numerous directives, see Hist, Ind Serv, Dist Admin Br, vol. 101.

[6] (1) Memo of CofOrd for ASW, 11 Jul 40, sub: Contracts Awarded Under the FY 1941 Proc Program, OO 381/716 ASW; (2) Replies to questions submitted to Maj Gen C. T. Harris, Jr., 28 Feb 45, OHF; (3) Memo, Brig Gen Gladeon M. Barnes for Mr. John J. McCloy, OSW, 1 Apr 41, sub: Status of Ord Prod, OO 400.12/2386; (4) Statement of Maj Gen Wesson prepared for Truman Comm., Apr 41, OHF. The story of tank development is told in Green, Thomson, and Roots, *Planning Munitions for War,* and, from the procurement viewpoint, in Chapters X and XI, below.

[7] See Contract Forms and Legal Restrictions in preceding chapter. The attitudes of officers in the districts is reflected in the district histories. The problem is discussed at some length in Smith, *Army and Economic Mobilization,* Chapter III.

[8] (1) Lecture, Wesson, Ordnance Department Procurement; (2) Intervs with Maj Gen Charles T. Harris, Jr. and other officers in the summer of 1950. For the policy on artillery ammunition, see Contract Negotiation and Administration, Ord Dept, May 1945, I, ch. 5 (a), OHF.

of specific items to the arsenals for manufacture or for procurement from industry posed no special problems, for each arsenal had specialized for many years in one or two broad classes of matériel. Springfield Armory, the center of small arms development, was assigned production of the M1 Rifle, and Rock Island, the recuperator for the new 105-mm. howitzer. To Watertown went orders for gun tubes and carriages; to Watervliet, machining of cannon; to Picatinny, powder, explosives, and components of artillery ammunition; and to Frankford, ammunition and fire control instruments.[9] Over half the $50,000,000 awarded in arsenal orders during early July 1940 went for ammunition, and the remainder was distributed among such items as the M1 rifle, 37-mm. and 90-mm. antiaircraft guns and carriages, fire control instruments, and "high-speeding" old 75-mm. gun carriages by equipping them with pneumatic tires and improved springs.

Most of the awards to industry in July 1940 were for metal components of artillery ammunition, including such items as 577,000 75-mm. cartridge cases with the Bridgeport Brass Company, 285,000 3-inch shells with the Budd Wheel Company, 500,000 pieces of brass tubing with the Revere Brass and Copper Company, and over 3,000,000 artillery shells with the United States Steel Corporation. Under the heading of automotive equipment, an order for 500 heavy tractors went to the International Harvester Company, 1,057 scout cars to the White Motor Company, and an armor plate contract for over $5,000,000 to the United States Steel Corporation. Orders for small arms and small arms ammunition went mostly to such well known firms as General Motors, Colt, Remington, DuPont, and U.S. Steel, and one contract for construction of a smokeless powder plant costing $26,000,000 was placed with the DuPont Company.[10]

Activating the District Offices, August 1940

While the first orders under the July 1940 appropriations were being placed by the divisions of the Industrial Service in Washington, and by the arsenals, plans were on foot to give the districts an important share in the procurement process when the second supplemental appropriation, carrying $1,442,000,000 for Ordnance, should pass. At the end of July district chiefs and arsenal commanders met in Washington to review and discuss procurement plans. Two weeks later, on 16 August, the first General Directive on Contract Negotiation went out to all district offices.[11] This directive is generally regarded as marking the "activation" of the Ordnance districts in World War II. It did not give the districts authority to make final awards to industry but made them responsible for soliciting bids and discussing the terms of contracts.[12]

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[9] Army Ord Dept Tentative Program for Proc from Industry during the Fiscal Year Beginning 1 July 1940, OHF.

[10] (1) Memo, CofOrd for ASW, 11 Jul 40, sub: Contracts Awarded Under the FY 1941 Procurement Program, OO 381/716; (2) Interv with Maj Gen Charles T. Harris and Brig Gen Burton O. Lewis, 13 Jan 53. As new lines were added by supplemental agreement the cost of this plant eventually exceeded $100,000,000.

[11] (1) Conf of Dist Chiefs and Arsenal Comdrs, 30 Jul 40, Ord Tech Rcds; (2) Ltr, CofOrd to all dist offices, 16 Aug 40, sub: Gen Dir on Contr Negotiation, OHF.

[12] The published history of the New York Ordnance District presents a picture of these events as seen by a high-ranking officer of that district. Chester Mueller, *The New York Ordnance District in World War II* (New York: New York *Post* and Army Ordnance Association, 1947). The manuscript history, The Ordnance District System, 1918–1945, 8 May 45, describes these events

The ground rules to govern the negotiation of contracts were set forth in some detail by the Chief of Ordnance in the directive of 16 August. The importance of these rules is hard to exaggerate, for they helped to shape some of the most controversial features of the Ordnance program in 1940 and 1941. Because of the critical lack of machine tools, and the prevailing emphasis in the War Department on economy and speed of delivery, the districts were instructed to give first preference to plants already holding production orders if those plants could fill additional orders with existing capacity. Companies allocated to Ordnance and companies with educational orders, production studies, or accepted schedules of production were also to be given priority in bidding. No limit was set to the size of any contract or to the size of any producer, but the districts were warned that letting many small contracts would be uneconomical and would place an added strain on the already overloaded machine-tool and gage industries.

Along with the directive of 16 August went a list of items on which each district was to seek bids. The list had been drawn up by the Industrial Service in accordance with existing procurement plans of the districts, although in some cases the quantities were larger than the planning figures. In most cases the districts had in their files the technical data for each item, including drawings, specifications, and descriptions of manufacture as practiced at the arsenals. The list issued on 16 August was mainly for forging and machining artillery shells, for manufacture of cartridge cases, bomb bodies and fins, booster cases, pyrotechnics, and a wide variety of fuzes for shells and bombs. A few examples will illustrate. The Cleveland District was assigned solicitation of bids for over two million 37-mm. shells, with small quantities of the same shell going to San Francisco, New York, and Cincinnati. The machining of nearly four million 60-mm. mortar shells was divided among the Cleveland, St. Louis, Philadelphia, and Detroit districts. In most cases the production load was divided among at least six districts. Deliveries were to start during January or February 1941 and were to be completed within twelve months.

With issuance of the August directive, the usefulness of the district procurement plans was put to the test. The results varied, but in general were good. Virtually all orders went to allocated facilities, and many went to firms that had completed educational orders, production studies, or schedules of production.[13] The procurement program got off to a fast start, and by early November orders had been placed for all ammunition components at a total cost of $190,000,000.[14]

All of this work called for intensive effort by the small staff of officers and civilians in the Office of the Chief of Ordnance (usually abbreviated OCO) and necessitated speedy enlargement of the staff. General Wesson's staff at the end of May 1940

as seen by Brig. Gen. Alfred B. Quinton, Jr., Chief of the District Administration Branch in 1940–41. OHF. See Harry B. Yoshpe, "Economic Mobilization Planning between the Two World Wars," *Military Affairs* (Summer 1952), p. 76.

[13] (1) History, Boston Ordnance District, I, p. 27; (2) Hist, Birmingham Ord Dist, I, pt. 1, pp. 137 and 177; (3) History, Cleveland Ordnance District, I, pp. 51–52; (4) Ord Dist Hist, Pittsburgh, I, Gen exs. 25, 26, and 27.

[14] Memo, CofOrd for ASW, Weekly Rpt of Accomplishments, 7 Nov 40, Ord Tech Rcds (hereafter cited as Weekly Rpt of Accomplishments and Difficulties).

numbered only 400—56 Regular Army officers, 3 Reserve officers, and 341 civilians.[15] During the next two years this staff grew by leaps and bounds, reaching a total of 5,000 in June 1942. It included a small but valuable contingent of Reserve officers who had trained with Ordnance during the years of peace and were thus prepared to step into important administrative positions. The Ordnance office outgrew its peacetime quarters in the Munitions Building, moved temporarily to the Social Security Building on Independence Avenue, and then to the newly built Pentagon, still under construction in the spring of 1942 when Ordnance moved in. Meanwhile, at Ordnance installations throughout the country—such as the district offices, arsenals, and depots—nearly 100,000 civilian workers were added to the rolls, not counting hundreds of thousands of other workers employed by Ordnance contractors. All the districts drew upon their pools of Reserve officers to find qualified administrators for key positions. In 1939 and 1940 the districts were able to recruit competent civilian engineers and procurement specialists, but during 1941 the recruitment task became more difficult, and many able employees were lost to industry or to the draft. The level of competence of district production engineers tended to decline as the demand for war production mounted.[16]

Successes and Failures

As was to be expected, not everything went according to plan during the hectic eighteen months leading up to Pearl Harbor. As a general rule, firms that had made production studies of ordnance items were able to submit more accurate bids than firms with less knowledge of the particular items. But the firms with most technical knowledge were sometimes underbid by competitors more eager to get the award or less conscious of production difficulties to be overcome. The lowest bid was more often a guess than an accurate estimate.[17] Further, the planned procurement pattern was upset by the fact that many businessmen frankly disliked War Department contracts because they entailed a great deal of red tape, demanded tolerances much closer than those commonly applied in commercial production, and required manufacturers to assume abnormal risks.[18] Some companies with which the districts had made procurement plans over the years either refused to bid or, it was suspected, deliberately entered high bids to avoid getting an award. As a result, contracts occasionally went to less desirable firms that experienced difficulty in meeting production schedules while the more dependable companies later took orders from the Navy or Air Corps on more favorable terms.[19]

Plant Allocations

The usefulness of plant allocations during the defense period caused sharp dis-

[15] Green, Thomson, and Roots, *Planning Munitions for War*, ch. IV.

[16] Lt Col Frederick C. Winter, Analysis of World War II Production Activities of New York Ordnance District, 5 Sep 47, Hist, New York Ord Dist, VII.

[17] Contract Negotiation and Administration, Ord Dept, May 45, ch. 6, p. 133. See also Hist, New York Ord Dist, VII, *op. cit.*

[18] For description of these conditions, see Hist, New York Ord Dist, I, pt. 2, pp. 70–73, and Hist, Rochester Ord Dist, I, p. 52. The "formidable web of red tape" surrounding government contracts is mentioned by Lt. Gen. Levin H. Campbell, *The Industry-Ordnance Team* (New York: Whittlesey House, McGraw Hill, 1946), p. 15.

[19] For examples, see histories of the Chicago, Cleveland, St. Louis, and Rochester Districts.

agreement among observers, both then and later. Critics of the allocation plan contended that, like so many other military plans, it was better designed for avoiding the known mistakes of the last war than for meeting the unforeseen needs of the next conflict.[20] Others, particularly Ordnance officers assigned to procurement duties during the emergency period, insisted that the allocation system worked remarkably well, even though it was not enforced by War Department authority.[21] They pointed out that, unlike the Quartermaster Corps, which, after due deliberation, abandoned its allocation plans during the emergency period, the Ordnance Department followed its plans quite closely, placing 90 percent or more of its orders with allocated plants.[22] Although the computations on which these statements were based have not been found, they are generally substantiated by a study made at the Industrial College in 1945 of military contracts let in four representative industrial areas in 1940–41.[23]

All generalizations as to the use made of the allocation plans must be taken with a grain of salt. Standing by themselves, the figures do not show whether the orders went to allocated companies because they were allocated or because they were well established firms ready to take production contracts. It must be borne in mind that, had there been no allocation plans at all, a large proportion of the orders would inevitably have gone to these firms, for allocated plants were generally the most important in their field. The plans were an important element in the picture, but not the only element. Lt. Col. Ray M. Hare, who was in the Office of the Under Secretary and in a good position to observe their operation in 1941, commented that many of the allocated plants got the contracts because they were "the best prepared and had the courage to bid the lowest and furnish the fastest deliveries on the tricky items of munitions that [Ordnance] has had to supply." [24]

More important than strict adherence to plans for use of allocated facilities, in the opinion of many Ordnance officers, was the very existence of the system in the summer of 1940 with all that it implied in terms of surveys and contacts with industry through district offices. The knowledge of available facilities gained by Ordnance officers in making surveys of allocated plants was never adequate but it was of immeasurable value in getting procurement under way, particularly during the latter half of 1940.[25] It is of some interest to note that the benefits of procurement planning were appreciated by industry as well as

[20] For example, see Yoshpe, "Economic Mobilization Planning between the Two World Wars," pt. II, *Military Affairs*, (Summer 1952), 71–83.

[21] Intervs with Maj Gen Harris, Maj Gen Alfred B. Quinton, Jr., Brig Gen Lewis, and others, 1952–53.

[22] (1) Lecture, Wesson, The Ordnance Department, 9 May 41, ICAF, p. 10; (2) Statement by Maj Gen Charles M. Wesson before WDAB, 1942, H.R., 77th Cong., 1st sess., p. 529. The same figure was cited by Harris in lecture, 25 Jul 41. The procedure followed in selecting contractors is described in detail in History, Pittsburgh Ordnance District, I, pt. 3, pp. 543ff.

[23] Clarence Niklason, Use of Industrial Mobilization Plan in World War II, ICAF Research Project, RP No. 24, Apr 45.

[24] Lecture, Lt Col Ray Hare, A Brief Résumé of Activities of the OUSW, 7 May 41, ICAF, p. 2.

[25] The histories of the districts during World War II describe in some detail the activities of these offices during the prewar years. See also Quinton, The Ordnance District System, pp. 1–8, and Olejar, Procurement Planning for War—Ordnance, pp. 45–60, OHF. Testimony before the House Appropriations Committee in the spring of 1941 gave high praise to the procurement planning of the War Department.

government. "The studies made in connection with the accepted schedules of production," the General Electric Company reported in July 1940, "are proving beneficial in connection with current problems as they provide capacity data useful in developing current schedules." [26]

District-Arsenal-OCO Relations

The directive giving the districts authority to negotiate contracts did not by any means indicate that the arsenals and the Office of the Chief of Ordnance (OCO) were out of the procurement picture. Not only did OCO retain full authority to make the awards on bids forwarded to Washington from the districts but, for major items such as tanks, it also conducted negotiations directly with industry without going through the district offices. The arsenals did the same for certain complex items, for development projects, and for supplies for their own use.[27] During 1941, for example, a single arsenal, Picatinny, sent out 200,000 invitations to bid, enclosing a total of more than 2,000,000 drawings. In mid-December 1940 the arsenals were told to turn over administration of all contracts to the districts, but not until May 1941 were the districts given independent authority to make awards. Although the districts steadily gained ground during the defense period, the arsenals and OCO carried a major share of the procurement load largely because the division chiefs in Washington were reluctant to turn over to the newly activated districts the power to place contracts.[28]

Under these circumstances there was not only friction between OCO and the districts but also confusion among manufacturers as to who was who in the Ordnance Department. When a businessman who had signed an accepted schedule of production with the district office for a certain item saw one of the arsenals or OCO place an order for that item with another company he questioned the authority of the district and the value of its procurement planning activities. In some cases, after a contract was signed, the contractor did not know whether he should deal with the district, with the arsenal that normally produced the item, or with the Industrial Service in Washington. The arsenal that produced a given item was regarded as the repository of production know-how, and the district was the authority on contractual terms, but the two sometimes overlapped, and there was always the feeling that the final authority was in Washington.[29] Even as late as August 1941 the district offices complained that they were being bypassed by businessmen who preferred to deal directly with the Washington office,[30] and in December the chief of the District Administration Branch declared at a staff conference that there was

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[26] Ltr, General Electric Co. to ANMB, 16 Jul 40, OO 381/1479 ASW.

[27] See Ord Dept Cir 135, 16 Aug 41, sub: Ordnance Department Procurement Procedure. For criticism of this procedure, see Mueller, *op. cit.*, p. 116, and History, Philadelphia Ordnance District, I, pt. 5, p. 30. The friction between the arsenals and the districts is mentioned in Quinton, *op. cit.*, p. 22.

[28] (1) Memo, CofOrd for dists, 27 May 41, sub: Procurement Without Advertising, ex. F in Hist, Ind Serv, Dist Admin Br., vol. 101; (2) Min, Wesson Confs, 22 Dec 41, p. 1253; (3) OCO Ind Serv, Contract Negotiation and Administration, Ord Dept, I, 11, May 1945. See also Ind Serv Gen Instructions No. 19, 12 Mar 41.

[29] Lt Col Frederick C. Winter, Analysis of World War II Production Activities of New York Ordnance District, 5 Sep 47, Hist, New York Ord Dist, I.

[30] Min, Wesson Confs, 16 Aug 41, p. 1045.

still "too much negotiating going on in Washington." [31]

Creating New Facilities

A large proportion of the Ordnance funds obligated during the latter half of 1940 went for new government-owned facilities, mostly plants for making powder and explosives and for loading ammunition. The contracts for these plants were negotiated not by the arsenals or districts but through an office created for the purpose in the Industrial Service by General Harris. It should be recalled that in July 1940 the capacity of the United States to produce specialized types of munitions was limited. Available facilities could turn out fewer than 100 light tanks and about 500 machine guns per month, and only 30 tons of smokeless powder and 12 tons of TNT per day. Against the requirements of the Munitions Program of 30 June these quantities were altogether inadequate.[32]

Ordnance signed its first contract for a new GOCO (government-owned, contractor-operated) plant in July 1940 with the DuPont Company for construction of a smokeless powder works (later named the Indiana Ordnance Works), followed in August by another with the Chrysler Corporation for construction of a tank arsenal (later named Detroit Ordnance Plant).[33] A contract with the Hercules Powder Company for another smokeless powder works was approved in August, as was a contract for an ammunition loading plant with the Atlas Powder Company. By December 1940, a full year before Pearl Harbor, the task of constructing and equipping twenty-two major new facilities was under way by private corporations for shell-loading and for production of chemicals, explosives, tanks, guns, and armor plate.[34] By the end of June 1941 the contracts for new facilities reached a total of $576,000,000, roughly equivalent to the sum planned the year before as necessary to supply the 2,000,000-man force.[35]

One of the major criticisms of the defense program made by the Truman Committee of the Senate and the Tolan Committee of the House of Representatives in 1941 was that the War Department had built new plants needlessly and had failed to make full use of existing plant capacity. The committees described Army procurement officers as comparatively helpless in dealing with large corporations which refused to convert their plants to war production and demanded that the government build new plants, with all new equipment, for producing munitions. The Army's acceptance of such industry proposals, the committee charged, wasted strategic building materials, contributed to

[31] Min, Wesson Confs, 22 Dec 41, p. 1253. Four months later the Cincinnati Field Survey made for ASF listed as one of its major conclusions, "District offices should be given more power." Contl Div files of ASF.

[32] A detailed summary of the types of new facilities may be found in Expansion of the Activities of the Ordnance Department, 1940–41, pp. 9–10, OHF, and in the various Weekly Statistical Report Summaries issued by the Statistical Branch, OUSW. See also Campbell, *op. cit.*, ch. 7, and Ann Rpt ASW, FY 40, p. 5.

[33] The names of new facilities, according to the Ordnance formula, consisted of three parts: (1) the location, (2) the word "Ordnance," and (3) "works" if basic materials were required for production and "plant" if the operation was only fabrication or assembly. Min, Wesson Confs, 5 Jul 40, OHF.

[34] Chronology of Ord Activities, OHF.

[35] Expansion of Activities of the Ordnance Department. The reluctance of powder manufacturers to engage in this military production, and risk being branded as "merchants of death," is described in Henry L. Stimson and McGeorge Bundy, *On Active Service in Peace and War* (New York: Harper & Brothers, 1948), p. 353.

the machine-tool shortage, and delayed production of essential equipment.[36]

Insofar as existing facilities that could economically be converted to defense production were not so converted, the criticisms of the Congressional committees were justified. But with Ordnance production the great bulk of the new facilities did not fall into that category. For producing smokeless powder and TNT, or for loading bombs and artillery shells, there simply were no existing facilities suitable for conversion. In December 1941, when the Under Secretary of War summed up the War Department answer to the Tolan Committee's criticisms, he vigorously defended the construction of new Ordnance facilities, and assured the committee that the Army had not proceeded with erection of new plants except where necessary.[37] Much of the criticism of undue facilities expansion during the defense period lost its meaning after the outbreak of war. What had appeared to be overexpansion in the fall of 1941 took on the appearance of underexpansion after Pearl Harbor. The mounting demand for munitions of all types early in 1942 put a severe strain on all existing Ordnance facilities and brought into war production an ever larger proportion of civilian industry, including both small businesses and the big automobile companies.[38]

Criticisms, Delays, and Difficulties

There was much impatience with the slowness of the rearmament program during the latter half of 1940, and throughout 1941. Observers found many opportunities to criticize as they watched the vast and cumbersome mechanism for Army procurement swing slowly into action with much creaking in the joints. After appropriation of funds by Congress, the supply services speedily placed their orders with industry, but delivery of hard-to-manufacture items was a mere trickle throughout the defense period. To experienced Ordnance officers the small quantities produced during 1940-41 came as no surprise. For a full generation they had been saying that mass-production of munitions could not even begin in less than eighteen months.[39] They pointed out that Germany had started to rearm in 1933 and seven years later had not yet reached full production. They cited reports of British experience showing that it took about two years, on the average, for a new munitions plant to reach full production. "In no case," reported Col. James H. Burns in June 1940, "was an ordnance plant [in England] constructed and placed in operation in less than 12 months from date of decision and in some instances the time factor exceeded three

[36] (1) S. Rpt No. 480, pt. 3, 17 Nov 41, pp. 191–99, Truman Comm., 77th Cong., 1st sess.; (2) Second Interim Rpt of Tolan Comm., 77th Cong., 1st sess., H.R. Rpt No. 1553. See also Mil Rqmts and Matériel Prod, Incl to Memo, Brig Gen Harris, Actg CofOrd, for USW, 9 Sep 40, OO 400.12/5853-1/2.

[37] Statement of USW before the Select Comm., *Investigating National Defense Migration*, H.R., 23 Dec 41.

[38] This process of production expansion is treated on a commodity basis, covering ammunition, artillery, small arms, and tanks, in later chapters.

[39] See General Wesson's lectures at the Army War College and Army Industrial College in the late 1930's. "Balanced armament production does not come overnight," the Ordnance Department told a House Committee in July 1941, "nor does it come within the first half year. It has always been recognized that a major military armament effort for the United States would require the first year to get under way and from six months to a year thereafter to reach full production." Ord Dept Reply to Questionnaire No. 2, Spec Comm. No. 3, H.R. Comm. on Mil Affairs, 14 Jul 41, OO 400.12/4454.

years." [40] But to many people unfamiliar with the problem of producing tools of war the Ordnance Department appeared to be slow and inefficient. In 1940–41, after two decades of neglect, and in an economy that had learned to eschew arms manufacture as something immoral, Ordnance was asked to perform an industrial miracle.[41]

Patterson's Criticisms

As early as 23 August 1940 the newly appointed Assistant Secretary of War, Robert P. Patterson, opened the season of criticism by writing to all the supply services that reports reaching him indicated that the procurement program was being retarded in some instances by four factors: (1) lack of clear requirements to be met by the suppliers; (2) unusual military specifications which could not be met under normal commercial procedures; (3) unnecessarily close tolerances and too severe inspection requirements; and (4) frequent changes in specifications and designs affecting work in progress.[42] Patterson directed all the supply services to take prompt action to eliminate these sources of delay, and three days later wrote a confidential memorandum to the Chief of Ordnance to emphasize particularly the need for freezing designs. He quoted an observer who said the desperate position of the British armed forces was due to their failure to freeze designs. "The best," he commented, "is the enemy of the good . . . Germany has demonstrated that thousands of imperfect tanks on the battlefield are better than scores of perfect tanks on the proving ground. . ." [43]

Patterson's advice was not as easy to practice as it was to preach. Ordnance could not freeze designs and resist all pressure to change, and at the same time meet demands for the most advanced weapons, particularly when the war in Europe was daily revealing a need for new or improved equipment. Everyone agreed that a thousand "imperfect" tanks on the battlefield were better than scores of "perfect" tanks on the proving ground, but whether they were better than 500 "more-nearly-perfect" tanks on the field of battle was a moot question. General Burns tells the story that on the day after issuing instructions to freeze designs Patterson was asked to approve a contract for helmets. "Are these the same old hats we had in 1918?" he asked. When told that they were, he refused to sign until a new helmet design was adopted.[44] In July 1940, Patterson's predecessor had written concerning the Munitions Program of 30 June: "The program obviously cannot be frozen either as to quantities or types. . . . A happy compromise must be effected between the two opposites of production

[40] Statement by Col Burns to H.R. Appropriations Comm., 5 Jun 40 (copy in Gen Burns' personal file). See also Munitions for the Army: A Five Year Report, prepared by Troyer S. Anderson in 1946 for Secretary Patterson, copy in OHF.

[41] For comparison with World War I, see manuscript study by Harvey A. De Weerd, Production Lag in the American Ordnance Program, 1917–18, particularly pp. 250–62, OHF. See also Memo, Col Burns for CofS, 1 Feb 40, sub: Industrial Preparedness Essential to Adequate National Defense, in Gen Burns' personal file. The slow progress toward British rearmament in the 1930's is described in Michael M. Postan, *British War Production* (London: Her Majesty's Stationery Office, 1952).

[42] Memo of ASW for supply services, 23 Aug 40, OO 400.12/312. Cf. Memo, CofOrd for ASW, 12 Aug 40, in General Minton's file.

[43] Memo, ASW for CofOrd, 26 Aug 40, sub: Freezing Designs, OO 400.114/752 Misc.

[44] Interv with Maj Gen James H. Burns, summer 1950.

and perfection in order to obtain most effective results." [45]

There can be little doubt that manufacturers' complaints of unusual production requirements and unnecessarily close tolerances in Ordnance drawings and specifications were sometimes justified. The small-scale operations during the peace years had left their mark on Ordnance designs and designers. The arsenals had produced small quantities of munitions with the men and machines available; they never had full opportunity to apply the most modern production-engineering ideas or use the newest machine tools. "If our designs, as some people have said," wrote Lt. Gen. Levin H. Campbell, "were 'wrapped around a milling machine,' it was because we simply could not afford production-engineering studies of our various models or pilots." [46] The educational orders had provided that the contractors recommend improved production methods and design changes to facilitate mass production, but such orders had covered only a small fraction of Ordnance items.

From this it should not be inferred that the Ordnance Industrial Service was unaware of the problem or was not production-minded. As far back as the days of Maj. Gen. Clarence C. Williams, Chief of Ordnance from 1918 to 1930, the philosophy of using standard industrial designs, and avoiding unusual manufacturing procedures, had become an established principle in the arsenals. It was forcefully restated by General Harris in the fall of 1940. Writing in *Army Ordnance,* he described in detail the painstaking efforts made at Springfield Armory to assure efficient mass production of the Garand rifle, and the installation of a modern high-speed production line at Frankford Arsenal for the manufacture of ammunition. "The Department is making certain," wrote General Harris, "that the trends of modern engineering and industry in the field of mass production shall be woven into the very fiber of its organization and practice." [47] Ordnance tried, to be sure, and made notable progress, but, as later events revealed, it fell short of full success in preparing for mass production.

There was also another side to this matter that should not be overlooked. When manufacturers accustomed to the production of civilian goods found themselves faced with the task of producing munitions with novel and exacting specifications, they sometimes tended to be unduly impatient and critical of Army methods. They did not always understand the essential complexity of guns and ammunition. The rapid-firing machine gun, for example, is an intricate and finely balanced mechanism whose design has been worked out over many years by specialists and tested under all sorts of atmospheric conditions. A slight change made to speed manufacture might appear perfectly innocent, even trivial, to the production engineer, but it might also throw the whole mechanism out of kilter. As with the matter of freezing designs, there was no easy solution to the problem of simplifying Ordnance specifications. Each component had

[45] Memo, ASW for Mr. McReynolds, 16 Jul 40, sub: Progress in Army Munitions Preparedness, G-4 file 31773.

[46] Campbell, *op. cit.,* p. 292. Criticism of Army designs, and of military hostility toward suggestions for improvement, is voiced by Donald M. Nelson in *Arsenal of Democracy* (New York: Harcourt Brace and Company, 1946), p. 34.

[47] Brig. Gen. Charles T. Harris, Jr., "Armament Production, a Study of Ordnance Engineering Policies," *Army Ordnance,* XXI, No. 123 (November–December 1940), 225.

to be studied separately and in relation to the other parts of its assembly, and before production-speeding modifications could safely be made it was necessary to consult the research and development specialists as well as the production engineers of industry. This was accomplished in large measure through engineering committees, such as the Tank Committee, formed in October 1940, that brought together representatives of industry and Ordnance to clarify drawings and specifications and to discuss changes to speed production.[48] But committee action was too often taken only after trouble developed.

Early in 1941 Ordnance prepared for signature by the Secretary of War a letter to all Ordnance districts, arsenals, plants, and works emphasizing the necessity for "the most searching analysis" of all factors affecting production and calling for prompt, decisive, energetic action.[49] Throughout the defense period, Patterson exhorted the supply services to speed up the procurement of munitions. Twice during one week in April 1941, when German submarines were taking heavy toll of Atlantic shipping, he asked the Chief of Ordnance to expedite deliveries, describing the need for increased production as "a matter of extreme urgency," and as "vital to our national existence." [50] He urged 'round-the-clock operation of critical machinery and unceasing effort to break production bottlenecks. In June 1941, when he requested all supply services to obligate the funds on hand before the end of the fiscal year, Ordnance negotiators worked night and day to place contracts with industry, and were rewarded with a commendation from Patterson for having placed under contract "the largest peacetime program of national defense procurement in the history of this country." [51]

Some Time-Consuming Factors

Production on some Ordnance items was disappointingly slow during the defense period. By July 1941, for example, only an estimated 3 percent of the matériel covered by the appropriations for the 1941 fiscal year, which had begun in July 1940, had been delivered to troops.[52] It is sometimes argued that one reason for the slow progress was that manufacturers who took defense orders in 1940 and 1941 were not spurred on by the urgency of actual war. But a comparison between 1941 and 1942 does not indicate that manufacturers were dilatory before Pearl Harbor. After the outbreak of war it took just as long as before to get into production on a new item. The experience of the 1940–42 era suggests that a delay of a year or more in getting into large-scale production on a new item of ordnance is practically inevitable, war or no war.[53]

[48] Brief notes about these committees may be found in Weekly Reports of Accomplishments and Difficulties, beginning with the report dated 31 October 1940.

[49] Ltr, SW to CofOrd and others, 19 Feb 41, sub: Ord Prod. . . , copy in OHF.

[50] (1) Memos, USW for CofOrd, 21 Apr and 25 Apr 41, in OHF Policy papers; (2) Chronology of Ord Activities; (3) Ltr, SW for CofOrd, 19 Feb 41, sub: Ord Prod under the National Defense Program, copy in History, Denver Ordnance Plant, I, ex. 71.

[51] Ltr, USW to CofOrd, 2 Jul 41, sub: Commendation. . . , OO 201.2/14. See also Min, Wesson Confs, 3 Jun 41, p. 896, and 19 Jun 41, p. 935, and Memo, USW for Supply Services, 31 May 41, sub: Obligation of Current Funds, OHF. Patterson also praised Ordnance for speedy placement of contracts when he testified before Congressional committees. See *Hearings, WDAB,* Apr 41, 77th Cong., 1st sess., p. 116.

[52] Ord Dept Reply, Questionnaire No. 2. Spec Comm. No. 3, H.R. Comm. on Mil Affairs, 14 Jul 41, p. 12, OO 400.12/4454.

[53] For discussion of this point see Hist, Pittsburgh Ord Dist, I, pt. 4, pp. 712–22.

A brief recital of time-consuming factors that delayed production in 1940–41 will illustrate. The time required to solicit bids, make awards, and draw up formal contracts—usually two or three months—was only the beginning. After receiving his government order the contractor had to make a detailed engineering study of his shop and perhaps rearrange his equipment for more efficient operation. In most cases he had to procure additional equipment, and the delay in delivery of a single item, such as a lathe or a heat-treating furnace, might hold up the entire production process for months. For most items of ordnance, manufacturers found it impossible to use existing production lines; they had to start nearly from scratch to create new production setups. When, for example, a large locomotive company in the New York District was awarded a contract for 155-mm. gun carriages in August 1940, it did not convert its existing production lines but removed all the old equipment from a long unused foundry building, put in new concrete floors, replaced the electric wiring, and literally built a new production line from the ground up. All this took time, but the company felt that it was sound manufacturing practice.[54]

After receiving his government order, every contractor had also to obtain a supply of materials—not always an easy job in 1940 when shortages were becoming increasingly common, particularly among the grades of steel, copper, and aluminum needed for ordnance manufacture. Each contract for the machining of shell had to be geared to the availability of forgings. To operate on a 3-shift, 24-hour day, contractors had to hire additional workers and train them for the specialized jobs they were to fill. In recruiting new workers, contractors found that the years of depression had taken a heavy toll of skilled labor throughout American industry. These years had also taken their toll of management if the occasional reports of production inefficiency are any criterion.[55]

During early 1941 Ordnance began to complain that new and expanding high-level agencies created in Washington to manage the defense program were hindering procurement. Accustomed to the comparatively simple administrative structure which prevailed before 1940, when the final authority on nearly all procurement matters for the Army was the Assistant Secretary of War, Ordnance officers frequently objected to the growing administrative overhead. At the end of May 1941, for example, General Harris went so far as to state that the whole production program might soon come to a standstill because "there are too many people in other echelons who desire to consider and approve each project." [56] He declared that it took six times as long in the spring of 1941 to place orders as it had taken in the fall of 1940, and cited as one example of unreasonable delay a project for tank parts which had been held in the Office of Production Management (OPM) for nearly a month. But General Harris' complaint did not stem the growth of the co-ordinating hierarchy, and Ordnance officers continued to complain of excessive administrative

[54] Hist, Rochester Ord Dist Hist, I, pt. 2, p. 59. See article in The New York *Times*, January 2, 1941, p. 14, outlining some 40 steps involved in procurement of each type of weapon.

[55] Hist, Pittsburgh Ord Dist, I, pt. 4, pp. 716–17.

[56] Min, Wesson Confs, 28 May 41. In his testimony before the Truman Committee in April 1941, Secretary of War Henry L. Stimson entered a similar complaint. *Hearings*, Truman Comm., pt. 1, 15 Apr 41, pp. 35–36. See also Smith, *Army and Economic Mobilization*.

machinery throughout the defense period and well into the war period.[57]

Because a large share of Ordnance production required the machining of metals to fine tolerances, the munitions program of 1940 brought a demand for thousands of complicated and costly tools such as grinding, boring, broaching, and drilling machines, and lathes of various types. In their prewar planning, Ordnance officers had attempted to catalog the tools possessed by various manufacturing concerns and select for wartime production the companies that would need least retooling. But in many instances manufacturers found that for most efficient mass-production of munitions they needed to add new machines or replace some of their standard machine tools with new, special-purpose equipment. Great Britain and France placed large orders in this country for machine tools early in 1940, as did companies holding Navy and Air Corps contracts, and the nation's small machine-tool industry was swamped with orders.[58]

In spite of the measures taken to alleviate it, the machine-tool shortage among Ordnance contractors continued to grow worse during the winter of 1940–41 and in mid-March became so critical that General Wesson presented the matter to the Under Secretary in a memorandum with the ominous title, Probable Failure of Ordnance Program. Citing the policy of the Army and Navy Munitions Board (ANMB) that gave first priority to Navy and Air Corps orders,[59] General Wesson declared that Ordnance contractors, with low priorities, could not acquire the tools they needed to get into production and meet their delivery schedules. With large new production programs in the offing, he recommended that remedial measures be taken before demands for new production brought further delays in machine-tool deliveries. "Otherwise," the general concluded, "the situation which is now critical may become calamitous." [60]

This was strong language, but the Under Secretary was not moved by it. Rather than propose a sweeping increase in Ordnance priorities, which would adversely affect other major programs, Patterson requested more specific details on machine tools most urgently needed by Ordnance contractors. To provide this detailed information the Ordnance office directed each district to get in touch with all its con-

[57] For further discussion of Ordnance relations with higher authorities see Green, Thomson, and Roots, *op. cit.*, Chapter VI. The history of the civilian superagencies is told in Bureau of the Budget, *The United States at War*, and Civilian Production Administration, *Industrial Mobilization for War*.

[58] For a brief description of the machine-tool problem in 1941, see testimony of Secretary of War Stimson and Mr. Knudsen before the Truman Committee, in *Hearings*. Truman Comm., pt. 1, pp. 13 and 102. The file kept by Maj. Elmer E. Barnes, Chief of Priorities Section in the OUSW, contains weekly reports on the priorities system during 1940–41. See ASF 205.04, Prod Div 319.1. The Minutes, Wesson Conferences, in early 1941 contain many references to the problem.

[59] The priorities directive issued by the ANMB on 27 November 1940 gave the highest rating, A–1–a, to supplies and equipment for manufacture of machine tools and gages. The second highest rating, A–1–b, went almost entirely to Air Corps and Navy items, and included only a few Ordnance items, chiefly aircraft machine guns and small arms ammunition. By May 1941 only small arms and ammunition were as high as the A–1–b category. See Min, Wesson Confs, 31 May 41, pp. 892-93.

[60] Memo, CofOrd for USW, 12 Mar 41, sub: Probable Failure of Ordnance Program, OO 400.-12/2085. See also Memo, Col Thomas J. Hayes for Lt. Col. Alfred B. Johnson, 4 Mar 41, OO 413.8/1772, and a report by USW, 3 Mar 41, sub: Estimate of Production Possibilities Calendar Years 1941 and 1942, copy in OHF. The histories of the districts describe the effect of the machine-tool shortage on production, particularly Hist, Rochester Ord Dist, I, pt. 2, p. 68.

tractors and compile a list of undelivered machine tools that were holding up production. It was a long and tedious process that went on for many weeks.[61]

Meanwhile the Office of Production Management tackled the problem from other angles. It stimulated the production of new tools, promoted the use of subcontractors possessing adequate equipment, took direct action to solve individual bottleneck cases, and endeavored to ferret out and put to work second-hand tools which were not being used. Late in August 1941 the ANMB issued a new priorities directive which slightly improved the Ordnance position,[62] but the lack of machine tools continued to hamper Ordnance production throughout 1941 and beyond. General Harris reported two days before Pearl Harbor that delivery dates on machine tools were "most unsatisfactory," [63]

As with the problem of freezing designs or simplifying Ordnance equipment, there was no easy solution to the machine-tool problem. Each case had to be considered on its merits, and in relation to all other cases. It was impossible for Patterson, the ANMB, or OPM to accede to General Wesson's request for a higher priority on Ordnance items without at the same time giving lower priorities to some Navy and Air Corps orders, a policy which would have amounted to little more than robbing Peter to pay Paul.[64] Whether, in the broad national view, considering the relative urgency of ships, airplanes, guns, tanks, and all the other paraphernalia of war, it was wise to give Ordnance production such a low priority is beyond the scope of this study to determine. But there can be no doubt that it was a physical impossibility for the Ordnance Department fully to overcome the handicap of that low priority during 1941. It was, in the words of General Campbell, "the most heartbreaking bottleneck of the early armament period." [65]

Engineering Advisory Committees

At the start of the munitions program, Ordnance officers realized that countless questions and problems would arise as civilian manufacturers undertook to make complex military items on the basis of Ordnance drawings and specifications. From experience in World War I, they knew that interpretation of drawings and specifications would require close supervision if widespread failure to pass inspection were to be avoided. Ordnance was also aware of the fact that its drawings and specifications, running into tens of thousands, were not perfect and would need careful checking. To meet this situation Ordnance created, in the spring of 1941, twenty-five groups known as Engineering Advisory Committees. All manufacturers of tanks were represented on one committee, all manufacturers of mobile artillery

[61] Correspondence on this and other phases of the machine-tool problem is filed in OO 413.8. For a brief statement on the specific Ordnance items being delayed for lack of machine tools, see Weekly Stat Rpt Summary No. 51, 21 Jun 41, Stat Br, OASW.

[62] ANMB Priorities Dir, 20 Aug 41. See also correspondence related to this directive in History of Ordnance Priorities Unit, OHF.

[63] Ord Cir Ltr, 5 Dec 41, sub: Machine Tools, OO 413.8/9334. Tanks were given A–1–a priority by ANMB ltr to all supply services, 4 Dec 41, copy in Hist, Ord Priorities Unit.

[64] See Memo from Patterson and James V. Forrestal for ANMB Priorities Comm., 20 Aug 41, directing the committee not to yield to pressure for higher priorities.

[65] Campbell, *op. cit.*, p. 15. For discussion of the parallel position of the British Army during the rearmament period, see Postan, *op. cit.*, pp. 27ff. Because of its low priority the author calls the British Army "the Cinderella service."

carriages on another, and so on down the list through rifles, shells, machine guns, bomb fuzes, etc. A representative of industry headed each committee while an Ordnance officer served as permanent secretary. An opinion of the Attorney General in April 1941 provided some assurance that as long as the committees kept within prescribed bounds they would not stand in violation of the antitrust laws.[66]

At meetings of the committees the members, usually engineers, exchanged information about sources of scarce materials, use of substitute materials, or new production techniques. They frequently recommended to the Ordnance Department that certain design changes be made or that specifications be revised to speed production. All this activity was beneficial to Ordnance, for it brought to bear on each problem topflight engineering talent from industry. But in the opinion of Brig. Gen. Gladeon M. Barnes, who was in charge of all Ordnance engineering, the greatest benefit was the healthy psychological reaction from the association of Ordnance officers and civilian engineers. "The meetings have done much to overcome the industrial conception of the massive immobility of Government agencies," wrote General Barnes, "and have increased the desirability [of] Government contracts." [67] These engineering committees were the forerunners of scores of industry integration committees formed the following year under the leadership of General Campbell.[68]

Big Business vs Small Business

During 1940–41 a steady drumfire of criticism was directed at the defense agencies—Navy as well as Army—for placing orders with big business to the neglect of many small concerns scattered throughout the country. The criticism appeared in newspaper and magazine articles and in official reports of the Truman and Tolan Committees which investigated the defense program during 1941 and later. These Congressional committees observed that, in spite of procurement plans, all the services in 1940 entered into a "mad scramble" to procure the munitions they needed, and each desired to place its contracts with the biggest and most reliable concerns. The investigators charged that procurement officers favored big business because it was less trouble, and took less time, to award a single large contract to a big corporation than to divide up the order among many small companies, or provide for extensive subcontracting. They denounced the disproportionate emphasis put on big business by the military services, asserting that it led to unnecessary plant expansion, delays in production, heavy migration of workers to congested areas, and other problems.[69]

In answering criticism of this nature, War Department spokesmen delcared that it should have caused no great surprise when large concerns which normally got the lion's share of civilian business also got

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[66] Ltr, Attorney Gen Robert H. Jackson to John Lord O'Brian, Gen Counsel, OPM, 29 Apr 41, copy in History, Small Arms Branch, Ind Div., OHF.

[67] Brig. Gen. Gladeon M. Barnes, "Armament Engineering," *Army Ordnance,* XXII, No. 127 (July–August 1941), 33–35. See also Min, Wesson Confs, 30 Jan 42, on which date Col. William A. Borden submitted an oral report on the engineering committee organized by the Industrial Service.

[68] See chs. VI and VIII, below.

[69] (1) S. Rpt No. 480, pt. 3, pp. 191–99, Truman Comm., 77th Cong., 1st sess.; (2) Third Interim Rpt, Tolan Comm., 77th Cong., 2d sess., 9 Mar 42, H.R. Rpt No. 1879. For testimony by witnesses, see *Hearings,* Truman Comm., pt. 6. Similar testimony appears in *WDAB,* 1942, H.R. 77th Cong., 1st sess.

the lion's share of defense contracts. They pointed out that military procurement officers, and their associations in OPM, were not social reformers bent upon changing the nation's industrial pattern, but practical realists charged with the sobering responsibility for procuring munitions as quickly and surely as possible. Although it dealt with some small concerns, Ordnance awarded the great majority of its early contracts to big corporations because these corporations had the facilities, the experience, and the engineering skill to turn out the required armament in the shortest possible time. Most Ordnance contracts went to allocated plants that had been surveyed and selected beforehand as the most promising producers of war matériel. "To have done otherwise," wrote General Campbell, "would have been national suicide. The small plants of the country could not have turned out one day's requirements of ammunition. . . . Heavy manufacturing automatically demanded large concerns." [70]

It was largely through subcontracting that small businesses were brought into the Ordnance program in the defense period.[71] Although Ordnance had no authority to direct its prime contractors to use specific subcontractors, or otherwise attempt to tell them how to manage their affairs, it did encourage voluntary subcontracting wherever possible. To assist small businesses—usually defined as those employing fewer than five hundred workers—General Wesson in February 1941 directed each district to establish a display room to exhibit samples and photographs of Ordnance items, assemblies, and components.[72] By visiting these rooms, examining in detail the items on display, and discussing manufacturing requirements with district officials, a small businessman could decide which items or components he was qualified to produce, either as prime contractor or subcontractor. When the Defense Contract Service was created in OPM early in 1941 each Ordnance district appointed an officer to maintain liaison with that service. In September 1941, to promote wider distribution of defense orders, the requirement that the districts negotiate only with allocated facilities was rescinded,[73] and in November and December Ordnance participated in the Defense Special Trains that toured the country to show small manufacturers what the supply services wished to buy.

Bringing small business into the defense program was an endless task that continued throughout the defense period and

[70] (1) Campbell, *op. cit.*, p. 89; (2) Memo, CofOrd to [no addressee given], 4 Apr 41, sub: S. Res No. 71, OO 032/37; (3) Statement of Patterson before the Select Comm., *Investigating National Defense Migration*, H.R., 23 Dec 41, USW file 004.4 Allocation of facilities, Colonel Hare; (4) Statements of Patterson before Truman Committee, 16 Apr 41 and 15 Jul 41, *Hearings*, Truman Comm., pt. 1, pp. 60–61, and pt. 6, p. 1515. The official history of WPB observes that Mr. Knudsen's ties with big industry, and his emphasis on proven ability to produce, delayed the utilization of small business. Civilian Production Administration, *Industrial Mobilization for War*, p. 31.

[71] For an account of this process, and a collection of documentary evidence, see R. F. McMullen, Smaller War Plants: Their Part in the Ordnance War Effort, PSP 71, Jun 45, OHF, and Maj. Gen. Levin H. Campbell, Jr., Subcontracting in Ordnance Procurement, a rpt, 18 Jun 42, OHF. The difficulties of subcontracting as seen at the district office level are set forth by Lt. Col. Frederick C. Winter, Analysis of World War II Production Activities of the New York Ordnance District, Hist, New York Ord Dist, VII, pp. 22–24.

[72] Cir Ltr, CofOrd, 21 Feb 41, sub: Display Rooms, OO 381/19091. See also ASW Ltr to Chiefs of Supply Arms and Servs, 20 Dec 40, sub: Use of Sub-contractors. . ., OHF.

[73] Cir Ltr, CofOrd, 23 Sep 41, sub: Distribution of Defense Orders, ex. 6 in study entitled Subcontracting in Ordnance Procurement, OHF.

the years of war.[74] As production increased there was some spreading of prime contracts to smaller firms such as those that made up the New England Small Arms Corporation.[75] Even more important, small business firms got into defense production as subcontractors or subsubcontractors. For this reason the extent to which Ordnance used small business during the defense period is not easy to measure, but one investigation of the problem made in the Cincinnati area for ASF a few months after Pearl Harbor sheds some light on the matter. "We hunted for the 'small business' which could take on prime war contracts with its existing equipment and which is not already at work or well known to the supply arms and services," the survey team reported. "We found none. . . . The 'small business' which needs only money or a contract to get going on critical material is, in this area, a myth." [76]

Status of Rearmament, December 1941

To what extent did the United States succeed in rearming during the eighteen months before December 1941? Critics of the armed services have charged that the rearmament effort was bungled, while military spokesmen have stoutly denied the charge. In December 1941, for example, the Tolan Committee pulled no punches in asserting that defense production to date had been a failure, and a few days later the Under Secretary of War vehemently denied that it had been a failure. The arguments on both sides have continued to command widespread interest among military planners because the accomplishments and shortcomings of the procurement effort during the defense period afford a tangible means of evaluating the methods employed to mobilize the nation for war.[77]

By considering only the more important types of guns, ammunition, and combat vehicles actually produced during the defense period, the Ordnance record may be quickly summarized. (*Table 2*) In most cases the quantities procured far exceeded the quantities for initial equipment of the PMP force of 1,200,000 men. When compared with the Time Objective issued in August 1940 the record reveals that, in small arms, light artillery, and tanks, production went far beyond the original requirements. But with medium and heavy artillery, notably the 105-mm. howitzer and the 155-mm. gun, the quantities procured fell considerably short of requirements. Among smaller items, the steel helmet also lagged far behind the 1940 schedule, primarily because a satisfactory helmet design had not been developed and standardized before 1940. With small arms ammunition, the goals set by the Time Objective were not reached by the fall of 1941, for Frankford Arsenal remained the

[74] For an account of the problem from the NDAC and OPM level, see Civilian Production Administration, *Industrial Mobilization for War,* pp. 61–63 and pp. 146–47.

[75] Hist, Boston Ord Dist, VI–VII (Jan–Jun 44), pp. 40–48. See also ch. VII, below.

[76] Cincinnati Field Survey, Apr 42, Contl Br, ASF, p. 16. See also Memo, Alfred R. Glancy, ASF Hq, for CofOrd, quoted in History, Cincinnati Ordnance District, I, pt. 1, pp. 60–61.

[77] See the Second Interim Rpt of the Select Comm., *Investigating National Defense Migration,* December 19, 1941, H.R., 77th Cong., 1st sess., H.R. Rpt 1553, and the reply by Patterson, December 23, 1941, USW file 004.4 Allocation of Facilities. For high praise of the prewar planning and the speed with which Ordnance launched its procurement program in the defense and early war periods, see remarks by Somervell in Rpt of Conf, Ord Dist Chiefs, 22 Apr 44, copy in Hist, Detroit Ord Dist, vol. 117.

TABLE 2—SELECTED ORDNANCE ITEMS PROCURED, JULY 1940–DECEMBER 1941

Item	Total
Rifle, .30 cal. M1	375,000
Submachine gun, .45 cal.	217,000
Machine gun, .30 cal.	31,000
Machine gun, .50 cal.	54,000
Mortar, 60-mm. and 81-mm.	9,518
Gun, 37-mm. (tank, AT, AA, aircraft)	9,057
Gun and howitzer, 75-mm.	2,592
Gun, 90-mm., antiaircraft	171
Gun, 3", field and antitank	140
Howitzer, 105-mm.	597
Gun, 155-mm.	65
Light tanks	2,916
Medium tanks	1,467
Scout cars and carriers	8,124
Small arms ammunition (rds)	1,225,000,000
Artillery ammunition (rds)	13,000,000
Bombs	397,000

Source: Theodore E. Whiting *et al.*, Statistics, a volume to be published in the series UNITED STATES ARMY IN WORLD WAR II.

only source of production until new plants were completed. In the over-all picture of the Army's equipment on hand there was little room for complacency on the eve of Pearl Harbor.

More important, in the eyes of Ordnance procurement officers, than matériel on hand, was the promise of vastly increased future production that lay in the new facilities built and equipped during 1940–41. It is not too much to say that within a period of less than eighteen months something resembling a new industry had been created, with seventeen government-owned, contractor-operated (GOCO) plants actually in production and thirty-two additional plants under construction or in the negotiation stage.[78] Several large ammunition plants and works —Lake City, Denver, Baytown, Gadsden, Iowa, Kankakee, Weldon Springs, and others—came into production in September and October 1941, and by the end of the year there was at least one of every essential type of government-owned ammunition plant in operation, including TNT, DNT, tetryl, toluene, anhydrous ammonia, smokeless powder, bag loading, and shell loading.[79] A dozen new privately owned plants were also in production, including 6 for machine guns, 4 for artillery, 1 for armor plate, and 1 for tanks. Only 3 of these plants had required new construction (the tank, armor-plate, and 37-mm. gun plants) but all had required com-

[78] (1) Weekly Stat Rpt Summary No. 25, 20 Dec 41, Stat Br, OUSW; (2) Directory of GOCO Plants, OHF.

[79] (1) Notes on lecture by Brig Gen Leonard Ayres before H.R. Comm. on Mil Affairs, 25 Feb 42, ASF Contl Div file 350.001; (2) Memo, USW for Harry Hopkins, 13 Jan 42, and Memo of CofOrd for USW, 7 Jan 42, in USW file 104, Ammunition. For further discussion of ammunition production, see Chapters VI and VII, below.

pletely new equipment.[80] Although the materiel turned out by these new plants during the defense period does not loom large in the total production figures—about 5 percent of total 1940–45 Ordnance procurement—the existence of these producing units in December 1941 was of inestimable value to the United States and its allies during the war years that lay ahead.[81]

Neither Ordnance nor the War Department itself was given full freedom during the defense period to procure all the munitions it felt the Army needed. Both were limited by Congressional appropriations and bound by long-established regulations and policies that set the framework within which procurement took place. Hurried production is usually high-cost production, and the defense period was not a time of all-out production at any cost. It was more nearly a time for "business as usual." Ordnance was also handicapped by having to take a third-rate priority behind the Navy and Air Corps, and by having to meet constantly shifting requirements for items that took a long time to produce. In the mushrooming defense economy Ordnance found great difficulty in recruiting capable production engineers and procurement experts to staff its arsenals, districts, and Washington offices. As a result of these and other factors Ordnance encountered many delays and difficulties which under different circumstances might have been avoided. Nevertheless, it must be recorded that the really essential things were accomplished with remarkable speed—contracts were let, district procurement offices were activated, new plants were built, the arsenals began to hum with activity, and production of war matériel started at countless private industrial plants. By the time of the attack on Pearl Harbor, just eighteen months from June 1940, the Ordnance program in most lines was shifting into high gear and needed only further acceleration and expansion along the established course to meet the requirements of a world-wide shooting war.[82]

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[80] Weekly Stat Rpt Summary No. 20, 15 Nov 41, Stat Br, OUSW.

[81] For comment on this matter see Anderson, Munitions for the Army.

[82] For a parallel appraisal of the defense period from the ASF level, see Hist of Purchases Div, ASF, a manuscript in OCMH files. For a contemporary journalistic comment see *Time*, October 27, 1941, p. 38: "On some counts [Ordnance] has not made a passing grade. Overall, the average has been reasonably good." Figures showing the mounting volume of munitions produced in 1942 are shown in Civilian Production Administration, *Official Munitions Production of the United States*, (Washington, 1 May 1947).

CHAPTER IV

The Problem of Requirements

To persons not intimately acquainted with procurement of military supplies the critical importance of exact and timely requirements figures is often not fully apparent. But a moment's reflection suggests that the mass production of weapons and ammunition cannot get under way in an orderly manner until procurement officials know exactly what types are to be produced, what quantities are required, and what delivery schedules are to be met. Only with such detailed information, along with countless technical specifications and blueprints, can production engineers determine what plants and equipment will be needed, how much labor will be required, and what materials will be necessary. Without computation of requirements for each of the thousands of items of equipment needed by the armed forces of the United States and its allies in World War II, scheduling of balanced production would have been impossible and the whole productive effort would have run the risk of being plunged into chaos.[1] "It is literally true," wrote a War Production Board official, "that half the production battle is won when we have decided what we want to produce, how much . . . we want to produce, and when we want it." [2]

A story that dramatically illustrates the importance of exact figures for military supply requirements was told by men who were close to William S. Knudsen when he came to Washington in the spring of 1940 to help mobilize American industry for war production. In conference with Army procurement officials, one of Knudsen's first questions was stated bluntly and simply: "What do you want?" When advised of the Army's mobilization plan with its provision for arming an initial protective force of four hundred thousand men within three months of M-Day, and an additional eight hundred thousand men after one year, Knudsen shook his head. "That's not what I want," he declared.

[1] For the history of requirements from the War Department level, see Smith, *Army and Economic Mobilization,* ch. VI–VIII, and Leighton and Coakley, *Global Logistics and Strategy, 1940–1943,* ch. XII. See also a typescript study, Lt. Col. Simon M. Frank, The Determination of Army Supply Requirements, OCMH Files. A similar study from the Ordnance level, entitled Ordnance Requirements, 1939–46, consisting of one volume of narrative and three volumes of documents, was prepared as PSP 55 by the Ordnance Historical Branch, July 1945, OHF. Another is Chapter XVII in Ordnance Administration, part IV, a draft manuscript by Richard F. McMullen, 1945, OHF. For the WPB viewpoint, see CPA, *Industrial Mobilization for War,* Part III, Chapter 4.

[2] Unsigned Memo in WPB PD file 212 Prod Program—Objectives, NA. For a brief review of military requirements as viewed from the WPB level, see Wartime Production Achievements and the Reconversion Outlook report of WPB chairman, 9 Oct 45. See also Richard U. Sherman, Jr., The Formulation of Military Requirements for Munitions and Raw Materials, written chiefly from WPB sources, Mar 53, ICAF library UG 633S4.

"I want to know what kind of equipment you need for these men—and how many pieces of each kind. Please tell me *how many pieces.*"[3]

For the Ordnance Department, knowing well in advance "how many pieces" was of utmost importance because mass production of munitions could not be improvised on the spur of the moment as could the production of many civilian-type articles. In World War I, U.S. troops were ready for combat within a year after the declaration of war, but they had to be equipped in large measure with munitions obtained from the Allies. As the preceding chapters have emphasized, it takes months, or even years, for civilian industry to get ready to produce intricate weapons of war such as tanks, artillery, and fire control instruments. From 1940 to 1942 hard-to-manufacture munitions were generally known as "critical" items as distinguished from "essential" items which posed less serious production problems. For both classes, but particulary for those in the critical category, it was most desirable that requirements be established as accurately as possible, and long in advance of expected need.[4] The fact that the objective was never wholly achieved constituted one of the most serious difficulties faced by Ordnance during World War II. On this point all Ordnance officers charged with broad procurement responsibility were agreed. How this came about and how the shape and nature of the requirements problem were determined by a variety of factors can be understood, at least in part, by looking into the process of forming policy and making the computations.

Elements of Requirements Computation

The Ordnance Department did not participate directly in making top-level policy decisions that determined over-all requirements for military supplies. It had the technical service function of making detailed computations on the basis of policies determined by higher authority. The size of the Army, manner of its organization, nature of its equipment, and schedules for its deployment overseas—all these matters were decided by the nation's highest military and political authorities.[5] Once made, these decisions were passed on to Ordnance and other supply branches by the General Staff in the form of numerous lists and tables on which procurement computations were based. To describe each of these documents and to outline the various steps in the procedure of requirements calculation would lead into bypaths of interest to no one but the requirements specialist. The following account, therefore, touches only broad principles and problems.[6]

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[3] Interv with Maj Gen James H. Burns, summer 1950. See also Knudsen's and Leon Henderson's comments in CPA, *Minutes of the Advisory Commission to the Council of National Defense* (Washington, 1946), p. 12.

[4] For an excellent contemporary statement of the matter, see Memo, Col James H. Burns for ASW, 10 May 40, sub: Adequacy of Supply Preparedness, copy in OHF.

[5] Several other volumes in the series UNITED STATES ARMY IN WORLD WAR II deal with these matters, among them being Watson, *Chief of Staff,* Smith, *Army and Economic Mobilization,* John D. Millett, *The Organization and Role of the Army Service Forces* (Washington, 1954), and Leighton and Coakley, *Global Logistics, 1940–1943.*

[6] For a detailed analysis of the process as viewed by the Ordnance Department, see History of the Matériel Control Division, OCO, Dec 45; Manual of the Replacement Factor Branch, OCO, 1945; and PSP 55. All in OHF. For a description of the process as seen from the ASF level, see ASF Ann Rpt for FY 1943, ch. II; Ann Rpt ASF Rqmts Div, FY 1944; and Notes on Presentation of Rqmts Div before Proc Review Bd, ASF Contl Div file.

Tables and Their Multiplication

The most important document for requirements computation by the supply services was the Troop Basis, which specified the strength of the Army and listed all units actually in existence or to be formed in the near future.[7] It was supplemented by tables prescribing the strength of each type of Army unit and listing the quantities of supplies authorized for each type. As there were some five thousand different kinds of units there were thousands of these tables, variously known as tables of organization, tables of allowances, tables of basic allowances, and tables of equipment. In addition, for units on special missions there were separate lists of equipment that applied either to individually numbered units or to all units in a given geographic area.[8]

The first step Ordnance took in computing requirements was to multiply the quantity of each item of equipment authorized for each type of unit by the number of such units in the Troop Basis. The number of rifles authorized for a rifle company, for example, was multiplied by the number of rifle companies, the trucks per infantry regiment by the number of infantry regiments, and so on until all items were accounted for. The computations were all made by hand before the installation of tabulating machines in the fall of 1940.[9] The figures thus determined represented initial allowances for units in the Troop Basis. The next step was to project these calculations into the future and provide additional equipment for replacement of losses, for filling supply pipelines, for supplying certain items to the Navy and Marine Corps, and for foreign aid. The quantity added for replacement was calculated on the basis of a replacement factor (or maintenance factor, as it was sometimes called) established for each major item of equipment by the General Staff after study of recommendations submitted by the arms and services. Expressed as a percentage of the initial issue, it represented an estimate of the quantity of matériel that would be needed during a given period of time to replace equipment lost, worn out, stolen, or destroyed by enemy action.[10] Finally, to arrive at net requirement figures, the quantity of each item already on hand, whether in storage, in transit, or in possession of troops, was subtracted from the total of gross require-

[7] For examples, see Table B of Notes on Presentation . . . Proc Review Bd; and Ltr, TAG to Chiefs of Arms and Services, 14 May 41, sub: Revision of Troop Unit Basis, FY 1942, with Incl, AG 320.2 (5-13-41) MC-C-M.

[8] AR 310-60 (1942) and Ann Rpt Rqmts Div, ASF, FY 1944, ASF Req Div. Tables of Organization prescribed the organic structure and personnel strength of Army units. Tables of Allowances covered all items of equipment normally required for use at posts, camps, and stations which were not taken by units upon change of station. Tables of Basic Allowances prescribed the equipment for individuals and units other than training equipment or that issued to posts, camps, and stations. In October 1942, Tables of Basic Allowances were superseded by Tables of Equipment.

[9] For an intimate view of the process, see report of interview by Capt. Paul D. Olejar and others of personnel of the OCO Requirements Division, 8 May 45, ex. 8, PSP 55, vol. 3.

[10] "Replacement factor" was defined in ASF Manual M412, The Supply Control System, 10 April 1945, OHF, as follows: "The estimated percentage of equipment in use that will need to be replaced each month. It includes losses due to wearing out beyond repair, capture, abandonment, pilferage, and all other causes except in-transit losses attributable to ship sinkings, losses of certain items of clothing incident to the separation of personnel from the service, and losses from such other categories of attrition as may be specifically expected from time to time." For World War II replacement factors, see War Dept Supply Bull 38-4-WD, Replacement Factors. . . 29 May 47. Spare parts requirements are discussed in Chapter XIII, below.

ments. The whole process was, in the words of a G–4 memo, "a very demanding, exacting and tedious task." [11]

Days of Supply and Replacement Factors

The computation of ammunition requirements was altogether different from the computation of requirements for weapons, vehicles, and other general supplies, for ammunition was expendable. As food for guns it ranked in importance with the supply of food for troops, and posed far more difficult requirements problems because its rate of consumption was irregular and unpredictable. There were no tables showing the number of rounds to be issued to any tactical unit, but there was a figure known as the "day of supply" on which ammunition requirements for individual weapons were based. The ammunition day of supply was an estimate of the average number of rounds that would be expended by each type of weapon per day in the course of planned operations.[12] The rate for each weapon included a breakdown showing the estimate for each type of shell—high explosive, armor piercing, incendiary, and so on—and for each type of fuze when more than one type could be used on a shell. (*Table 3*) To compute ammunition requirements for a tactical unit the Ordnance planners multiplied the appropriate day of supply for each type of weapon by the number of such weapons authorized for the unit, and then multiplied the total by the number of days for which supplies were to be provided. Like the replacement factor for general supplies, the ammunition day of supply was established by the General Staff on recommendations of the arms and services. For training in the United States specified quantities per man were authorized.[13]

After the 1918 armistice most of the statistical data and technical knowledge of requirements gained during the war were lost through disuse and through failure to study the records before marking them for destruction. Like many other elements of the War Department, Ordnance failed to provide Civil Service grades and salaries high enough to attract and keep technically qualified research employees. There were only five persons on the requirements staff during the interwar years, and the highest paid received an annual salary of about $2,300. It is doubtful that much progress could have been made under any circumstances in peacetime, but the lack of an adequate nucleus of competent requirements specialists insured failure.[14]

At the beginning of World War II, and for nearly two years thereafter, replacement factors for weapons and days of supply for ammunition were based largely on guesswork. No one knew how long the Army's equipment, much of it far different from that used in 1917–18, would stand up under rigorous combat conditions, nor did anyone have an accurate notion of how much ammunition an infantry regiment or field artillery battalion would need in an active theater of operations. Virtually the only source of information on the sub-

[11] Memo, G–4 for CofS, 29 Nov 40, sub: Stabilization of Bases for . . . Rqmts, G–4/32277.

[12] The adoption and definition of this term are described in Ltr, TAG to CG AGF and others, 16 Feb 43, sub: Ammunition Supply Policies, OO 471/1728, copy in OHF. See also Smith, *Army and Economic Mobilization,* ch. VI–VIII; and Rpt on Methods Used in the Ord Dept in Determining . . . Needs . . ., submitted to Mead Comm. of U.S. Senate, Aug 46, copy in OHF (hereafter cited as Mead Comm. Rpt). Another source is Ann Rpt, ASF Rqmts Div, FY 1944.

[13] Folders marked Day of Supply in OCO Rqmts Br, FS Div files, and Rqmts Docs. in OHF.

[14] Hist of Matériel Contl Div, ch. I.

TABLE 3—EXAMPLES OF GROUND AMMUNITION DAY OF SUPPLY FOR THEATER OF OPERATIONS, 23 DECEMBER 1941

Item	Rds per weapon per day	Proportion of types
Machine gun, .30-cal., M1917A1	150	[a] 80% AP [a] 20% Tracer
Rifle, .30-cal., M1	5	[a] 80% AP [a] 20% Tracer
Carbine, .30-cal., M1	2	100% Ball
Gun, submachine, .45-cal.	20	80% Ball 20% Tracer
Gun, 37-mm. AT	10	90% AP 10% HE
Gun, 40-mm. AA	10	90% HE 10% AP
Gun, 75-mm. Tank	10	50% AP 50% HE (Normal)
Howitzer, 105-mm. field, SP mount	30	80% HE 10% WP 10% HS
Howitzer, 240-mm. field	5	100% HE

[a] This proportion of types was approved in principle, but the old figures (65% Ball, 20% AP, and 15% Tracer) continued until production could be rescheduled.

Source: Day of Supply of Ammunition other than Aircraft for Theater of Operations, 23 December 1941, copy in OHF.

ject at the beginning of World War II was the Partridge Board Report made in 1938 by a board of Ordnance officers headed by Lt. Col. Clarence E. Partridge.[15] Based in part on fragmentary records of World War I experience and in part on "educated guesses," it was concerned more with general principles than with exact statistical data. As late as March 1943 the Chief of Ordnance reported that "factors now in use are based largely on inadequate and obsolete data obtained from the last war, supplemented by opinion as to present needs. No current battle experience data are available."[16]

[15] (1) Ord Day of Supply of Ammo. . ., 30 Nov 38, AG 381.4 (1-25-39) Misc D; (2) Manual Replacement Factor Br, ch. 8; (3) WD Supply Bull 38-4-WD, Replacement Factors. . ., 29 May 47. The other members of the Partridge board were Lt. Cols. Burton O. Lewis, Donald Armstrong, and Sidney P. Spalding. See also FM 101-10, Jun 41, as cited in Leighton and Coakley, *Global Logistics, 1940-1943*, p. 301, n. 21.

[16] Memo, CofOrd for CG, ASF, 31 Mar 43, sub: Determination of Distribution and Maint Factors, OO 210.3/724, copy in OHF.

The day of supply figures used in 1940 and 1941 had two principal defects: they were too high, and they did not allow for differences among theaters. Although Ordnance was convinced that the figures were too high, and recommended their reduction, there was no combat experience during the defense period to support the Ordnance view. No change occurred until December 1941 when the day of supply for .30-caliber machine guns was cut nearly in half—from 250 to 150—and others were reduced in varying degrees.[17]

The second difficulty with the original figures, as just noted, was that a single set of rates was applied equally to all theaters of operation. In June 1943, after several theaters had been activated and some combat experience accumulated, Army Service Forces directed the supply services to begin systematic collection of data on which to base revisions of maintenance factors and days of supply.[18] During the North African campaign no provision had been made for systematic reporting of loss and expenditure rates. In July 1943 Ordnance sent teams of officers schooled in requirements work to headquarters in England, Algeria, Egypt, India, New Caledonia, and Australia. The teams met with varying degrees of success, but in general their work was hampered by a lack of appreciation in the theaters of the far-reaching importance of accurate replacement factors. The theater Ordnance officers, under constant pressure to provide adequate supplies at all times, were far more interested in maintaining an ample supply of everything than in providing data for refined statistical computations by planners back in Washington. This gave rise to one of the most persistent supply problems of the war, the tendency of each echelon to hoard supplies and build up its own reserve. The requirements teams also found that theater records did not provide adequate data on quantities of equipment in the hands of troops, and contained practically nothing on quantities lost. Theater officers insisted that data for determining replacement factors were more readily obtainable at ports of embarkation than overseas. "Officers in this theater," wrote a member of the team sent to North Africa, "are of the firm belief that our mission is a wild goose chase and utterly futile. . . ."[19]

In spite of these difficulties, the teams made some progress. Their reports showed that different rates were required for the various theaters because weapons and types of ammunition varied in importance from theater to theater. Beginning in February 1944 the War Department required each theater to submit detailed information in a regular monthly report of matériel consumed, and in June it established separate days of supply for the ZI and for

[17] (1) Day of Supply of Ammo Other than Aircraft for Theater of Operations, 23 Dec 41, Rqmts Docs, OHF; (2) Hist of Matériel Contl Div, OCO, ch. 4; (3) Mtg of the Ord Bd on Spare Parts, 27 Nov 41, copy in OHF. See also correspondence on day of supply in Sep–Oct 43 in collection of requirements documents, OHF, and Day of Supply correspondence in G–4/20052–67, TAG.

[18] (1) Notes on Presentation . . . Proc Review Bd, p. 33; (2) Ltr, SW for CG's Overseas Commands, 24 Jun 43, sub: Determination of Maint Factors. . . , AG 400 (21 Jun 43) OB–S–SPOPP–M; (3) Rpt of Richards Comm. in Levels of Supply and Supply Procedures, 1 Jan 44, copy in OCMH; (4) WD Supply Bull 38–4–WD, *op. cit.;* (5) Manual Determination and Use of Maint Factors and Distribution, ASF, Jul 43; (6) Memo, Col John J. Binns, Director Plng Div, for Director of Plans and Opns, ASF, 20 Nov 43, sub: Study of Ammo Rqmts, ASF Plng Div, Theater Br file 471 Ammo, vol. I, Box 389, NA.

[19] (1) Manual Replacement Factor Br; (2) PSP 55, pp. 115–18; (3) Memo, Deputy TIG to Deputy CofS, 21 Jun 44, sub: Memo, 1 Jan 1944. . ., in WD Spec 334, vol. 2, G–4.

three major overseas areas—Europe, North Africa, and the Pacific.[20] Differences among theaters were substantial. In the South Pacific, for example, the replacement rates for bayonets, trench knives, and carbines were from ten to thirty times as great as in North Africa. In the summer of 1944 the number of items covered by replacement factors was sharply reduced, and a new set of replacement factors submitted to ASF headquarters was approved with minor changes.[21] But replacement factors were seldom constant for long periods of time in any active theater, since they varied with the intensity of the fighting, the nature of enemy tactics, the method of reporting losses, and even with changes in the weather.

In addition to replacement factors and days of supply the Partridge Board Report had pointed out in 1938 that two other elements entered into the distribution of supplies. First was the time required to ship matériel from the point of origin to the point of use, and second was the quantity of supplies absorbed within the system itself, chiefly in the form of depot stocks. The Partridge Board recommended that the first of these elements be covered by advancing delivery dates by the number of days required for the shipment of supplies to any given troop units. It recommended that distribution stocks be provided by increasing the total requirements by a certain percentage to be known as the distribution factor. Exactly what percentage should be allotted for distribution was, of course, a question the Partridge Board could not answer because of the paucity of experience data.[22]

Aviation Ordnance

Guns and ammunition for war planes formed another distinct phase of the requirements picture. In 1940 the method used for calculating aviation ordnance requirements was the same as that used for ground ordnance, but in 1941 a new system was worked out by the Ordnance Requirements Division. The new method made no attempt to multiply tables of equipment or allowances by the number of units to be supplied, but based requirements on airplane production schedules compiled by the Office of Production Management and later by WPB. The number of guns per plane, taken from armament charts prepared by the Air Technical Service Command, was multiplied by the number of planes to be produced. To this total was added what the Air Force felt was a sufficient quantity to provide replacements for these weapons.[23] Although considered at the time to be a radical departure from traditional requirements practice, the new system proved successful and continued in effect without change until the summer of 1944 when it was modified to provide ammunition and bombs only for planes in active theaters. The Army Air Forces had meanwhile collected sufficient experience data from its units overseas to provide a statistical basis for more refined techniques of requirements determination and supply control. Mission rates for each theater were developed for each type of squadron in much

[20] Copies are in folders marked Day of Supply in OCO Rqmts Br, FS Div files. See also correspondence on the subject in AG 471; Ord Comm. Min 24343, 6 Jul 44; and Ann Rpt ASF Rqmts Div FY 1944.

[21] (1) Mead Comm. Rpt, pp. 15–16; (2) Frank, *op. cit.*, p. 127.

[22] Hist, Matériel Contl Div, ch. 8.

[23] Hist, Matériel Contl Div, ch. 6. For a more detailed statement, see Ltr CG AAF for CG SOS, 8 Jan 43, sub: Basis for Computation. . . , copy in Frank, *op. cit.*, vol. 3, ex. 76.

the same manner as were days of supply for ground ammunition. In the European theater seasonal rates were used because of lessened air activity during winter months.[24]

The early requirements for bombs and aircraft ammunition called for production of a 5-month supply for each bomber, based on aircraft production schedules, the estimated number of sorties a month for each plane, and the number of bombs dropped and rounds fired per sortie. The bomb supply for 4-engine bombers, for example, was based on an estimated eight missions per month over a period of five months. These computations soon resulted in overproduction of bombs and aircraft ammunition, largely because all planes did not go immediately from factory to overseas theater, nor did they all engage in bombing raids exactly as planned. "We now have in storage in the United Kingdom," reported the McCoy Board in August 1943, "a greater tonnage of bombs than has been dropped over Europe by the RAF since the beginning of the war."[25] Deep cuts in bomb requirements came in 1943, cuts that soon proved to be too deep. As the air war mounted in intensity during 1944 many of the cuts had to be restored.[26]

Fluctuating Requirements

It is no exaggeration to say that the worst problem facing Ordnance production planners during World War II stemmed from the fact that requirements were always changing. As soon as one set of figures came out of the machines it was necessary to incorporate changes in one or more of the basic lists and make the computations all over again.[27] The figures in the over-all Troop Basis rose and fell every few months as the strategic situation worsened or improved, and as the War Department planners estimated and re-estimated military needs in terms of the capacity of the nation to support forces of varying sizes.[28]

The situation was further complicated by the fact that the Ordnance Requirements Division always had to work with two different versions of the Troop Basis, one coming from G–3 and the other from G–4. Ordnance normally prepared its allowance figures on the basis of the former and its requirements on the latter. The two versions of the Troop Basis were not identical and were often not even reconcilable, at times being as much as half a million men apart on specific dates. As late as the spring of 1944 Ordnance complained, "The essence of the problem is that the troop basis furnished is not synchronized with the factual situation as to activation and deployment of troops. . . ."[29] Another difficulty arose in correctly identifying the units included in the Troop Basis. When units appeared without adequate identifying information it was impossible

[24] (1) Hist, Matériel Contl Div, ch. 6; (2) Ord Rpt to Mead Comm., 12 Aug 46, OO 400.12/2311 and copy in OHF.

[25] (1) Rpt WD Proc Review Bd, 31 Aug 43, p. 50, ASF 334, 020 CofS U.S. Army. Copy also in Levels of Supply and Supply Procedure, 1 Jan 44, OCMH file; (2) Rpt WD Spec Comm. for Re-study of Reserves, 13 Nov 43, p. 48.

[26] (1) Ann Rpt ASF Rqmts Div FY 1944, pp. 17-18; (2) Dr. Ralph Ilsley, The Facilities Program of the Ammunition Division, Oct 44, vol. 2, pp. 160–63, OHF.

[27] Memo, G–4 for CofS, 17 Dec 40, sub: Stabilization of . . . Rqmts, G–4/32277, copy in OHF.

[28] Memo, G–4 for CofS, 29 Nov 40, sub: Stabilization of Bases for . . . Rqmts, G–4/32277. See also McMullen, *op. cit.*, pp. 646–47.

[29] PSP 55, p. 142, and ex. 9 in vol. 3, Docs.

to know which equipment table applied to them.[30]

Of nearly equal importance with fluctuations in the Troop Basis were the constant revisions of tables of equipment. During the latter part of 1940, in addition to changes resulting from expansion of the air arm, creation of an armored force, and the transition from square to triangular infantry divisions, there were innumerable changes in allowances of equipment for both individuals and units.[31] In the early stages of the war when planners were considering the possibility of air raids on the United States and on American bases and troop units overseas, large numbers of antiaircraft units were scheduled for activation, and requirements for antiaircraft guns and accessories were high. The open type of warfare encountered in North Africa late in 1942 demanded that tanks and antitank guns be given first priority, and later still the demands for heavy artillery topped the list when American troops came up against heavily fortified positions in Italy and France. Each change, however small, demanded a revision of total requirements figures, and every major change in requirements meant a revision of production schedules.

The nature of the equipment changes that occurred between 1940 and 1945 may be illustrated by the single example of the infantry regiment. In 1940 an infantry regiment numbered 3,449 men, but in 1942 it had only 3,088, and in 1943, 3,257. It was authorized 1,181 pistols in 1940, 213 in 1941, 233 in 1942, 275 in 1943, and 293 in 1944. It had no 1/4-ton trucks in 1940 but was authorized 103 in 1941, 68 in 1942, 146 in 1943, and 149 in 1944. Of the basic weapon, the M1 rifle, it had 2,099 in 1940, 1,600 in 1941, 1,678 in 1942, and 1,882 in 1943, 1944, and 1945. These were by no means all the changes in the equipment of the infantry regiment during World War II, but they serve to illustrate the frequency and extent of the revisions of equipment tables. In terms of individual units the changes were often small, but, when multipled many times over and added to those of other organizations, the cumulative effect on total requirements figures was anything but small. Yet it should not be suggested that nothing was static. The number of .30-caliber machine guns (M1917) in an infantry regiment remained at 24 year after year. Throughout the war there were always twenty-seven 60-mm. mortars and eighteen 81-mm. mortars per regiment of infantry. The number of BAR's dropped from 189 to 81 between 1941 and 1942 but thereafter held steady.[32]

Changes in plans for armored divisions had greater impact on Ordnance than did changes in infantry divisions, for equipment of armored units required far more industrial effort than did equipment of infantry units of the same size. A measure of the gradual decline in Ordnance requirements is found in the number of armored divisions scheduled for activation. In early 1942, estimates went as high as 46; the

[30] *Ibid.* See also lecture, Lt Gen LeRoy Lutes, the ASP, 23 Sep 46, ICAF, and Marvin A. Kreidberg and Lt. Merton G. Henry, *Military Mobilization in the U.S. Army, 1775–1945,* Dept of the Army Pamphlet No. 20–212 (Washington, 1955), ch. XVIII.

[31] (1) Memo of Lt Col Walter A. Wood, Jr., quoted in Frank, *op. cit.,* p. 10; (2) Memo, G–4 for CofS, 17 Dec 40, sub: Stabilization of . . . Rqmts, G–4/32277; (3) Memo, ACofS, G–4 for CofOrd, 6 Sep 40, sub: Rqmts for Combat Vehicles, with Incls, G–4/29365–71, copy in PSP 55, ex. 6.

[32] (1) Mead Comm. Rpt, pp. 14–15; (2) PSP 55, vol. 3, Docs, ex. 9. The latter contains a table of major items of infantry regiment equipment, year by year, 1940–45 inclusive.

Troop Basis of November 1942 called for only 20; the following summer the figure was down to 16, the number actually formed.[33] Tank requirements, set at 169,000 in early 1942, were scaled down to half that number before the war ended.

Ordnance officers fully realized the need for timely revision of the Troop Basis and reorganization of tactical units. They recognized that sudden shifts in the worldwide strategic situation sometimes necessitated drastic revision of supply requirements. They knew that losses through ship sinkings had to be taken into account, that plans for sending troops and supplies overseas had to be geared to available shipping space, and that combat experience frequently demanded changes in types or quantities of equipment. But they nevertheless felt that General Staff planners, not fully aware of the consequences of changes in supply requirements, sometimes ordered such changes without full consideration of their effects. They felt, rightly or wrongly, that ASF and staff planners did not realize that every modification in the tables of equipment meant elaborate recomputations of requirements and also, much more important, far-reaching revisions of production and distribution schedules. They became convinced that staff planners did not realize the need for supplying data well in advance to allow a long lead time for Ordnance production.[34]

Over and above all this was an intangible but nonetheless real psychological factor that caused requirements planners to adopt a bullish attitude when the war news was good and to turn bearish when it was bad. Requirements were not always determined in the light of pure reason. Sometimes, Ordnance requirements specialists testified, an entire computation would be thrown out and a new one demanded because the results "were not in accord with the 'feeling' of those who had initially established the method for the first computation." [35] There was also the practical matter of how much could be produced. Theoretically, requirements were always fully stated regardless of the potentialities of supply but in fact there were ways and means of reducing requirements that seemed unattainable.[36]

The truth of the matter seems to be that the General Staff and ASF planners were well aware of the need for firm long-range requirements even though they were not always fully aware of the details of Ordnance operations. They tried hard to keep requirements on an even keel, and it was not ignorance of procurement but the exigencies of war that forced them to revise the Army Supply Program.[37] "The conclusion is inescapable," wrote Brig. Gen. Walter A. Wood, Jr., in 1943, "that such a program cannot be static . . . it requires constant review . . . continuing study, and never-ending adjustment."[38]

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[33] Kent Roberts Greenfield, Robert R. Palmer, and Bell I. Wiley, *The Army Ground Forces: Organization of Ground Combat Troops* UNITED STATES ARMY IN WORLD WAR II (Washington, 1947), p. 161.

[34] (1) Lutes, Lecture, The ASP; (2) Intervs with many Ord officers.

[35] Hist, Matériel Contl Div, ch. 10.

[36] *Ibid.*, ch. 1.

[37] See, for examples, Memo, G-4 for CofS, 29 Nov 40, sub: Stabilization of . . . Rqmts (with G-3 concurrence), G-432277; comments by Gen Somervell in Review of Prod Plans of Ammo Div, 19 Jun 42, p. 6, T652-C; and Memo, CG ASF for Tech Services, 15 Jun 43, sub: Computation of Rqmts. . . . SPRML 400, copy in folder marked Dirs, Basic Data for . . . ASP, in OCO Rqmts Br, FS Div files.

[38] Notes on Presentation . . . Proc Review Bd, *op. cit.*, p. 9. See also Background of the Army Supply Program, an ASF document apparently written by Brig. Gen. Walter A. Wood, Jr., no date, pp. 3-4, copy in OHF, and Leighton and Coakley, *Global Logistics, 1940-1943*, p. 302.

Requirements in the Defense Period, 1940–41

Multiplication of a given Troop Basis by the proper equipment tables, and subtraction of stocks on hand, yielded a theoretical statement of Army requirements, but for procurement purposes, particularly in 1940–41, everything depended upon the availability of money. In the uncertain period before Pearl Harbor, and immediately after, requirements were computed for scores of different theoretical situations, but the only results that counted for Ordnance were those covered by appropriations and embodied in an Expenditure Program approved by G–4. Enactment of an appropriation bill, it should be noted, did not automatically give the supply services a green light for procurement. Only after an item of equipment appeared on an Expenditure Program did the supply services have authority to proceed with its procurement.[39]

All told, ten Expenditure Programs were issued between July 1940 and July 1942, each based on an appropriation measure. The Ordnance share of the funds in each varied from $38 million to more than $12 billion. When added together the 10 programs allotted to Ordnance approximated $31 billion, or three-fourths of all funds appropriated for Ordnance during the 1940–45 period.[40] (*Table 4*)

Before issuance of the first Expenditure Program, Ordnance made a series of computations leading up to the regular appropriation for the fiscal year 1941. Work on this subject began with a request from the War Department Budget Officer in September 1939, after the invasion of Poland, that Ordnance list the items it would include in a $250 million program to eliminate shortages of critical items for the PMP.[41] Ordnance quickly complied with this request and with others that came during succeeding months, including such questions as the following: What additional ordnance would be required for a 17,000-man increase in the Regular Army and a 500-plane increase in the Air Corps? What items would be short if a 600,000-man Army, plus PMP augmentation, were to be equipped? What would be needed at each stage during the Regular Army's expansion in enlisted strength from 173,000 to 242,000, to 280,000, to 375,000? All these calculations, combined with those from other supply services, were used in drawing up the Army appropriation for fiscal year 1941 and the first supplemental, totaling approximately $500 million for Ordnance. This program was widely known as the first Expenditure Program until it was officially decided that the 12 August 1940 statement of requirements for the Munitions Program of 30 June 1940 would be considered the first such program.[42]

Even before it was passed, the regular 1941 appropriation was known to be inadequate to meet the Army's needs in view of the swift German victories in Europe during May and June 1940, and the transfer to the hard-pressed British of

[39] For a late example, see Equipment Expenditure Program . . . FY 1943, 30 Jun 42, copy in OCO-Detroit file.

[40] For discussion of prewar finances, see Green, Thomson, and Roots, *Planning Munitions for War*, Chapter III, and Smith, *Army and Economic Mobilization*. [Wood], Background of the ASP, briefly covers the whole period from 1920 to World War II.

[41] Memo of WD Budget Officer for CofOrd, 6 Sep 39, sub: Supplemental Estimates. . . , copy in PSP 55, ex. 2.

[42] For detailed listing of items, see Fig. 4, p. 59, PSP 55. See also [Wood], Background of the ASP, pp. 10–11, and Frank, *op. cit.*

TABLE 4—SUMMARY TABULATION OF ORDNANCE SHARE OF EXPENDITURE PROGRAMS

Expenditure Program	Date	Expended for Ordnance
1st	12 Aug 40	$2 billion
2d	8 Oct 40	$38 million
3d	8 Apr 41	$725 million
4th	9 Jun 41	$220 million
5th	25 Aug 41	$2.7 billion
6th	12 Dec 41	$3.7 billion
7th	31 Dec 41	$1.5 billion
8th	21 Feb 42	$12.4 billion
9th	16 Apr 42	$409 million
10th	30 Jun 42	$7.4 billion

Source: PSP 55, pp. 65–88.

615,000 Enfield rifles, 25,000 BAR's, and other supplies after Dunkerque.[43] At the direction of the President the Army hastily drew up in June 1940 a new statement of broad military requirements.[44] The bulk of this program, known as the Munitions Program of 30 June 1940, was financed by the second supplemental appropriation, which allotted $1,442,000,000 for Ordnance. As noted in the preceding chapter, the first Expenditure Program issued by G–4 on 12 August 1940 gave Ordnance authority to proceed with procurement under this and the two preceding appropriations.[45] The authority came at a dark hour for the western democracies. With France conquered, the British army driven from the continent after losing all its heavy equipment, and the German air force opening its assault on England itself, there were some who felt that further resistance by the British was useless. For the United States the need to strengthen its defenses was clear, but there was still doubt as to how that need should be met.

The second Expenditure Program was a relatively minor one, totaling only $38 million. Drawn up in September—while plans were being made to inaugurate peacetime conscription—it provided essential items for an additional 200,000 men to bring the PMP force up to 1,400,000. The

[43] See Green, Thomson, and Roots, *Planning Munitions for War,* ch. III.

[44] Munitions Program of 30 June 1940, dr G43 ASF Contl Div. The contribution of an Ordnance officer, Col. (later Maj. Gen.) James H. Burns, executive officer to the Assistant Secretary of War, to this and later programs is described in Watson, *Chief of Staff,* Pages 172–82, and Smith, *Army and Economic Mobilization,* Chapter VII.

[45] On the importance of this program see Smith, *Army and Economic Mobilization,* Chapter VI.

third Expenditure Program appeared in April 1941, just after enactment of lend-lease, and provided $725 million for Ordnance, mostly for artillery ammunition. The fourth covered Air Force and Field Artillery requirements financed by the regular fiscal 1942 appropriation. By far the largest of the pre-Pearl Harbor programs was the fifth, dated 25 August 1941; it placed major emphasis on ammunition and combat vehicles and was based on an Army strength of 1,820,000 to be raised eventually to 3,200,000.[46]

By the time the fifth Expenditure Program appeared, Ordnance had been allotted over $6 billion and its procurement program was well under way. But meanwhile the whole defense effort came in for a good deal of criticism, some bearing directly on the problem of Ordnance requirements. Early in September 1941, for example, Ordnance was criticized because the bulk of its production was not scheduled for completion before 30 June 1943 and some items such as antiaircraft guns and armor-piercing ammunition would run well into fiscal year 1944. There was complaint that Ordnance was giving new orders to the few firms already holding contracts and was thus not broadening the base for procurement but was "extending a relatively narrow stream of production farther and farther into the future." The report making this charge stated further that, in spite of multibillion-dollar appropriations, existing production schedules for many items would fall far short of meeting either British or United States requirements by June 1942. "The lag of production behind requirements is general," the report concluded, "and is not the result of specific items being produced at the expense of other items. Increased total output in all areas is essential." [47]

In commenting on this report General Harris, acting Chief of Ordnance, pointed to many discrepancies in it, particularly as they concerned plans and appropriations. He declared that the report took contemplated programs not yet submitted to Congress—much less enacted into law—and added them to approved requirements in order to make production schedules, which were based only on approved requirements, appear inadequate. Defending the award of new contracts to established producers, General Harris argued that the creation of new production capacity was a long and costly process that was not encouraged by the receipt of requirements "in small successive increments." The source of most of the difficulties encountered in scheduling Ordnance production, the general declared, was the problem of requirements, and on this subject he clearly stated the Ordnance position in words that bear quotation at some length.

> There has not been since the beginning of the Defense Program a comprehensive long-range Schedule of Ordnance Requirements which would permit planning for adequate production capacity. On the contrary, the program has been changed at least seven times in the last fifteen months for most items. . . . It is impracticable to create production capacity without definite orders, especially if extensive subcontracting is to be used in accordance with existing instructions of the War Department. Defense Aid orders have been even more varied, repetitive, unpredictable, and apparently unstudied than the United States orders, and action in filling the orders has been correspondingly difficult and unsatisfactory.
>
> The Ordnance Department believes strongly that a carefully studied, long-range pro-

[46] The directive initiating this program appears as exhibit 11 in Frank, *op. cit.*

[47] Mil Rqmts and Matériel Prod, Incl 1 to Memo of Maj Gen Harris, Actg CofOrd, for USW, 9 Sep 41, OO 400.12/5853-1/2.

gram of munitions requirements for the democracies should be determined as soon as possible and thereafter adhered to with a minimum of change. . . . It will then, and not until then, be possible for the Ordnance Department, as well as the other supply arms and services of the War Department, to proceed with assurance that planned production will satisfactorily meet requirements.[48]

While General Harris was thus appealing for a sound and comprehensive statement of requirements, others in the War Department recognized that a new approach to the problem was needed.[49] It was obvious that the Expenditure Programs were not altogether satisfactory documents for stating procurement objectives. Because they were primarily fiscal rather than supply documents they did not list supplies needed by the armed forces for long-range planning but only supplies to be bought with money appropriated for a given fiscal year. Being short-range projections, they kept procurement on something of a hand-to-mouth basis. Further, they omitted important categories such as Army-type materiel procured for the Navy, and they did not establish any definite time periods for delivery of new matériel, though the separate documents known as Time Objectives were issued to fill this latter gap. All things considered, the Expenditure Programs were inadequate as bases for accurate production scheduling and for determining the need for raw materials and industrial facilities. "During 1941 . . ." wrote the chief of the Ordnance Branch of WPB, "procurement officers, and others, requested and failed to get any answers to the three basic questions of—What? How many? When?"[50] After Pearl Harbor, when the critical factor in military planning was no longer money but time, the Army Supply Program (ASP) was developed to replace the Expenditure Program as the basic document for stating requirements and procurement objectives. The transition was not made immediately but extended over the first half of 1942. More than any other individual, Lt. Gen. Brehon B. Somervell, as G–4 and later as head of Services of Supply, was responsible for its introduction.[51]

Many civilian critics of the War Department have declared that in the pre-Pearl Harbor years the Army, conservative by nature and suffering from two decades of penny-pinching, could not change overnight to meet the challenge of a new day.[52] Military planners set their sights too low, according to the War Production Board history, and it was left to the more realistic and aggressive members of the civilian agencies to push for adequate defense production. These charges are not fully borne out by the official record. There undoubt-

[48] Incl No. 2 to Memo of Maj Gen Harris, for USW, 9 Sep 41, sub: Comments on Study Entitled Mil Rqmts and Matériel Prod, OO 400.12/5853-1/2 and OHF. For similar comments from the WPB level, see CPA, *Industrial Mobilization for War*, page 13.

[49] See Min of conf on the ASP in Somervell's office, 29 Jan 42, copy in folder marked Rqmts Div 1943, ASF. For an excellent brief summary of Somervell's views, see his Memo for Maj. Gen. Richard C. Moore, Deputy CofS, 22 Jan 42, sub: Army Supply Program, ASF, Rqmts Div 1943, copy in Frank, *op. cit.*, vol. 2, ex. 21.

[50] Summary Rpt, Ord Br, WPB, OHF. See also Maj. Paul D. Olejar, Ordnance Requirements and the Control of Production, 1939–45, Project Papers, 6, 7, and 12, dtd Aug 45, OHF.

[51] (1) Lecture, Lutes, The ASP; (2) Frank, *op. cit.*, p. 15; (3) Summary Rpt, Ord Br, WPB; (4) Memo, Col Clinton F. Robinson for Brig Gen Wilhelm D. Styer, 16 Jul 42, sub: Equipment Expenditure Program, ASF folder marked Rqmts Div 1943. The delicate political situation facing the administration in 1940, and the tense international scene, accounted in part for the lack of a more forthright approach to the requirements problem.

[52] CPA, *Industrial Mobilization for War*, and Sherman, The Formulation of Mil Rqmts.

edly was some timidity and hesitation in the War Department in 1938–39, but not in later years. The Munitions Program of 30 June 1940, for example, developed by the Army under the leadership of Assistant Secretary of War Louis Johnson, was both big and bold. Its original totals were scaled down, not by shortsighted generals but by President Roosevelt, who feared Congress would not accept such huge expenditures for military purposes. Earlier proposals by G–4 and General Marshall had called for speedy and substantial increases in national defense expenditures, but they too had failed to win full approval. The only qualifying element in the picture is the delay inherent in drafting requirements and forwarding them through the proper channels to Congress, with the result that expansion plans drawn up in mid-1939 before the European war broke out were obsolete when they reached Congress a year later. But that the Army set its sights too low and had to be prodded into preparedness by the civilian agencies hastily organized in 1940 is a myth.[53]

Strongest pressure for raising requirements sights came from the British, especially from Lord Beaverbrook and Prime Minister Churchill, who came to Washington shortly after Pearl Harbor. Depending upon American aid for Britain's survival, they urged astronomical figures that soon proved to be entirely unrealistic. Their pleas were directed just as much toward civilian production men such as Donald Nelson as to military leaders.[54] The net effect of British urging was the adoption of altogether unrealistic goals.

The Army Supply Program, 1942–44

As early as July 1941, shortly after Germany invaded Russia, President Roosevelt had directed the armed services to draw up a long-range statement of requirements such as General Harris had in mind. "I wish you would explore the munitions and mechanical equipment of all types which in your opinion would be required to exceed by an appropriate amount that available to our enemies." [55] The evolution of the resulting Victory Program during 1941 and early 1942 has been described elsewhere and need not be repeated in detail here, but a brief sketch of some of the steps in its development will help to provide essential background for the Ordnance phase of the Army Supply Program.[56]

Assuming that victory over all potential enemies might require the maximum number of troops the nation could provide, the War Plans Division of the General Staff drafted a troop basis in August 1941 calling for mobilization within two years of nearly 9 million men, organized into 215 divisions, of which 61 were to be armored. This was more than double the maximum force of 4 million men that had been a factor in earlier plans, and, in terms of divisions, was more than twice the number actually organized during World War II. In terms of manpower this troop basis proved a remarkably accurate forecast, but in terms of divisions equipped and put into the field, it was very wide of the mark.[57]

While computation of matériel require-

[53] See Watson, *Chief of Staff*, Chapter VI, for discussion of Army requests for funds in 1939–40.

[54] CPA, *Industrial Mobilization for War*, pt. III, ch. 4.

[55] Ltr, President to SW, 9 Jul 41, copy in OHF.

[56] (1) Frank, *op. cit.*, pp. 15–22; (2) Watson, *Chief of Staff*, ch. XI; (3) Smith, *Army and Economic Mobilization*, ch. VI; (4) [Wood], Background of the ASP.

[57] (1) Leighton and Coakley, *Global Logistics, 1940–1943*, ch. V; (2) Watson, *Chief of Staff*, ch. XI; (3) Memo, G–4 for CofOrd, 26 Aug 41, sub: Spec Computation. . . , OO 475/1064.

ments for a force of this size was in progress the President requested that additional calculations be made of munitions to be supplied Great Britain, the Soviet Union, and other countries at war with the Axis. The completed estimates for all these purposes were quickly assembled and given limited distribution in September, but no steps were taken to implement the program as it was to be held in reserve for an emergency. On 7 December 1941 the emergency arrived.

For Army planners the weeks following the attack on Pearl Harbor may fairly be described as hectic. The sixth Expenditure Program, published on 12 December 1941, was larger than any of its predecessors. Computed on a Troop Basis of 2 million men, with proposed augmentation to 3.7 million, it provided more than $3 billion for Ordnance matériel. But it was obviously inadequate in view of the entrance of the United States into the war against Japan, Germany, and Italy, and attention was quickly turned to implementing the Victory Program.[58] While the War Department planning agencies were working feverishly on the details of the program, and adjusting their calculations to the actuality of war with specific enemies, President Roosevelt dropped a bombshell in their midst on 3 January 1942. In a letter to the Secretary of War he wrote:

> The victory over our enemies will be achieved in the last analysis not only by the bravery, skill, and determination of our men, but by our overwhelming mastery in the munitions of war.
>
> The concept of our industrial capacity must be completely overhauled under the impulse of the peril to our nation.
>
> Our associates amongst the united nations are already extended to the utmost in the manufacture of munitions, and their factories fall far short of the needs of their own armies. We must not only provide munitions for our own fighting forces but vast quantities to be used against the enemy in every appropriate theater of war, wherever that may be.

The President then proceeded to name five types of equipment—four of them Ordnance responsibilities—and to list specific quantities to be procured during the two calendar years ahead. (*Table 5*) For ammunition the President stated that he wanted production to be based on the assumption that these weapons were to be used in combat.[59]

The President's letter to the Secretary of War, and his address to Congress three days later, constituted a striking example of lack of co-ordination between the White House and the Army staff. The President apparently drew up his plans in consultation with a few close advisers and with the British delegation that had come to Washington soon after Pearl Harbor, but without consulting his own generals. Reaction in Ordnance to these goals was not favorable, for they were regarded as unbalanced and in some cases unattainable. But there could be no outspoken criticism of the decision of the Commander in Chief.

The War Department issued its hurried calculation of requirements for the Victory Program on 11 February 1942 as the Overall Requirements for the War Munitions Program.[60] This new statement provided

[58] By way of illustration, see Memo, SW for the President, 26 Dec 41, sub: Victory Program, copy in Frank, *op. cit.*, II, ex. 18.

[59] Memo of President to SW, 3 Jan 42, AG 452.1 (1-3-42) (1), copy in PSP 55, ex. 19. The President made a dramatic public announcement of these objectives in his State of the Union message to Congress on 6 January. For discussion of their origin, see CPA, *Industrial Mobilization for War*, Part III, Chapter 4.

[60] Copy in OCO-Detroit files. For a brief history of this program, see PSP 55, I, pp. 91-95.

TABLE 5—PRESIDENTIAL OBJECTIVES: ORDNANCE ITEMS, 3 JANUARY 1942

Items	1942	1943
Totals	45,000	75,000
Tanks		
Heavy	500	5,000
Medium	25,000	50,000
Light	19,500	20,000
Totals	20,000	35,000
AA Guns		
37-mm.	1,600	
40-mm.	13,000	25,000
90-mm.	5,400	10,000
Totals	14,900	4,000
AT Guns		
37-mm.	13,700	
3-inch	1,200	4,000
Totals	500,000	500,000
Machine Guns (Ground, tank, AA)		
.30-cal.	330,000	330,000
.50-cal.	170,000	170,000

for three stages of Army expansion: 3.6 million troops to be fully equipped by the end of 1942; double that number by the end of 1943; and an "ultimate" force of over 10 million equipped by the end of 1944. The Army staff estimated the cost of the 1942 and 1943 programs combined at about $63 billion, far above the $45 billion maximum the production experts had earlier set for 1942.[61]

Despite the term "over-all" in the title, the new program was far from all-inclusive. It made no provision for construction needs, miscellaneous supplies, Navy items procured by the Army, or allowances to fill distribution pipelines, nor did it show quantities of matériel on hand. To remedy these inadequacies, and to keep requirements within estimated production capacity, the program was completely restudied during the weeks that followed and was replaced early in April by the Army Supply Program issued by the newly created Services of Supply (later redesignated Army Service Forces, or ASF).[62] The first

[61] (1) ASF Ann Rpt FY 1943, p. 18; (2) Leighton and Coakley, *Global Logistics, 1940–1943*, ch. VIII.

[62] For the reorganization of the War Department early in 1942, and the creation of the Services of Supply, see Millett, *Organization of the Army Service Forces*, ch. II, and Leighton and Coakley, *Global Logistics, 1940–1943*, ch. IX. For the relationship between Ordnance and ASF, see ch. VI of Green, Thomson, and Roots, *Planning*

ASP, sometimes called the Balanced Program, consisted of several sections that projected Army needs for three calendar years, 1942, 1943, and 1944, and provided what General Somervell once called "a spelled-out all-out program of complete Army requirements." [63] Since the War Department reorganization gave the air arm a status independent of the Army Ground Forces and Services of Supply, the ASP did not include requirements for airplanes but did include Ordnance-supplied aircraft guns, ammunition, and bombs. Where requirements for tanks, antitank guns, antiaircraft guns, and machine guns, computed in the orthodox fashion, did not equal the figures set by the President in January they were arbitrarily increased to match the Presidential objectives. Total required production for 1942–43 was about $48 billion, but the ASP, unlike Expenditure Programs, did not at first show the dollar value of requirements and made no reference to appropriations.[64]

Upon receipt of the ASP or other statements of requirements, Ordnance drew up a production planning book for each category of equipment. Using separate sheets for each item of matériel, these books showed total requirements, facilities in production or scheduled for future production, and estimated delivery rates for each month during 1942 and 1943, and sometimes early 1944. Each book included a statement of production accomplishments and difficulties to date, availability of machine tools and materials, and actions recommended by Ordnance to speed production. When discussed by the appropriate division chief at production conferences attended by representatives of the War Production Board, the Under Secretary's office, and other high-level agencies, these books played an important role in helping to formulate requirements policies during the first six to eight months after Pearl Harbor.

All during this period officials of the Office of Production Management and the War Production Board contended that requirements were being set at unrealistic levels. In the so-called feasibility dispute they took the position that the Army's goals were too high to be achieved in the time allotted. Although not familiar with the strategic justification for all the guns, ammunition, and tanks included in the various programs, they nevertheless doubted the need for such huge quantities of equipment; and, knowing the hard facts of munitions production, they questioned the feasibility of the objectives. In this matter they were joined by Ordnance officers who felt that the President and the General Staff were allowing their judgment to be unduly influenced by urgent British requests for aid and by the public clamor for prompt action that followed

Munitions for War. The evolution of the ASP is described briefly in Ann Rpt ASF FY 1943, ch. 2, and more fully in Frank, *op. cit.*, with copies of numerous basic documents. See also Min of the conf on the ASP held in Somervell's office.

[63] Memo, Somervell for Moore, 22 Jan 42. For detailed statement of regulations governing its preparation, see SOS Admin Memo 38, 16 Sep 42, OO 381/9948 Misc and WD Tech Manual 38–210, 25 Jan 44. The ASP was briefly described by Maj. Gen Lucius D. Clay in "The Army Supply Program," *Fortune*, February 1943, pp. 96–97, 225.

[64] (1) Smith, *Army and Economic Mobilization;* (2) McMullen, Ordnance Administration, pt. IV, ch. XVII, p. 650, OHF. For the War Department's effort to persuade the President to reduce his objectives, see Ltr, Actg SW to President, 10 Jan 42, and reply dated 12 Jan 42, ASF Contl Div files, 400 Time Objective.

the outbreak of war.[65] Describing the goals as wholly impossible, the War Production Board planning committee in March 1942 called for reduction of the Army Ordnance portion of the total program from $15.6 billion in 1942 to $9.2 billion.[66] Ordnance officers concentrated their fire on foreign aid requirements, which loomed rather large in the over-all picture, arguing that they were far too high and were not based on precise calculation of needs. There was virtually no argument on this score within the Army. The prevailing view was expressed by Maj. Gen. Richard C. Moore, former Deputy Chief of Staff, who remarked at a production conference in June 1942: "I'll tell you one thing about Defense Aid—they just guessed the requirements. They never had a true basis. They didn't have any foundation. They just reached up in the air and got what they thought the United States would give them." General Somervell agreed. "That's entirely correct." [67]

In spite of the President's reiteration on 1 May of his desire to see the January goals attained, the Army Supply Program underwent constant revision during 1942 and, to the relief of Ordnance leaders, was steadily scaled down.[68] (*Table 6*) The authors of the program had hoped that it would require full recomputation only once each year, but the need for revision became apparent almost as soon as the first ASP was distributed. Reductions in production goals were dictated in part by the rubber shortage that followed the loss of Malaya and in part by lack of enough production capacity for Army trucks. Lend-lease requirements were cut and less mechanized equipment was provided for the U.S. forces. A few weeks later, in mid-July 1942, ASF informed the technical services that the ground equipment section would have to be revised again because of "changes in the Troop Basis, modifications in the Tables of Organization, Tables of Basic Allowances, and Tables of Allowances, and the adoption of new maintenance and distribution factors." [69] In this edition, major reductions resulted from earmarking certain units in the Troop Basis as training units that would remain in the United States during 1942 and would therefore require only half the authorized allowance of certain items. Requirements for small arms ammunition were sharply reduced in the summer of 1942, bringing them closer to Ordnance recommendations, and causing cancellation of 43 production lines.

During the second half of 1942 the Ordnance load was both increased and de-

[65] Ordnance views were made plain in the production conferences of 1942 and were repeated by many retired Ordnance officers during interviews while this volume was in preparation. For WPB views, see Smith, *Army and Economic Mobilization,* Chapter X; CPA, *Industrial Mobilization for War,* part III, chapter 4; John E. Brigante, *The Feasibility Dispute* (Washington: Committee on Public Administration Cases, 1950); and Memo, WPB Plng Comm. to Donald Nelson, 17 Mar 42, WPB PD 212 Prod Programs, NA. The whole subject is reviewed in Leighton and Coakley, *Global Logistics, 1940–1943,* ch. VIII.

[66] Memo, Plng Comm. to Nelson, 17 Mar 42.

[67] Review of the Prod Plans of the Ammo Div, OCO, 19 Jun 42, T652-C. See also Production Progress and Production Scheduling, p. 7, a rpt based on the presentation to the WPB by SOS on 1 Dec 42, ASF 200.02. The growing pains of lend-lease are described in Leighton and Coakley, *Global Logistics, 1940–1943,* ch. III.

[68] For the broad background see Smith, *Army and Economic Mobilization;* Leighton and Coakley, *Global Logistics,* Production Progress and Production Scheduling, pp. 7–8; and CPA *Industrial Mobilization for War.*

[69] Memo, ASF for tech servs, 15 Jul 42, sub: Recomputation of . . . ASP, ex. 39 in Frank, *op. cit.* For broad picture of Troop Basis planning, see Greenfield, Palmer, and Wiley, *Organization of Ground Combat Troops,* pp. 189–259.

TABLE 6—DECLINE IN TANK REQUIREMENTS DURING 1942
[IN ROUND NUMBERS]

Type	11 February 1942 Over-all Requirements for War Munitions Program	6 April 1942 Army Supply Program	1 September 1942 Army Supply Program	12 November 1942 Army Supply Program
Totals	169,000	136,115	121,230	99,230
Light	61,000	41,000	41,000	37,000
Medium	105,000	95,000	80,000	62,000
Heavy	3,000	115	230	230

creased. The increase came in September with transfer from the Quartermaster Corps to Ordnance of all responsibility for trucks and other noncombat vehicles. The decrease came two months later when, after the President's decision to boost output of ships and planes during 1943 and cut back requirements for armored forces, a new computation of the ASP was issued under date of 12 November 1942.[70] It reduced requirements for medium tanks and allied vehicles by some 21,000 units and marked the end of the "all out" effort to build tanks. As the danger of air attacks faded, some 11,000 AA guns were eliminated from 1943 requirements. At the same time—less than one year after Pearl Harbor—small arms ammunition requirements were cut back further and construction work on new ammunition plants was canceled. All together, work was stopped on more than 75 Ordnance projects.[71] The new ASP called for production of only about $22 billion in 1943 instead of over $31 billion required for 1943 by the first edition.[72] By the end of 1942 the troop basis listed only one hundred divisions, instead of the two hundred earlier planned, and the number of armored divisions had dropped from over sixty to only twenty.

Introduction of Supply Control, 1944–45

The cutbacks in 1942 did not prevent production in 1943 from reaching peak levels. Plants newly built or converted to munitions production during the first year of war poured forth a flood of military supplies in the second year. The accompanying list of Ordnance items selected

[70] Copy in OCO–Detroit file. See also Memo, Brig Gen L. D. Clay, ACofS Matériel, for CG SOS, 8 Nov 42, sub: Effect on Prod of Further Curtailment in Troop Basis, ASF; Memo, Clay to Somervell, 28 Aug 42, sub: Revision of ASP, ex. 44 in Frank, *op. cit.;* and Master Schedule, Ord Ind Div, 25 Nov 42, OHF.

[71] (1) Memo, CofOrd for Chief Prod Div, SOS, 21 Nov 42, sub: Review of Mil Construction, WPB file PD 411.33 Construction Projects, NA. (2) Memo, Maj Gen Lucius D. Clay for Somervell, 14 Dec 42, sub: Construction Stopped by Ord, ASF Prod Div, folder 400-Rqmts Gen 1943. (3) Major Items of Munitions Removed from 1943 War Prod Objectives. . . , WPB PD file 212 NA. For the status of deliveries, requirements, and scheduled production of all major items, see Master Schedule, Ord Ind Div, 25 Nov 42, OHF.

[72] For tabulation of dollar values for the editions of ASP, see Smith, *Army and Economic Mobilization,* Chapter VII. For quantities of items and planned monthly capacity, see various issues of Master Schedule of Ordnance Industrial Division, 10 August 1942, 20 September 1942, and 25 November 1942. See also bar charts showing required production at various intervals in [Wood], Background of the ASP.

TABLE 7—SELECTED ORDNANCE ITEMS, 1942–1943

Item	1942	1943
2½-ton trucks	132,000	168,000
Medium tanks	14,000	21,000
75-mm. howitzer	1,200	2,600
40-mm. AA guns	9,000	13,000
Bazookas	67,000	98,000
Aircraft machine guns	353,000	501,000
.30-cal. rifle M1	758,000	1,220,000
.50-cal. cartridges	1,632,145,000	4,405,554,000

more or less at random illustrates the contrast between 1942 and 1943. (*Table 7*)

By the end of the first year after Pearl Harbor the immense task of equipping the rapidly expanding Army was well under way. Sufficient supplies were on hand for the North Africa landings in November 1942, for the supply of other overseas forces, and for aid to allies. By the summer of 1943 the first phase of the supply process was virtually complete, and reserve stocks of many items were beginning to accumulate. In July and August 1943 the War Department Procurement Review Board headed by Maj. Gen. Frank R. McCoy, and including among its members a former Chief of Ordnance, General Williams, surveyed the whole situation and reached the conclusion that the time had come for closer screening of requirements and tighter control of inventories.[73] As noted above, a move in this direction had been taken by Ordnance and other technical services earlier in the year with the dispatch overseas of teams trained to survey actual consumption data.[74]

The conclusions of the McCoy Board were received with some misgivings at ASF headquarters. Maj. Gen. Lucius D. Clay, ASF Director of Matériel, had labored hard throughout 1942 to boost production and overcome equipment shortages. His goal had been to supply combat troops with all the fighting tools they needed, and to that end he had constantly urged industrial leaders and workers in the shops to put forth every effort to meet their production quotas. Now the McCoy report gave the impression that production had caught up with demand and that relaxation of effort was in order. "They came out with a report telling the world that we had too much of everything," complained General Clay in the spring of 1944, "and the emphasis went over on economy instead of man-you-don't-be-short." [75] In General Clay's opinion it was "the worst thing that ever happened around here," for it resulted in a slackening of effort on the home front during 1944. Cutbacks in some production schedules were certainly called for by the latter half of 1943, but there were major exceptions, such as artillery ammunition,

[73] For copy of McCoy Bd Rpt, see Levels of Supply and Supply Procedure, 1 Jan 44, *op. cit.* The board was appointed by WD SO No. 183, 2 Jul 43.

[74] PSP 55, p. 134.

[75] Telcon, Clay and Maj. Gen. Levin Campbell, Jr., 27 Mar 44, in folder Heavy Arty and Ammo, Ord ExecO file.

which should have been pushed ahead instead of being held back.[76]

As a follow-up to the McCoy Board report a special committee headed by Brig. Gen. George J. Richards studied reserve stocks in both the ZI and overseas. It recommended some cuts and urged improvement in methods for computing requirements and controlling reserve supplies, but did not take exception to the supplies of ammunition that had accumulated during the period of limited fighting. In view of the rise in total Army storage inventories to more than $5 billion the committee urged that for some types of equipment reliance be placed in the future on reserve production capacity rather than on reserve stocks. As sea lanes to all theaters were open the committee urged reduction in the huge reserve stocks in overseas depots. The so-called McNarney Directive of 1 January 1944 put these recommendations into effect and was soon followed by the introduction of new techniques that came to be known as Supply Control.[77] In essence, the new system was nothing more than a close integration of all supply data with known requirements. For each principal item of equipment, it brought together on one sheet of paper all data affecting supply and demand status, including past issue experience, estimated future issues to ports, and the schedule of future production. Monthly supply reports from overseas commands were used to keep procurement plans in line with the actual supply situation in the theaters of war. From the production standpoint an important feature of the Supply Control system was the fact that, unlike the ASP, it stated requirements on a monthly as well as an annual basis with a view toward keeping closer control of procurement and supply.[78]

Requirements leveled off in the 1944–45 period as compared to the earlier years. Production was mostly for replacement of equipment worn out or lost in action, and settled down to a fairly stable level month after month. But for Ordnance there were several major exceptions to this rule. Adoption of new types of weapons and ammunition, or suddenly increased demands for old types, caused sharp fluctuations in requirements.[79] A notable example was the emergence of rockets as major Ordnance items, resulting in a steadily rising curve of requirements for rockets and launchers during the latter half of the war. In other areas the trend was toward bigness—heavy artillery to batter down fixed defenses, blockbuster bombs to blast military targets, huge tanks to counter the German heavyweights, and large trucks to provide fast overland transport in the European theater. Whatever the nature of the change in requirements, they spelled trouble for Ordnance. In large measure

[76] See below, Chapter X, and Comparison of Victory Program Troop Basis of 22 Nov 43 with Victory Program Troop Basis of 15 June 1943, exhibit 94 in Frank, *op. cit.*, showing sharp drop in AA artillery and armor.

[77] (1) Smith, *Army and Economic Mobilization*, ch. VII; (2) Frank, *op. cit.;* (3) PSP 55, I, p. 132ff; (4) ASF Cir 67, 7 Mar 44, pt. 3; (5) ASF Manual M413. The McNarney directive, the report of the McCoy Board, and the report of the Richards Committee appear in Levels of Supply and Supply Procedure, 1 Jan 44, copy in OCMH. The background is discussed in Annual Report of Requirements Division, ASF, FY 1944, and in Memo, ASF Director of Matériel for ASF, directory 28 Jan 44, copy in OHF.

[78] PSP 55, I, discusses this topic in some detail. See also Frank, *op. cit.*, pp. 138ff and Smith, *Army and Economic Mobilization*, ch. VI–VIII. Since the impact of the new procedures within Ordnance was greatest in Field Service the subject is discussed below in Chapter XVI.

[79] For summary statements see Ann Rpt ASF FY 1944, ch. 7, and Memo, CG ASF for Director OWMR, 7 Dec 44, ASF Director Matériel file, dr 1595, Reading File, Matériel.

the chapters that follow are devoted to the maneuvers necessary to keep production in line with stated requirements.

As early as 1943 the War Department took steps to estimate the effect on requirements of the end of the war in Europe. To guard against adverse psychological effects of announcing that the Army was already planning for the end of the war, the fact that demobilization studies were being conducted was not made public, and within the Army they were discreetly referred to as "special planning" studies. They began in the fall of 1943 with a requirements computation based on a reduced troop basis for Period I—after defeat of Germany but before defeat of Japan—and from that time forward special planning computations played a more and more important role as the end of the war came closer. After the defeat of Germany in early May 1945, the Ordnance Materiel Control Division (the former Requirements Division) continued its calculations for the redeployment of matériel from Europe to the Far East. The task involved determining what quantities should be kept in Europe and what surplus matériel was serviceable enough, or could be properly repaired, for shipment to the Pacific. In the war against Japan the Army planned to use more heavy infantry weapons, more amphibious equipment, more self-propelled artillery, and fewer heavy tanks. While these calculations were in process the Japanese surrender was announced and the war was over.

CHAPTER V

Artillery

Artillery weapons were the dark horses of World War II. Less spectacular and newsworthy than tanks and planes, they were sometimes neglected, if not forgotten, until the need for them reached the crisis stage. The artillery lessons of World War I had been forcefully set down in 1919 when the Westervelt Board emphasized the need for systematic development of improved weapons. But lack of funds during the interwar period slowed research to a snail's pace and practically stopped all procurement of new matériel.[1] At the start of the defense period in 1939 and 1940 there was a tendency, stronger at the General Staff level than in Ordnance, to feel that big guns were outmoded, that aerial bombardment would in the future largely replace artillery fire. The ground forces believed that nothing larger than the 155-mm. gun "Long Tom" would be needed. But experience soon exposed the error of these notions. Fighting in North Africa, at Stalingrad, on Pacific islands, and in Italy proved there was no substitute for big, powerful guns to blast enemy fortifications or lay down a curtain of fire before advancing foot soldiers. No lesson of World War II was plainer than this. Only heavy artillery could provide sustained, accurately placed fire on a 'round-the-clock basis regardless of weather conditions.[2] In Italy the Allied forces found themselves consistently outranged by German heavy artillery but they accepted only reluctantly the assignment of 240-mm. howitzers and 8-inch guns.[3]

As the war progressed, demands arose for more powerful tank guns, automatic aircraft guns, and a variety of self-propelled antitank and antiaircraft weapons. Rapid-firing guns of intermediate caliber proved essential for AA defense as guns powerful and accurate enough to reach fast, high-flying bombers. The trend in tank armament was all toward more powerful guns firing armor-piercing am-

[1] Green, Thomson, and Roots, *Planning Munitions for War,* ch. VII. See also History of the Procurement Activities of the Ordnance Department Since 1938 in Truman Comm. *Report,* Aug 46, OHF.

[2] For discussion of this theme, see address by Maj. Gen. Gladeon M. Barnes before the American Society for Metals, 19 Oct 44, Cleveland O., OHF. The same thought was vigorously presented by Senator Harry S. Truman in Truman Comm. *Hearings,* pt. 25. See also Campbell's Memo for Somervell, 3 Jun 43, quoting letter from Col. D. J. Crawford, Ordnance officer in Africa, OHF, and Brig. Gen. Gordon M. Wells "The New 155-mm. Howitzer," *Army Ordnance,* vol. XXVIII, No. 149 (March–April 1945), 223-25. The Air Force view is set forth in Wesley Frank Craven and James Lea Cate, eds., "The Army Air Forces in World War II," vol. III, *Europe: Argument to V–E Day, January 1944 to May 1945* (Chicago: The University of Chicago Press, 1951), ch. X.

[3] Lida Mayo, draft MS for Ordnance Overseas, Anzio ch., OHF.

munition. In addition to .50-caliber machine guns, airplanes required automatic weapons of artillery caliber, chiefly the 20-mm. and 37-mm.[4] When the United States began to rearm in 1940 the Ordnance Department, still suffering from twenty years of poverty, was ill prepared to meet the new demands. Speedy development of improved types or adoption of war-tested foreign models became the order of the day with the result that nearly all the artillery pieces in the hands of U.S. troops in 1943 were different from those standard in 1938.[5]

The prewar neglect of artillery development was a sad mistake, for the design and manufacture of big guns cannot be improvised on the spur of the moment. Design and test of a new weapon takes months, even years, of effort. Adoption of foreign weapons always entails a host of production problems and delays. Building new plants and tooling them for the manufacture of complete artillery pieces in quantity are always time-consuming processes. For the U.S. Army this lesson had been forcibly driven home in 1917–1918 when only a few American-made artillery weapons reached France in time to contribute to the defeat of Germany.[6] During the two decades that followed the Armistice, some effort was devoted to improving manufacturing techniques, but the over-all advance was slight.[7] Big guns were expensive items that the small Ordnance budget would not adequately cover. Nevertheless, when war appeared imminent in 1940 even the slight progress made during the lean years was important, and the mere existence of arsenals with long experience in the manufacture and procurement of guns, recoil mechanisms, carriages, and fire control instruments was of incalculable help in getting production started.

Artillery on Hand in 1940

In the spring of 1940 the Army's stock of field artillery was made up for the most part of antiquated pieces left over from World War I. About 40 percent of the weapons (including mortars) on hand were 75-mm. guns of World War I vintage, most of French manufacture. Though excellent in their day, they had long since been outmoded.[8] During the 1930's some of the old 75's had been "high-speeded" with roller bearings and pneumatic tires that enabled them to travel 50 miles per hour on good roads but had no effect on their firepower. For the 75 an improved carriage with split trails was developed to increase its range, angle of elevation, and traverse, but, for lack of money, only a few weapons had been so improved. Throughout the 1930's the using arms considered this gun their standard field artillery weapon and stoutly defended it even as late as 1939 and 1940. But on the eve of World

[4] The dividing line between small arms and artillery was drawn at .60-caliber by Ordnance in World War II.

[5] (1) Green, Thomson, and Roots, *Planning Munitions for War,* especially ch. VII; (2) Hist, Arty Div, Ind Serv OCO, 1940–45, I, sec. 2; (3) The Development Record in Artillery, draft in typescript form apparently prepared in Ord Hist Br in 1945, OHF.

[6] (1) Final Rpt, Gen John J. Pershing, 1 Sep 19, pt. III, sec. 24; (2) Rpt SW, 11 Nov 19, pp. 4–5.

[7] (1) Brig. Gen. Gordon M. Wells, "Artillery" in Army Ordnance Association pamphlet, *Artillery in World War II and Plans for the Future,* May 1946, OHF; (2) Campbell, *op. cit.,* pp. 206–07; (3) Green, Thomson, and Roots, *Planning Munitions for War,* ch. VII; (4) Hist, Arty Div, Ind Serv, OCO, I, sec. 2.

[8] For frank criticism of the 75, see remarks of Senator Thomas (Okla.), *Congressional Record,* 96th Cong., 3d sess., May 15, 1940, vol 86, pt. 6, p. 6135. For comparison of American with German and Japanese artillery, see The Development Record in Artillery.

TABLE 8—ARTILLERY AVAILABLE, 30 JUNE 1940

Item	Amount	Item	Amount
Antiaircraft guns:		Tank and antitank guns:	
37-mm.	8	37-mm. antitank	228
3-inch	807	37-mm. tank	184
105-mm.	13		
		Field guns:	
Howitzers:		75-mm. (all models)	4,236
75-mm.	91	155-mm. (all models)	973
105-mm.	14		
155-mm.	[a] 2,971	Mortars:	
8-inch	475	60-mm.	[b] 33
240-mm.	320	81-mm.	150
		3-inch trench	1,226

Source: Green, Thomson, Roots, *Planning Munitions for War*, p. 74. Compare tabulation as of 31 Dec 39 in Hist, Arty Div, I, sec. 10, Fig. 1. Compare also artillery available to British Home Forces on 8 June 1940 as summarized by Peter Fleming in *Operation Sea Lion* (New York: Simon and Schuster, 1957), pp. 198–99.

a Includes 599 high-speeded.

b Number produced before 30 June 1940 according to production records of Weapons and Fire Contl Br. Ind Div, OCO.

War II it was superseded by the more powerful and more modern 105-mm. howitzer.[9]

Nearly all the remaining guns and howitzers in stock were obsolete—deficient in range, mobility, or other important tactical features. The situation had not changed much since early 1939 when the Chief of Staff had declared, "Twenty years after the close of the World War finds us equipped with much the same type of artillery we used during the war." [10] Furthermore, the limited stocks were depleted after Dunkerque by transfer to the British Army of some 895 75-mm. guns, along with small arms and ammunition of various calibers.[11] By the end of June 1940, when the French surrendered and the outlook for all the democracies was gloomy, the sum total of mobile artillery available to the U.S. Army was not impressive. (*Table 8*) The only reasonably modern weapons on this list were the new 105-mm. howitzers just going into production, the 155-mm. "Long Tom" guns, and the 75-mm. pack howitzers, and the newly adopted 60-mm. and 81-mm. mortars. The 37-mm. tank and antitank weapons were effective against light tanks but useless against the heavy, thick-skinned tanks coming into service in Europe.[12] In like manner the 3-inch anti-

[9] For Congressional reluctance to modernize the obsolescent 75's, see H.R. Rpt No. 112, 76th Cong., 1st sess., 1 Mar 39, p. 9. For the Army's defense of the 75, see *WDAB*, H.R., 76th Cong., 3d sess., pp. 5–7, and *WDAB*, S., H.R. 4630, 76th Cong., 1st sess., 15 Mar 39, pp. 38–41. See also Min, Wesson Confs, 22 Oct 41.

[10] Statement by Gen Malin Craig, *WDAB*, H.R., 76th Cong., 1st sess., 1940, 24 Jan 39. See also Kreidberg and Henry *Military Mobilization*, pp. 550–51.

[11] For a detailed account of British artillery development and use during these years, see Brigadier A. L. Pemberton, *The Development of Artillery Tactics and Equipment* (London, 1950).

[12] PSP 31, The Design, Development and Production of Wheeled Antitank Guns, May 1945, I, p. 2, OHF.



INSPECTING A 75-MM. PACK HOWITZER *during Third Army maneuvers prior to World War II. From left, in civilian clothes, are Congressmen J. Buell Snyder, Overton Brooks, and Francis Case.*

aircraft gun was ineffective against high-flying planes then being produced.[13] Ordnance was designing and testing improved weapons to make good these deficiencies, but the supply of guns ready for action was both meager and out of date, and the prospects for immediate new production were limited. As late as the winter of 1943–44 some 155-mm. howitzers of World War I vintage were in service in Italy. Their tubes were still in good condition but their carriages and recoil mechanisms gave no end of trouble, largely due to their old age.[14]

Production Preparedness

To the average citizen, familiar only with cannon displayed in the village square, these weapons appear to be nothing more than simple steel tubes mounted on sets of wheels. But close examination of World War II guns reveals that they were highly complicated mechanisms demanding top quality steel and precision workmanship, with tubes or barrels[15] strong

[13] For contemporary criticism and rebuttal, see article by Arthur Krock in New York *Times*, October 1, 1940, and Memo, CofOrd for ASW, 2 Oct 40, ExecO file M–Matériel–Cannon.

[14] Ltr, Lt Col Harry P. Storke, Arty officer, Hq II Corps, to Brig Gen Wells, Hq Fifth Army, 4 Jan 44, sub: Comments on Arty Matériel, copy in OHF. This 8-page letter reports on performance of all types of U.S. artillery.

[15] The term "barrel," as applied to gun tubes, derives from the ancient practice of forming cannon from metal rods arranged like barrel staves and held in place by hoops.

enough to withstand pressures of approximately forty thousand pounds per square inch. Every step in the process of gun production had to be rigidly controlled to assure the desired metallurgical results. After the forged or cast gun tube was carefully machined inside and out, its bore had to be honed to a mirror finish and then rifled to precise dimensions, with measurements to the thousandth of an inch the rule rather than the exception.[16] Recoil mechanisms and recuperators, mounted on the carriage to take up the force of recoil and return the gun to firing position, were made of cylinders and pistons that could withstand extremely high internal pressures. "The action of the 240-mm. recuperator after a shot," wrote Benedict Crowell following World War I, "is equivalent to stopping a locomotive [traveling at more than 50 miles per hour] in less than 4 feet in half a second without damage." [17] Recoil mechanisms had to be built with great care to withstand repeated firings, for failure of a recoil mechanism was potentially as dangerous as failure of the gun tube itself. Carriages and mounts were rugged platforms capable of absorbing all the stresses and strains of firing the piece. They also carried sighting and ranging devices, fuze setters, and gears and hand wheels for aiming the gun. "On-carriage" fire control equipment for field artillery was fairly simple—telescopes and gunner's quadrants—but "off-carriage" directors for antiaircraft guns were incredibly complex, containing thousands of precision-made parts.[18]

The most encouraging factor in the production picture in 1940 was the existence of four Ordnance arsenals experienced in manufacture of artillery components. Watervliet was the center for production of finished guns. Watertown made gun castings as well as carriages and recoil mechanisms for seacoast and antiaircraft guns. Rock Island made carriages and recoil mechanisms for field guns, and Frankford supplied fire control instruments. These four arsenals were prepared in 1940 to do two things immediately: manufacture and assemble artillery components on a small scale in their own shops, and instruct industry in the mysteries of the gunmaker's art.[19] Before the outbreak of the war in Europe there had been no production of field artillery by American private industry for many years. In fact, during the two decades of peace between the wars, there had been very little production of big guns anywhere in the United States. The small additions to Army supplies permitted year by year had come chiefly from the Ordnance arsenals, while a few private contractors and the Naval Gun Factory—supplemented on occasion by the Ordnance arsenals—had supplied the Navy's needs.[20] Equipped in 1938 and 1939 with many new machine tools and staffed with experienced craftsmen, the Ordnance arsenals were ready in 1940 to go immediately into

[16] Lt. Col. Thomas J. Hayes, *Elements of Ordnance* (New York: J. Wiley and Sons, 1938), pp. 158–67, pp. 200–11. For an older but nonetheless useful account, see Benedict Crowell, *America's Munitions 1917–18* (Washington, 1919), pp. 21–56.

[17] Crowell, *America's Munitions*, p. 57.

[18] (1) Artillery, 1 Jul 40–31 Aug 45, prepared in Ord Hist Sec by F. D. McHugh, C. B. Rosa, and F. W. F. Gleason, under the direction of Brig Gen John K. Christmas, 31 Dec 45, OHF; (2) Rpt on M5 Director by Singer Mfg Co. in Hist, New York Ord Dist, 100, pt. 3.

[19] History, Artillery Division, OCO, *op. cit.*, I, sec. 3, and Truman Comm. *Report*. Compare with the situation in 1917 as described in Crowell, *op. cit.*

[20] For the Navy experiences, see Lt. Cdr. Buford Rowland and Lt. William B. Boyd, *U.S. Navy Bureau of Ordnance in World War II* (Washington, 1953).

production. They constituted a ready industrial reserve to help meet the national emergency and during the defense period produced approximately 25 percent of all artillery built for the Army.[21] But it was well understood that they could supply only a small fraction of the Army's artillery demands in time of war. To arm a large force, and to help supply friendly nations, main reliance would have to be placed on production by private industry.

The hitch was that industry was unfamiliar with the manufacture of artillery.[22] Through its industrial surveys, which were given added impetus in the late 1930's, Ordnance had acquired some knowledge of the firms most suitable for war production and had discussed with them the problem of gun manufacture. In the spring of 1939 Ordnance took a further step, placing with R. Hoe and Company, a New York manufacturer of printing presses, an educational order for five recoil mechanisms for the 3-inch AA gun. One of the first four educational orders placed by Ordnance, it was satisfactorily completed within a year. The company was then given a production contract for 125 mechanisms of the same type, and completed them in less time than it took to make the first 5. Having proved its ability to deliver the goods, R. Hoe and Company was asked to make recoil mechanisms for the new 90-mm. AA gun, which replaced the 3-inch, and thereafter Hoe continued as a major Ordnance supplier.[23]

During 1940 and early 1941 additional educational orders for recoil mechanisms went to another printing press facility, Walter Scott and Company of New Jersey, and to the Byron Jackson Company of California, a leader in the oil equipment industry. The contract with Walter Scott turned out badly and had to be terminated a year later without delivery of any mechanisms, but Byron Jackson completed its order in the spring of 1942 and continued during the war to produce recoil mechanisms for Ordnance. Another educational order went to the Duraloy Company for work on centrifugal castings, and several were awarded other firms, principally Eastman Kodak Company, and Mergenthaler-Linotype Company, for telescopes, aiming circles, and related fire control instruments. To cover additional artillery items Ordnance turned to the less costly production study,[24] which did not call for production of matériel but nevertheless provided essential data on methods of manufacture. While R. Hoe and Company was completing production of recoil mechanisms for the 3-inch AA gun the Otis Elevator Company undertook a production study on the same process.[25] The Wood Newspaper Machinery Corp. studied production of the 155-mm. mechanism and American Type Founders, Inc., the 75-mm. mechanism. In the spring of 1940 the Cowdrey Machine Works undertook a production study of the 75-mm. pack howitzer, the

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[21] Campbell, *op. cit.*, p. 214.

[22] For comments on this theme, see Notes for New York Mtg, 12 Jun 45 by Brig Gen Gordon M. Wells, OHF.

[23] (1) Maj Carl A. Gerstacker, Recoil Mechanisms and Equilibrators, Apr 39–May 45, bk. I, ch. 1, OHF; (2) Hist, New York Ord Dist, 100, pt. 3, statement by Harry M. Tillinghast, chairman of the board of R. Hoe and Co.; (3) Green, Thomson, and Roots, *Planning Munitions for War*, p. 58; (4) Documents in Educational Orders file, OHF; (5) "Welding Plays Top Role in AA Gun Recoils" by Joseph L. Auer, vice president R. Hoe and Co., *American Machinist*, 86 (November 26, 1942), 1371–82.

[24] See Chapter II above for discussion of this technique of procurement planning.

[25] For a revealing account of Otis' experience, see its historical report in Hist, New York Ord Dist, 100, pt. 3, OHF.

National Pneumatic Company did the same for the 37-mm. tank gun, and the Nash Engineering Company took on the 81-mm. mortar and its mount. Between educational orders and production studies Ordnance attempted to stretch its meager funds over the most important problem items in the manufacture of artillery and thus prepare industry for munitions production if war should come.[26]

Launching the Program, 1940–41

Though war did not come to the United States in 1940, production got under way on something approaching a wartime scale, as the smoldering conflict in Europe burst into flames. Congress appropriated billions of dollars for rearmament, and Ordnance was given the green light to put its procurement machinery in action. Firms with educational orders received production contracts, and the district offices intensified their search for other qualified producers.

After business firms signed contracts to produce artillery items they sent their engineers and master mechanics to arsenal shops and drafting rooms to learn all they could about tool design, gages, specifications, and requirements for material. "They all go to Watertown and Watervliet," General Wesson reported at a conference. "They are just overrun with these fellows." [27] The arsenals were able not only to provide specifications but also to advise on tool design and requirements for machinery, and to make gages available for study. When manufacturers ran into trouble with specific processes they could call upon the arsenals to send out trained experts to give help. In one instance a Picatinny expert on automatic drilling machines was lent to an Ordnance contractor for three months to help install new equipment and to train company employees in its operation and upkeep.[28] Fundamental knowledge of the gunmaking art, carefully preserved and nurtured at the arsenals during the interwar years, was thus quickly passed on to industry at the very start of the rearmament effort.[29]

All the arsenals bustled with unaccustomed activity in 1940–41. They overhauled and modernized weapons in stock, installed new machine tools, and reconditioned buildings that had long been neglected. Barbed wire was strung along the top of stone walls surrounding Watervliet, and floodlights were turned on at night. Carloads of specialized gunmaking machines held in arsenal storage since World War I were shipped to Ordnance contractors. Manufacturing techniques developed during the years of peace were given an opportunity to prove their worth. In October 1940 Watervliet came into the national spotlight for a day when it was honored with a visit by President Roosevelt. The curve of gun production at Watervliet rose steadily until an entire year's production at the 1938 rate could be turned out in a single day. Producing thousands of centrifugally cast gun tubes, Watertown became in the 1940–41 period the only important source of medium caliber gun tubes for the Army. The number of

[26] Documents in Educational Orders folder, OHF.

[27] Review Prod Plans of the Arty Div, 13 Feb 42, p. 34. OHF.

[28] Campbell, *op. cit.*, pp. 44–45. See also History of the Watervliet Arsenal, XV, particularly 111–15.

[29] The histories of the arsenals on file in OHF are replete with examples. See also radio speech by Col Steven L. Conner, Apr 42, quoted in Hist, Watervliet, XV, 114–16. For detailed data on procurement procedures in 1940–41, see Hist, Arty Div, Ind Serv, OCO, 1 Jul 40–1 Oct 45, I, pt. 2, especially ch. 9.



MAJOR CALIBER GUN SHOP AT WATERVLIET, *New York, in operation before the beginning of World War II.*

employees at all the arsenals nearly doubled in the twelve months following June 1940, and production rose in proportion, its value totaling over $138 million in calendar year 1941.[30]

The task of getting production started at the arsenals was not without its problems, but far more difficult was the job of bringing private firms into production. The Ordnance procurement list included cannon of many different sizes, all with complicated recoil mechanisms, carriages, and fire control instruments. As the type of manufacturing equipment needed for these components varied widely, and individual firms lacked the machinery to make complete guns, contracts did not call for complete weapons but only for certain major components. As a result, meeting production schedules demanded widespread cooperative effort among all the producers. With the 37-mm. antitank gun, for example, Watervliet in the spring of 1940 made the gun, Rock Island the carriage, and Bausch and Lomb Company the sight. The 37-mm. antiaircraft gun was more complicated, requiring, in addition to Watervliet tubes and Watertown carriages, gun mechanisms from Colt's Patent Fire Arms Manufacturing Company, control sets from Bendix Aviation Corporation, and sights from General Electric. For the powerful 90-mm. AA gun Ordnance contracted with the Sperry Corporation for directors, Bausch and Lomb for height finders, Bendix for data transmission systems, and R. Hoe and Otis Elevator for recoil mecha-

[30] For detailed data, see Hist, Arty Div, Jul 40–Oct 45, I, ch. 1, Figs. 2 and 3.

nisms. All told, more than thirty components of this gun were procured on separate prime contracts, and the cost of a single complete weapon with its proportionate share of fire control instruments amounted to about $50,000.[31] In addition to parts for assembly into complete weapons, Ordnance called upon industry to produce large quantities of spare parts, particularly spare tubes to replace those worn out in service.[32]

AA Guns

Because of the growing menace of the bombing plane in 1940–41 high priority went to guns for antiaircraft defense. They were a relatively new type, as time is measured in the history of artillery, having emerged only as hasty improvisations during the early 1900's.[33] After World War I Ordnance had devoted a goodly portion of its weapons research funds to development and production of a 3-inch AA gun, with the result that about eight hundred were on hand in 1940. In peacetime that appeared to be a not inconsiderable quantity but it was in fact less than the British had in 1940 to defend the single city of London.[34] Development work of the interwar years had also led to standardization of an intermediate AA gun, the 37-mm., but, as it was just going into production in 1940 at the Colt's Patent Fire Arms Manufacturing Company, there was no prospect of speedy improvement in output.[35] General Marshall told a Senate committee in the spring of 1940 that, at the current rate of production, the Army would gain only enough for three additional regiments by the end of the year, and four more by the end of 1941. He referred soberly to "the long and maybe tragic delay involved in securing such material after appropriations have actually been made." [36] While General Marshall was speaking, the 3-inch (76.2-mm.) gun was on its way out in favor of the newer and more powerful 90-mm. gun being readied for production after its adoption in February 1940.[37] Within a year the 37-mm. AA gun was to suffer the same fate.

Aside from the obsolescent 3-inch, the 37-mm. was the only antiaircraft gun produced in the United States in 1940, and production amounted to but 170. By January 1941 the Colt Company was turning this gun out at the rate of forty per month, and plans were afoot to adapt the new British director to the 37-mm. and produce it in the United States. But in February, because of the urgent need for 37-mm. aircraft guns, Ordnance was ordered to sidetrack the 37-mm. AA weapon.[38] At the same time a new and more powerful

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[31] (1) Sources of Arty Matériel, Incl to Memo, Brig Gen Harris, for CofS, 13 May 40, OO 381/36045 NA; (2) Memo, Lt Albert L. Keneman, Jr., for Lt Col Willis R. Slaughter, 16 Nov 40, sub: 37-mm. gun, AA, ASF Prod Div 472.93 AA guns, Job 19B, G 1867; (3) Hist, Arty Div, I, ch. 1, secs. 3 and 4, and ch. VI on spare parts.

[32] For a detailed description of artillery spare parts, see History, Artillery Division, Volume I, Chapter 6, and Volume 100.

[33] For research and development background, see Green, Thomson, and Roots, *Planning Munitions for War,* Chapter XIV.

[34] Congressional Record, S, 14 May 40, 76th Cong., 3d sess., vol. 86, pt. 6, p. 6137.

[35] For details on production delays, see Memo, Keneman for Slaughter, 16 Nov 40, sub: 37-mm. gun, AA, ASF Prod Div 472.93 AA Guns, Job 19B, G 1867.

[36] *Ibid.* For background on the 37-mm. gun, see PSP 29, 37-mm. and 40-mm. AA Guns, Design, Development, and Production (May 1945), OHF.

[37] William S. Lohr, 90-mm. AA Matériel, OHF.

[38] (1) Ltr, TAG to CofOrd, 20 Feb 41, sub: Schedule for 37-mm. guns, AG 472.91 (2-5-41) M-D; (2) Memo, William E. Curley for Slaughter, 14 Jul 41, sub: Prod of 37-mm. AA Gun, ASF Prod Div 472.93 AA Guns, Job 19B, G 1867.

AA gun entered the picture, a 40-mm. weapon made in Sweden by the Bofors Company. It was strongly recommended by the Chief of Coast Artillery, but Ordnance was reluctant to abandon its heavy investment in the 37-mm. and spend many months tooling up for the 40-mm.[39]

The Bofors gun had proved its worth in the Spanish civil war and on the beaches at Dunkerque, and was generally held to be superior to the 37-mm.[40] For sale to any nation that cared to buy it, it had come to the attention of the Ordnance Department as early as 1937, but for one reason or another, no sample gun was obtained for testing. In the fall of 1940, when the British were eager to buy munitions from American firms, they supplied Ordnance with one of their Bofors guns at about the same time that the U.S. Navy obtained one directly from Sweden. After performing admirably in tests the 40-mm. was adopted by the Army. The Navy, equally enthusiastic about the gun, negotiated with Bofors for a license to permit manufacture in this country of both the Army type air-cooled mobile gun and carriage and the Navy type water-cooled twin mount. The contract, signed in June 1941, covered manufacturing rights, blueprints, manufacturing drawings, and the services for one year of two production experts, who, unfortunately, never arrived.[41] Early in February 1941 Ordnance contracted with Chrysler to prepare working drawings and two pilot models of the gun, and a few weeks later placed another contract with Firestone Tire and Rubber Company to do the same for the carriage. The first letters of intent to start the tooling up process went out over Navy signature to take advantage of the higher Navy priorities. Barrels for the two pilot guns were made by a Canadian firm and were rifled at Watervliet. The Navy meanwhile contracted with the York Safe and Lock Company to supply Navy requirements.[42]

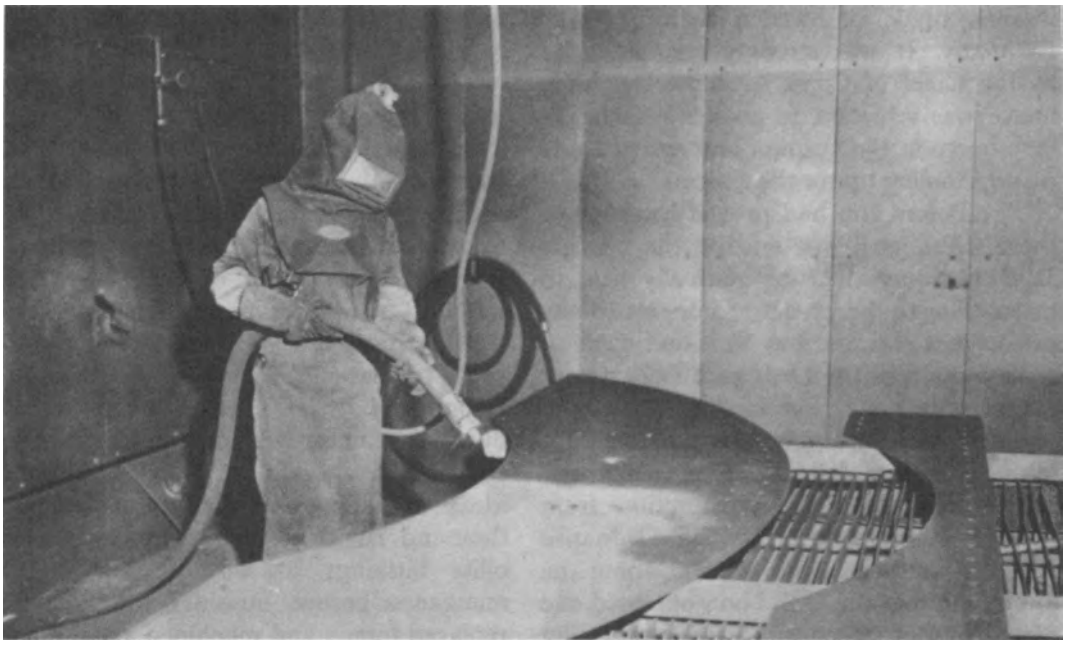
The complexity of the 40-mm. carriage forced Firestone to spread its work among more than 350 subcontractors. Firestone had not only to translate all metric measurements into inches, sometimes with troublesome decimals, but also had to make all threads and gear shapes conform to standard American practice and prepare tracings in accord with Ordnance drafting room regulations. Urged by Ordnance to recommend design changes to speed production or improve operations, Firestone contributed a wide variety of acceptable ideas. It adopted welding to replace one thousand rivets in the Bofors design and oilite bushings instead of the original manganese-bronze bushings. Steel tubing replaced forged and machined axles, a new type of traverse mechanism was employed, and the carriage was equipped with electric instead of hydraulic brakes. These steps were typical of the "Americanization" of the 40-mm., converting its production from a slow, painstaking job according to

[39] (1) Min, Wesson Confs, Feb 41; (2) Memo, CofOrd for CofS Gen Marshall, 17 Jan 41, sub: Characteristics of the 37-mm. AA . . . , AG 472.91 (1-17-41); (3) PSP 29; (4) Folder marked 40-mm. Bofors Matériel, OHF.

[40] PSP 29, pt. IV.

[41] Gen Barnes, diary, *passim,* and folder marked 40-mm. Bofors Matériel, both in OHF. For Navy background, see Lt. Col. George M. Chinn, *The Machine Gun,* III, Chapter 22 (Washington, 1953), and Rowland and Boyd, *U.S. Navy Bureau of Ordnance in World War II,* Chapter 11.

[42] (1) McHugh, Rosa, and Gleason, Artillery; (2) Barnes, diary, 11 Apr 41, 17 May 41, *passim;* (3) Maj Daniel J. Martin, "The 40-mm. AA Cannon," *Army Ordnance,* XXII, No. 129 (November–December 1941), 386; (4) J. E. Trainer, "Antiaircraft Gun Carriages," *Army Ordnance,* XXII, No. 130 (January–February 1942), 543; (5) Hist, Detroit Ord Dist, 100, pt. 18, pp. 45ff; (6) Chinn, *op. cit.;* (7) Rowland and Boyd, *op. cit.*



PLATFORM FOR 90-MM. AA GUN CARRIAGE *in production at Watertown Arsenal, Mass., September 1940.*

European practice to speedy quantity production on the pattern of American industry. After the two pilot guns were shipped to Aberdeen for test in July 1941, both Firestone and Chrysler began tooling up and were ready for quantity production soon after the Japanese attacked Pearl Harbor. But by the end of the year no 40-mm. guns had been completed. The only intermediate AA weapon on hand was the 37-mm., and it continued in short supply. The Colt Company, swamped with demands on its small staff and plagued with labor trouble, had run into one production delay after another, and by December 1941 had turned out only five hundred gun mechanisms.[43]

To reach high-flying planes the 90-mm. AA gun was adopted in February 1940, replacing the 3-inch. With requirements for the new gun totaling only 114 in the spring of 1940, Watertown was assigned the production of carriages and Watervliet the gun tubes.[44] In the fall, with requirements soaring above the one thousand mark, invitations for bids on carriages were issued to a dozen companies. Because the 90-mm. carriage was a new, difficult, and untried item, industry was reluctant to undertake its manufacture; only one concern, the York Safe and Lock Company, then making the 3-inch AA mount, entered a bid. As Ordnance considered the York price too high, another and more successful

[43] (1) PSP 29; (2) Memo, CofOrd for USW, 19 Dec 41, sub: The Colt Patent Fire Arms Mfg Co., OO 472.54/6972.

[44] Memo, CofOrd for USW, 18 Mar 41, sub: Comparison of Prod Possibilities of British . . . and American . . . Guns, OO 472.93/1961.

effort was made in October to attract bidders. Awards were then made to York, Allis-Chalmers, and Worthington Pump, with Watertown also taking on a portion of the total. The guns themselves were made only by Watervliet at the start, but private contractors were later brought into the picture, chief among them being the Chevrolet Division of General Motors Corporation (GMC), the Wheland Company, and the Oliver Farm Machinery Company. Production was not only slow to start because of the need for factory conversion, but it fell below expectations. For the year 1941 it amounted to only 171 complete units, less than half of which had been assembled and proof fired.[45] The lack of big AA guns worried Under Secretary Patterson. "If we get into a shooting war," he wrote in August 1941, "the demand for weapons of these types will be pressing and immediate. Every city will be demanding antiaircraft guns, and there will be very few on hand." [46]

Aircraft Cannon

The story of aircraft guns parallels that of the AA weapons. As the need had arisen in the late 1930's for an intermediate AA gun, so there came a demand for an aircraft weapon more powerful than the standard .50-caliber machine gun, but not as large as the 37-mm. After all known weapons in this intermediate range had been tested by Ordnance and the Air Corps, both services, in the spring of 1940, recommended adoption of the 20-mm. Hispano-Suiza gun known as Birkigt type 404.[47] Thirty-three of these weapons had been purchased from the French owners in the winter of 1939–40, along with an option on manufacturing rights. In April and May 1940 Watervliet made drawings that could be used as a basis for competitive bids, thus avoiding delay in waiting for French drawings. Of three bids entered, the lowest was that by Bendix Aviation Corporation (Eclipse Machine Division), a firm that had been interested in the gun for several years.[48] In September 1940, even before a final contract for manufacturing rights had been signed, Ordnance contracted with Bendix to make some 1,200 guns (for Air Corps, Navy, and British) with Ordnance providing about $1 million for special tools, jogs, fixtures, and dies.[49]

Tooling up at the Bendix plant in Elmira, N. Y., was a long, slow process, partly because the gun (designated M1 and AN–M2) carried the relatively low priority rating of A–1–c throughout 1940. Watervliet helped by leasing tools to Bendix, and after the fall of France tools ordered in the United States by the French government were diverted to Bendix, even after some

[45] (1) PSP 29, The Design, Development and Production of 90-mm. and 120-mm. AA Guns (May 1945), OHF; (2) Lt Walter G. Finch, Study of 90-mm. AA Gun, 19 Feb 42, OHF; (3) Memo, USW for CofOrd, 15 Nov 41, OO 472/1084.

[46] Memo, USW for Moore, 30 Aug 41, OUSW file 104, folder marked Guns, AT, Aircraft, and so on.

[47] (1) Ltr, CofAir Corps to CofOrd, 12 Apr 40, sub: Intermediate Aircraft Cannon, OO 472.91/2105; (2) OCM 15739, 19 Apr 40 and OCM 15827, 21 May 40; (3) Ltr, CofOrd to TAG, 23 Oct 39, Purchase of 20-mm. Aircraft Cannon, copy in OHF Arty docs.; (4) Green, Thomson, and Roots, *Planning Munitions for War,* ch. XV.

[48] For correspondence with Bendix, see OO 472.91, NA.

[49] For background of the Hispano-Suiza gun, see Chinn, *op. cit.,* ch. 13. See also B. D. Barrow, Production of 20-mm. Automatic Guns, M1 and AN–M2, OHF, and Design, Development and Production of 20-mm. Guns, M1 and AN–M2 (Nov 44), both in OHF. The latter study contains copies of many pertinent documents.

of them were on the high seas.[50] To meet the rising demand for guns for the Air Corps program, Ordnance brought three more producers into the picture in the spring of 1941. The Army and Navy Munitions Board raised the priority rating to A-1-b, and eventually to A-1-a. Contracts were placed with the Oldsmobile Division of GMC for nine thousand guns, with International Harvester for a like amount, and with Munitions Manufacturing Corporation of Poughkeepsie, N.Y., a wholly owned subsidiary of International Business Machines Corporation, for over thirteen thousand. All told, requirements for U.S. and British forces exceeded forty thousand, and the four contractors raced to get into production. Bendix, which had a head start, completed five weapons for test during the summer of 1941 and was ready for quantity production in September, but production was temporarily delayed because forgings were not available. After a few guns came off the line in October, design changes in several parts delayed the start of volume production until November. Meanwhile a trickle of production came from Oldsmobile and Munitions just before Pearl Harbor, and International Harvester came along early in 1942.[51]

With the 37-mm. aircraft gun there was no problem of foreign patents or drawings, but nevertheless production lagged behind requirements all during the defense period. The only source for this weapon was Colt's Patent Fire Arms Manufacturing Company, owner of all the basic patents. An old, well established gun-making firm, Colt had started production with a small order in the winter of 1939-40. In August 1940 Ordnance placed a new contract with Colt for production at the rate of two hundred units per month, at the same time authorizing expenditure of nearly $4 million for new machinery, dies, gages, and fixtures. In the spring of 1941 Ordnance foresaw difficulties in meeting the demand for 37-mm. guns and pleaded in vain for funds to establish a second producer.[52] Colt delivered a few guns in March 1941, but throughout the rest of the year deliveries were disappointing and did not keep pace with production of P-39 planes.[53] On the day after Pearl Harbor, Under Secretary Patterson, disturbed at the "apparent complacency of the Colt Company," directed it and all its subcontractors to go on a 24-hour day, 7-day-week schedule until the shortage was overcome.[54] A few days later Patterson called upon General Wesson to "bring about promptly a change in management in the Colt Plant."[55] General Wesson went to Hartford in person, made an appeal to the workers for increased production, and conferred at length with company officials. General Wesson knew that the company had taken on so much war work that it had spread its management dangerously thin. Confident that

[50] Hist, Rochester Ord Dist, XV, bk. II, 269-70.

[51] (1) Barrow, Prod of 20-mm. Automatic Guns: (2) Barrow, Design, Development, and Prod of 20-mm. Guns; (3) Hist, New York Ord Dist, 100, pt. 5, sec. 2, IBM Corp, OHF; (4) Review of the Prod Plans of the Arty Div, OCO, 4 Mar 42, p. 3.

[52] Memo, CofOrd to TAG, 5 May 41, sub: 37-mm. Automatic Cannon, AG 472.93/2299.

[53] Min, Wesson Confs, 16 Aug 41.

[54] (1) Memo, USW for Wesson, 8 Dec 41, sub: 37-mm. Aircraft Gun, ExecO file; (2) Memo, USW for CofOrd, 15 Nov 41, OO 472/1084; (3) PSP 30, Design, Development and Production of 37-mm. Gun, M4 (Nov 44), pt. 2, OHF.

[55] (1) Memo, USW for CofOrd, 13 Dec 41, ExecO file M-Matériel-Cannon; (2) Martin, Memo of conf at Colt Plant on 17 Dec 41, 19 Dec 41, OO 472.91/1365; (3) Memo, CofOrd for USW, 19 Dec 41, sub: The Colt Patent Fire Arms Mfg Co., OUSW file 104, folder Guns, AT, and son on; (4) Memo, USW for Brig Gen Thomas J. Hayes, 22 Dec 41, same file.

the company could overcome its difficulties, he decided against making a change in management, but offered help instead. He directed that Springfield Armory send Col. Elbert L. Ford and several production engineers and expediters to the Colt plant to help boost production. The results were gratifying. More than 6,000 guns were produced in calendar year 1942 as compared with 390 in 1941.

Tank and Antitank Guns

Though destined soon to be replaced by more powerful weapons, the 37-mm. was the most important tank and antitank gun before Pearl Harbor, and was produced in the largest quantities. As a tank gun the 37-mm. went into production at Watervliet in November 1938 with an order for eighteen pieces, followed in June 1939 by an order for some four hundred more.[56] These orders were awarded to Watervliet because that arsenal had taken an active part in developing the weapon, had manufactured the pilot models, and possessed both the equipment and the trained personnel for its production. After the first 18 guns were shipped in February 1940 the production rate was gradually stepped up to 150 per month early in 1941. Meanwhile contracts for tank guns (M5) were placed in the summer of 1940 with United Shoe Machinery Corporation and National Pneumatic Company.[57] Both concerns got into production quickly and between them completed delivery of over 2,800 guns before Pearl Harbor, when they switched over to an improved model, the M6. Late in 1940 a contract for the M6 gun had been placed with American Type Founders, which completed some 900 guns before the end of 1941. By the end of the year total output by Watervliet and the three contractors had passed the 5,000 mark, but requirements, including several thousand guns for the British, had meanwhile risen to nearly 35,000.[58]

As an antitank gun the 37-mm. went into production at the arsenals during the winter of 1939–40, Watervliet making the guns and Rock Island the carriages.[59] As early as April 1940 contracts were placed with the York Safe and Lock Company for both guns and carriages. Within a few weeks two other concerns signed up to make guns—the United Shoe Machinery Corporation and National Pneumatic Company—and two others agreed to make carriages—Muncie Gear Works and Duplex Printing Press Company.[60] But there was a wide gulf between signing contracts and delivering finished weapons. "Delivery of 37-mm. AT guns is very slow," reported G–4 in June 1940, "and it will be at least 18 months before the requirements for existing units will be filled."[61]

While the 37-mm. was being adopted for light tanks in the late 1930's, reports from abroad indicated the need for a more powerful weapon for medium tanks. By the spring of 1940 Ordnance had tested one medium tank with a 75-mm. howitzer in a sponson and with the 37-mm. as the secondary weapon in the turret. Soon thereafter a 75-mm. gun was hurriedly

[56] These were procured as field guns M3 because the tank gun M5 had not yet been developed.

[57] Hist, New York Ord Dist, 100, pt. 14.

[58] PSP 28, 37-mm. Guns M5 and M6, Design, Development, Production (Apr 45), OHF.

[59] See comments on this weapon by the Army Chief of Staff, Gen Malin Craig, in *WDAB,* H.R., 1940, 24 Jan 39. An early Ordnance report on it appears in ltr, CofOrd to CofS, 2 Sep 37, sub: AT and AA Development, OO 472/3371.

[60] PSP 28.

[61] Memo, ACofS, G–4 for CofS, 11 Jun 40, sub: Sale of 75-mm guns, AG 472 (6–11–40).



M3 MEDIUM TANK MOUNTING A 75-MM. GUN *delivered to the U.S. Army by the Chrysler Corporation. Standing in front of the tank from left: Brig. Gen. Adna R. Chaffee, Maj. Gen. Charles M. Wesson, and Mr. K. T. Keller.*

modified for the General Grant medium tank and adopted as standard. Although a makeshift, this arrangement was hailed in 1940 as the only available answer to the threat of German armor, and by September demands for 75-mm. tank guns reached the 2,500 mark.

An order for 1,308 75-mm. tank guns was assigned to Watervliet in mid-July 1940, and 9 months later the first completed units were shipped. By September 1941 Watervliet was turning out 75-mm's. at the rate of one hundred per month, and had completed nearly one thousand by the end of the year. Meanwhile, as requirements continued to rise, two commercial firms were given contracts in August and September of 1940, the Empire Ordnance Corporation of Philadelphia and the Cowdrey Machine Works of Fitchburg, Mass.[62] Both were slow to get into production, and neither was regarded as a strong source.[63] Empire shipped its first guns in August 1941 and Cowdrey in January 1942. Just a week before Pearl Harbor, with total requirements rising above twenty thousand and guns lagging behind tank production, a third source was added, the Oldsmobile Division of General Motors Corporation. Watervliet carried the burden of production during the critical months of the emergency period, manufacturing

[62] The Cowdrey firm was soon taken over by American Type Founders, becoming its Cowdrey Machine Division.

[63] Memo, USW for CofOrd, 15 Nov 41, OO 472/1084.

1,000 of the 1,200 guns produced during 1941.[64]

In the category of antitank and general field artillery weapons the change on the eve of war from the 75-mm. gun to the 105-mm. howitzer slowed production temporarily.[65] Only 597 105's were delivered in 1941 but nearly 10,000 were added in the next three years. In the fall of 1941 slow deliveries of the 105-mm. howitzer were a cause of serious concern to the Secretary of War and the Chief of Field Artillery. Production of this weapon was hampered from the beginning by frequent changes in requirements, low priority (A-1-g at the start), and lack of essential machine tools. But by the end of the year production was at the rate of 250 per month.[66]

The larger weapons, the so-called medium and heavy artillery, were neglected during the defense period, as were self-propelled weapons. Only 65 155-mm. guns were built before Pearl Harbor. No 155-mm. howitzers, 4.5-inch guns, 8-inch guns, 8-inch howitzers, or 240-mm. howitzers were produced because Army planners considered them less useful than lighter weapons. Ordnance was not authorized to procure self-propelled artillery until the closing weeks of 1941.[67]

All told, the production figures for the defense period were discouraging. In the cold grey days following Pearl Harbor, the Chief of Ordnance had to report that during the preceding eighteen months of rearmament he had managed to procure only those artillery items listed in the accompanying table. The quantities were admittedly small. But to Ordnance officers the really important fact was not revealed in the statistics. That was the existence of production capacity—plants tooled up and manned for quantity production. By the end of 1941 Ordnance had procured only small quantities of finished weapons but it had laid a solid foundation for volume production in 1942-43. (*Table 9*)

The First Year of War

Within four weeks of the Pearl Harbor attack, President Roosevelt set new and challenging goals for artillery production.[68]

In his letter to the Secretary of War on 3 January the President called specifically for delivery of 55,000 antiaircraft guns and 18,900 antitank guns within two years. These goals were high, but the really big artillery requirements were only implied in the President's letter and in his state of the

[64] (1) PSP 28, III, 75-mm. Guns M2 and M3, Design, Development and Production, OHF; (2) Memo, E. F. Johnson, OPM, for CofOrd, 12 Nov 41, sub: 75-mm. Guns for Medium Tanks, ExecO file M-Matériel-Cannon. The M2 was standardized in May 1941 and the M3 in June 1941.

[65] Typical of the thinking of the time is Ltr, CofFA to TAG, 28 Mar 40, sub: Use to be Made of 75-mm. Field Gun. . ., OO 381/34198, NA.

[66] (1) Memo, CofOrd for SW, 15 Oct 41, sub: Delays in 105-mm. howitzer program, ExecO file M-Matériel-Cannon; (2) Memo, Brig Gen Hayes, Director ASF Prod Br, to USW, 12 Nov 41, OUSW file, 104, folder marked Guns, AT, acft and so on; (3) Memo, CofFA for ACofS G-4, 26 Dec 41, sub: Prod of 105-mm. Howitzers, OO 472.22/1269; (4) Memo, Col Burnett R. Olmsted for CofOrd, 21 Jan 42, sub: Status of Prod of 105. . ., ExecO file M-Matériel-Cannon.

[67] (1) Memo, CofOrd for Deputy CofS, 20 Dec 41, sub: SP Arty, OO 451/2846; (2) Memo, Deputy CofS for CofOrd, 20 Dec 41, sub: Approval of and Expediting of SP Arty Projects, OHF. For an account of development of self-propelled artillery, see Green, Thomson, and Roots, *Planning Munitions for War,* pages 314-17.

[68] Ltr, President to SW, 3 Jan 42, copy in OO 472/1218. The address on the state of the Union, 6 Jan 42, in *Public Papers and Addresses of Franklin D. Roosevelt, 1942 Volume, Humanity on the Defensive,* compiled by Samuel I. Rosenman (New York: Harper & Brothers, 1950) pp. 36-37.

TABLE 9—ARTILLERY PRODUCTION, 1 JULY 1940–31 DECEMBER 1941

Item	Amount
20-mm. gun, aircraft	1,395
37-mm. gun, AT	2,592
37-mm. gun, AA	504
37-mm. gun, tank	5,571
37-mm. gun, aircraft	390
75-mm. gun, AT	918
75-mm. gun, tank	1,216
75-mm. howitzer	458
3-inch gun, field	140
90-mm. gun, AA	171
105-mm. howitzer	597
155-mm. gun	65
Mortars	9,518

Source: Extracted from MS draft, dated 9 Apr 52, of Procurement section, prepared by Richard H. Crawford and Lindsley F. Cook under the direction of Theodore E. Whiting for Statistics.

Union message on 6 January. These were the guns for 120,000 tanks and 145,000 airplanes to be built during 1942–43. In mid-January 1942 the Artillery Division estimated that, to meet the President's program, it would have to procure during 1942 alone some 200,000 artillery pieces, evenly divided between tank and aircraft types.[69] To Ordnance officers familiar with the complexities of gun manufacture, and keenly aware of the vast quantities of tools and materials needed, the task appeared impossible. But with the President's words still ringing in their ears—"Let no man say it cannot be done. It must be done. . . ."—they set about the task of planning new production schedules.

The chief bottleneck at the start was the lack of machine tools, and the lack of tools stemmed from low priorities on artillery. During the last 6 months of 1941 Ordnance artillery contractors had received only 1,363 tools out of a total national production of 80,000.[70] The first step taken by Ordnance to remedy this situation after announcement of the President's "must program" was to request AA or A–1–a priority on needed tools and equipment.[71] The request brought higher ratings for a few selected items, but for months antitank and field artillery weapons continued to carry such low priorities that it was almost impossible to get deliveries of new tools. Next Ordnance drew up a detailed tabulation of artillery requirements, placing opposite each item the name of

[69] Rpt of Prod Plans, Arty Div, Ind Serv, 18 Jan 42. For an itemized list, see Overall Requirements for War Munitions Program, 11 Feb 42, which called for 105,000 75-mm. tank guns, copy in OCO–Detroit file.

[70] Review . . . Arty Div, 4 Mar 42, p. 2.

[71] (1) Memo USW for ANMB, 7 Jan 42, sub: Schedules for manufacture. . . , OO 472/1219; (2) Conclusions reached at a conf held in Wesson's office, 7 Jan 42, ExecO file Matériel–Cannon; (3) Review Prod Plans of Arty Div, 4 Mar 42, pp. 29–31.

producing companies and needed production month by month. To every important prime contractor went a letter from General Wesson stating exactly what each had to produce to meet the President's directive. "We believe that if machine tools and materials come in exactly as wanted, this thing might be done," Col. Gordon M. Wells, Chief of the Artillery Division, reported in mid-February. "But on the basis of past experience it seems rather impossible." [72]

Colonel Wells moved slowly in contracting for new plants because he did not want to spread too thin the few machine tools available. "We will get better and quicker results," he observed in mid-February, "by giving the tools to a few strong companies." [73] How to get production with the fewest new tools was a prime consideration in awarding all contracts. As a result, the firms under contract before Pearl Harbor continued as the backbone of the artillery program throughout 1942. There were increases in scheduled production, enlargement of plant capacity, and the enlistment of a few new producers but no wholesale additions to the pre-Pearl Harbor production base.[74]

Early in the defense period, contracts with industry were placed by the arsenals, under direction of the Chief of Ordnance; but after the district offices built up their staffs more of this work flowed through them.[75] Beginning in January 1942, in order to decentralize more activities from Washington to the field, a Fire Control Sub-Office was created at Frankford Arsenal, followed by similar offices at Watertown, Watervliet, and Rock Island. Responsible for production engineering, inspection standards, surveys of industrial capacity, cost analysis, and related matters, they served throughout the war.[76]

AA Guns

Antiaircraft guns were the chief artillery problem in 1942. The first item on the President's AA list—1,600 37-mm. weapons in 1942—could easily be met by Colt, but the newer 40-mm. and 90-mm. guns were different matters.[77] The President's program required something like 300 percent expansion of rates previously planned for these weapons. Both were extremely difficult to manufacture and required hundreds of new tools.[78] The 40-mm. was in the hands of two strong producers, Chrysler and the Pontiac Division of General Motors, but Chrysler was just starting production in February 1942 and Pontiac, with a priority of A-1-d, found it could not get essential tools.[79] When the priority was raised to A-1-a Pontiac could still not get tools because it had no "urgency standing." In view of these facts, Ord-

[72] Rpt of Prod Plans of Arty Div, 13 Feb 42, pp. 1–2.

[73] Rpt Prod Plans, 13 Feb 42, p. 3. See also Rpt Prod Plans, 15 Sep 42, pp. C and D of Foreword.

[74] *Ibid.* This report, and others throughout the year 1942, list all major items and their producers.

[75] Chapter II above describes the roles of districts and arsenals in procurement.

[76] (1) Hist, Arty Div, I, pt. 3, ch. X, XI, XII, XIII; (2) ODO 231, 27 Jan 42, OHF; (3) History, Cannon Sub-Office, Watervliet Arsenal, 9 vols., OHF.

[77] For a detailed analysis of the 37-mm. as of 2 Jan 42, see History, Artillery Division, Volume 102. More than a score of firms made important components of this weapon.

[78] (1) Review of the Prod Plans of the Arty Div, OCO, 4 Mar 42, summary; (2) Memo, USW for Gen Clay and Alfred R. Glancy, 30 May 42, ASF Prod Div 472.93 AA Guns, Job 19B, dr 1867; (3) Memo, Brig Gen Lucius D. Clay for USW, 5 Jun 42, ASF Prod Div, 472.93 AA Guns, Job 19B, dr G1867. For background on the 90-mm., see PSP 29 (2 May 45), OHF.

[79] For correspondence on the urgent need for machine tools for AA gun production, see Memos in ASF Prod Div, 472.93 AA Guns Job 19B, dr G1867.

nance recommended, and higher authorities approved, that the 37-mm. gun be accepted as a substitute to make up the deficit in 40-mm. output.[80]

"This is one of the tightest jobs we have," commented General Knudsen when the 90-mm. AA gun came up at an ordnance production conference in February 1942.[81] Watervliet was the only real producer at that time, turning out 120 per month and steadily increasing its output. Wheland was just reaching the production stage while Chevrolet and Oliver had only recently received contracts and were not expected to begin producing until near the end of the year. Ordnance estimated that only 3,650 guns would be produced during 1942 against the President's goal of 5,400.[82] As if this were not bad enough, output of carriages was lagging behind guns in spite of having Watertown Arsenal and seven commercial producers in the picture. None of the commercial firms was scheduled to reach production stage during the first half of the year, and most were expected to start producing only during the last three months of 1942.

The 90-mm. carriage was a complicated item, very difficult to make. "There are so many different devices on that carriage," General Knudsen commented, "if you once set up for the whole job it will be as big as the Detroit Tank Arsenal."[83] It was also a newly developed item that experienced all the difficulties inherent in production of a complicated piece of new equipment. Some of the most competent firms in the heavy machinery field found difficulty in meeting prescribed tolerances and specifications.[84] The brightest spot in the picture was production of recoil mechanisms. In addition to Watertown Arsenal, two old standbys, R. Hoe and Otis Elevator, were carrying the load for this component. Both concerns had got off to a head start through educational orders. The darkest spot was the director. Two strong sources, Sperry Gyroscope and Ford Motor, had contracts for directors for the 90-mm., but Ford was behind schedule on tooling and Sperry was just starting to produce. An extremely complicated computing machine, the director contained thousands of parts, cost about $20,000, and required precision workmanship throughout. "I think this is our real choke item on the 90-mm. program," reported Colonel Wells in February 1942,[85] and it remained a choke item for many months. At the March production conference Ordnance reported that it would probably be impossible to meet the President's directive on the 90-mm. unless extraordinary measures were taken to grant it overriding priority. General Somervell pointed out that scheduled monthly production of AA guns would supply sixty-two AA regiments a month, "a terrific number of guns." When General Wesson, who had grave doubts about the need for so many 90's, asked on what the President had based his directive, no one could answer. "I think what we ought to do," Donald

[80] (1) Review . . . Arty Div, 4 Mar 42, p. 10; (2) Memo, ACofS G-4 for CofOrd, 8 Mar 42, sub: 40-mm. AA guns, G-4/23631-92, copy in OO 472.93/18.

[81] Mtg on review of prod plans of the Arty Div, OCO, 13 Feb 42, p. 11.

[82] (1) *Ibid.;* (2) Prod Plng Rpt, Arty Div, 9 Feb 42, p. 27.

[83] Mtg on review of prod plans, Arty Div, OCO, 13 Feb 42, p. 14.

[84] For an account of the 90's history, see Col Well's statement in Review . . . Arty Div, 21 May 42, and also PSP 29, pp. 42-43.

[85] (1) Prod Plng Rpt, Arty Div, 9 Feb 42; (2) Review . . . Arty Div, 4 Mar 42, pp. 18-19; (3) Memo, CofOrd for CG ASF, 7 Oct 42, sub: Recommended Revisions in ASP. . ., OO 381/9948 Misc.

Nelson concluded, "is to review this in terms of its urgency in the picture . . . and then let's go back to the President and talk to him about it." [86] In less than a month the requirement was cut in half.[87]

Aircraft Guns

Production of aircraft cannon easily kept pace with plane deliveries in 1942. With four facilities making the 20-mm. gun, Ordnance estimated that output for the year would total 67,000 pieces, more than enough for aircraft use though short of the Time Objective figure of 89,000. A recomputation of requirements soon cut the latter figure in half and turned the 20-mm. deficit into a surplus. The 37-mm. gun was also well ahead of plane output, so far ahead, in fact, that plans were made in March to convert some of Oldsmobile's production to 37-mm. AA guns.[88]

Tank and Antitank Guns

Providing guns for all the tanks on the President's program meant building some 66,000 during 1942, but in February the Artillery Division nevertheless reported that it expected to reach its goal. Reasonable production of 37-mm. guns by Watervliet, United Shoe, National Pneumatic, American Type Founders, and York was calculated at 41,179 for the year. Production of the 75-mm. gun by Watervliet, Oldsmobile, Cowdrey, and Empire Ordnance was expected to reach 26,172. The 3-inch gun for the heavy tank, a new project, fell below requirements because the three producers, Vilter, Munitions, and Goodyear, had only A-1-d priorities and were unable to get tools. But the 3-inch was the least important of the tank weapons and caused no great concern.[89]

In spite of the hopeful outlook, guns lagged behind tanks all during the first half of 1942. The lag was not great if one counted every gun as soon as it came off the assembly line. But there was a delay of from ten to thirty days between completion of guns at the factory and their installation in tanks. This time was taken up in packing, shipping to proving grounds, proof firing, transporting to tank arsenals, and finally installing the guns. At the end of April the Under Secretary called Ordnance to task because more than half the light tanks and two-thirds of all medium tanks with armored divisions had no guns.[90] Ordnance immediately redoubled its efforts to speed proof firing and shipping. Hundreds of guns, intended for use with gyrostabilizers and special mounts on light tanks, were installed instead on medium tanks without special mounts,[91] and by June the number of tanks and guns was fairly well balanced.[92]

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[86] (1) Review . . . Arty Div, 4 Mar 42, pp. 20–22; (2) Memo, ACofS G–4 for CofOrd, 6 Mar 42, sub: Presidential Objectives for 1942 and 1943, and 1st Ind CofOrd to CG SOS 10 Mar 42, with 2 Incls. Copy attached to preceding document.

[87] (1) Review . . . Arty Div, 18 Apr 42; (2) ASP sec. I, 6 Apr 42, copy in OCO–Detroit file.

[88] (1) Review of Prod Plans by the Arty Div, 1942; (2) Memo, Maj Gen Thomas J. Hayes, for Lt Gen William S. Knudsen, 3 Jul 42, sub: June Prod of Important Arty Items, OO 400.12/729.

[89] (1) Review of prod plans, pp. 19ff; (2) Prod Plng. Rpt. pp. 47–52; (3) Overall Rqmts for War Munitions Program, 11 Feb 42.

[90] (1) Memo, USW for Brig Gen Charles D. Young, ASF Proc and Dist Div, 26 Apr 42, USW file 104, Guns, and so on; (2) Review . . . Arty Div, 18 Apr 42.

[91] Memo, CG SOS for USW, 5 May 42, sub: Acceleration of Tank Armament, USW file 104, Guns, and so on.

[92] (1) Memo, Glancy, ASF Prod Br, for USW, 8 Jun 42, sub: Progress of Tank Armament, USW file 104, Guns, and so on; (2) Rpt by Col Wells in Review . . . Arty Div, 21 May 42.

Antitank guns formed a weak segment in the allied arsenal.[93] Production of the 37-mm. AT gun was halted in 1943 after nearly twenty thousand had been delivered. The more powerful but still inadequate 57-mm. AT gun came into production in 1942 and ran well ahead of schedule. It remained the one most important U.S. antitank gun throughout the war, total output exceeding sixteen thousand. The 3-inch AT gun, after coming into production late in 1942, continued at a modest rate in 1943 and stopped in 1944. Ordnance meanwhile labored to develop a fourth AT weapon, the high velocity 76-mm. gun, but failed to get it into production before the war ended. An even more powerful 90-mm. AT gun was approved for limited procurement in May 1944, but further tests revealed the need for design changes to correct structural weaknesses in the carriage. Of two hundred produced, only one was sent overseas before the war's end.[94] At least part of the lack in AT guns was made up by the introduction of powerful and effective self-propelled weapons, often called tank destroyers or gun motor carriages. Most famous was the 105-mm. howitzer mounted on a medium tank chassis, nicknamed The Priest. After proving its value to the British in defeating Rommel's armor in North Africa, the 105-mm. howitzer was followed by the 3-inch and 90-mm. guns, both mounted on medium tank chassis, the 76-mm. gun on a special carriage, and smaller pieces down to the 37-mm.[95]

To provide mobile antitank defense, the 57-mm. gun (formerly the British 6 pounder) was mounted on a half track personnel carrier. Manufacture of this gun motor carriage was undertaken by the Diamond T Motor Company but, because of its limited tactical usefulness, less than one thousand were produced, and all were shipped to the British on lend-lease. These were clearly stop-gap weapons hurriedly designed to meet the threat of German armor. So was the 75-mm. gun motor carriage standardized late in 1941, the first piece of self-propelled artillery adopted by the U.S. Army in World War II. It consisted of a 75-mm. gun mounted on the standard half track personnel carrier and was manufactured in small quantities by Autocar. A companion weapon, the 75-mm. howitzer motor carriage, also utilized the half-track personnel carrier and was produced in small quantities by the White Motor Car Company. Another vehicle produced by the White Company was a half-track carrier for the 81-mm. mortar. Though standardized two full years before Pearl Harbor it was never in great demand. These weapons were not produced in large numbers because they lost out in competition with full-tracked antitank vehicles of greater power and cross-country maneuverability.[96]

Heavy mobile artillery and seacoast guns ran far behind schedule throughout 1942. Production of the 155-mm. howitzer scarcely got started because of its low

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[93] Testimony on this score appears in *Biennial Report of General George C. Marshall, the Chief of Staff of the United States Army to the Secretary of War, 1 July 1943 to 30 June 1945* (Washington: 1946), p. 97.

[94] McHugh *et al.*, Arty, p. 37.

[95] (1) Whiting, Statistics, Table PR-8; (2) Green, Thomson, and Roots, *Planning Munitions for War*, pp. 314–17; (3) McHugh, Arty, pp. 32–37.

[96] (1) Draft Project Report on Light Self-propelled Artillery prepared by Daniel Chase, Ord Hist Br, n.d. OHF; (2) TM 9-2800, Standard Military Vehicles, 1 Sep 43; (3) Catalog of Standard Ord Items, 1 Mar 44, Tank and Automotive Vehicles. The latter citation gives numerous references to Ordnance Committee Minutes (OCM's) for each item.

priority. Only 33 were delivered against a requirement of 452. "There never was a possibility of meeting the 1942 requirement of 452 units, as we have pointed out on many occasions," General Wells reported in December 1942.[97] The 155-mm. gun and 240-mm. howitzer were in better shape but still behind schedule while the 8-inch field gun barely met the year's requirement. The delay with all these weapons sprang from the combination of low priority and the need for elaborate equipment and preparation for production.[98]

Mortars

Mortars, among the simplest weapons employed in World War II, caused no major production problems, though diversion of seamless steel tubing to Air Force contractors in September 1942 completely stopped production of 60-mm. mortars for a time.[99] Both of the two main types, the 60-mm. and the 81-mm., were foreign models purchased in the 1930's from the Edgar Brandt firm in France. Both were manufactured first at Watervliet and then by industry as rearmament got under way in 1939 and 1940.

When the 60-mm. mortar was adopted in 1938, it was given the designation M1. Ordnance bought eight mortars, with French production drawings, from the Brandt company. When Watervliet Arsenal prepared production drawings of this weapon it adopted standard American threads and made minor dimensional changes to suit tubes and plates of American manufacture. To distinguish the French from the American model the latter was designated M2.[100] In January 1940 the first production contract for 1,500 mortars went to the Read Machinery Co.



THE PRIEST, A 105-MM. HOWITZER MOTOR CARRIAGE M7, *passing through a town in Sicily, July 1943.*

[97] Review of Prod Plans, Arty Div, 16 Dec 42.

[98] Memo, CofOrd for CG SOS, 7 Oct 42, sub: Recommended revisions in ASP Rqmts for Arty, OO 381/9948 Misc. For details on priorities, contractors, and production, see PSP 80, Medium Artillery Weapons, Design, Development and Production of the 155-mm. Howitzer and 4.5-inch Gun, OHF.

[99] (1) Production Progress and Production Scheduling, report by SOS to WPB, 1 Dec 42, p. 17, ASF 200.02; (2) Memo, CofOrd for CG SOS, 7 Oct 42, sub: Recommended Revisions in ASP. . . , OO 381/9948 Misc. For the development and use of mortars during and after World War I, see PSP 27, the Design, Development, and Production of Mortars, Feb 45, vol. 3, OHF, and the report of Board of Officers appointed by par. 142, SO No. 289-0, WD, 1918 (hereafter cited as Westervelt Bd Rpt), 5 May 1919.

[100] (1) OCM 14273, 4 Feb 38; (2) OCM 14421, 7 Apr 38; (3) OCM 15118, 22 Jun 39; (4) OCM 15229, 27 Jun 39; (5) PSP 27, vol. 1, OHF.

of York, Pennsylvania, and the Pullman-Standard Car Manufacturing Company signed a contract for the 81-mm. As requirements for the 60-mm. rose rapidly during 1940, Ordnance placed orders with a second producer, Kennedy-Van Saun Engineering and Manufacturing Company of Danville, Pennsylvania. Requirements dropped early in 1944 but by the fall of that year the demand for mortars in the European theater exceeded existing supplies. To meet the demand for 60-mm. mortars Ordnance took two steps; it ordered Read and Kennedy-Van Saun to boost production, and it placed a contract with Firestone Tire and Rubber Company for 24,250.[101] Production for the first eight months of 1945 totaled 30,152, nearly equal to total production of the three preceding years. No similar crisis marked the 81-mm. program. It moved along at a fairly even pace year after year, its requirements and production following the general pattern set by the 60-mm. but with less extreme fluctuations.[102]

Of four new mortar models procured in 1944 the smallest was a 60-mm. mortar that weighed only 19.5 pounds and could easily be carried and fired by one man. The largest was a powerful 155-mm. weapon that could easily be disassembled and transported to forward positions to provide the equivalent of divisional or corps artillery support. Between these extremes were a lightweight 81-mm. and a new 105-mm. mortar.[103] All were designed to meet the needs of troops in the South and Southwest Pacific Areas for mortars light enough to be carried forward through the jungle by infantry and yet powerful enough to blast prepared enemy positions at fairly long range. None of these new models was produced in large quantities and all remained limited procurement items with "T" designations.[104] The only real difficulty in manufacture arose from the fact that these new types were rushed into production before Watervliet had time to complete the manufacturing drawings. The contractors thus had to use research and development sketches at the outset, with the result that some of the early production mortars failed to pass proof firing tests.

Over the Hump

By the end of its first year of war Ordnance could feel that, regardless of what the future might hold, it was over the hump in artillery production. The heavy investment in plant capacity made during 1941 and early 1942 was beginning to pay dividends, and output was steadily rising. Production of all types of artillery weapons during 1942 totaled some 160,000 pieces, distributed roughly as follows:[105]

Aircraft guns	68,114
Antiaircraft guns	14,509
Tank guns and howitzers	42,731
Self-propelled weapons	8,751
Light field and AT weapons	20,536
Mortars	10,160
Heavy field artillery	647

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[101] (1) PSP 27; (2) Rpt on Visit to ETO, 23 Oct 44, by Christmas, Col Herbert R. White, and Col Theodore A. Weyher, par. 15, Incl to OO 350.05/15609. For month by month developments, see Review of Prod Plans, Arty Div.

[102] Whiting, Statistics, Table PR-8.

[103] Descriptive data and photographs may be found in Limited Procurement Supplement to Catalog of Standard Ord Items and in PSP 27, vol. 2. The latter reference includes copies of relevant OCM's.

[104] Production of the 155-mm. totaled 244; the 105-mm., 500; the 81-mm. (T27) 850; and the 60-mm. (T18E6), 6,145.

[105] For detailed figures on types and models, see Whiting, Statistics.

On the debit side Ordnance had to report that the Presidential goals for AA guns (40-mm. and 90-mm.) and for antitank guns (37-mm. and 3-inch) were not met. On the credit side, the figures showed that aircraft guns had kept well ahead of plane production all during the year, allowing some carryover to apply on the large 1943 requirements, and tank gun production had moved well ahead of tank output in the second half of the year. But more important than the President's objectives was the Army Supply Program (ASP) that brought together all artillery items in a balanced statement of requirements. On some items the ASP called for more than the Presidential directive, on others less, and it was revised several times during the year. As a result, no precise comparison of goals and achievements was possible. But output for the year, totaling roughly one billion dollars in value, was encouraging. The most serious deficiences in December were in directors and height finders for AA guns, other fire control items, 60-mm. mortars, and 155-mm. howitzers.[106]

There was no difficulty in identifying the factors that had hindered artillery production most. They were the same problems that had plagued all other Ordnance procurement efforts—lack of machine tools and lack of raw or semifinished materials. Throughout the nation there were too few machine tools to go around and Ordnance efforts to win higher priorities for its own matériel had been only moderately successful. In mid-summer of 1942, when it had become apparent that there was no immediate prospect of getting more tools, Ordnance decided to favor a few key gun plants where rapid expansion was most needed instead of assigning new tools to all contractors regardless of the urgency of their need. Plants making 40-mm. AA carriages and directors and 3-inch AT guns were put ahead of plants producing 57-mm. AT guns and 90-mm. AA guns and carriages, which were not as urgently needed by the middle of the year. Meanwhile, the Ordnance district offices put pressure on prime contractors to subcontract work they could not do with their own tools.

Each district formed a Machine-Tool Panel to help contractors solve their machine-tool problems. In January 1942 General Campbell conferred at length with a machine-tool distributor from Philadelphia, Mr. N. P. Lloyd, and evolved the idea of using industrial specialists to aid the Ordnance districts.[107] The Chicago district took the lead in forming a panel of machine-tool distributors familiar with the equipment in all plants within their business territory. The members served on a part-time basis and received no pay from the government, though they were reimbursed for travel expenses. When a contractor drew up a list of the tools he felt he needed, and submitted it to the district office, the Machine-Tool Panel would review it, urge greater use of subcontracting, suggest substitute types of machines that were known to be available, or recommend the use of idle equipment in the area. In one instance a Machine-Tool Panel was able to reduce the number of new machine tools for a given schedule of production from 1100 to 450.[108] Industry integration committees for the pooling of tools and materials also helped a great deal in the latter half of the year while a sharp cut-

[106] Review . . . Arty Div, 16 Dec 42.

[107] Campbell, *op. cit.*, ch. 9.

[108] Winter, Analysis of World War II Prod Activities of the New York Ord Dist, 5 Sep 47, pp. 20–22.

back in the Army Supply Program eased the pressure for production.[109]

As early as June 1942 Colonel Wells had reported that, more than any other factor, lack of materials would hold back artillery production for 1942. The urgency of the need was dramatized by Watervliet's contribution to the national scrap drive of hundreds of tons of material, including iron fence, antique cannon, and large cannon balls that had been piled at the base of the arsenal flagpole since Civil War days. To the general materials shortage that affected all wartime production there was added for the artillery program the need for a wide range of semifinished materials, often in such small quantities that rolling mills and other suppliers were not interested in them.

There was no effective procedure for scheduling and balancing production of artillery components during 1941–42. The practice was to schedule all components for production in the shortest possible time, working plants at full capacity. Not until the end of 1942 did a system of scheduling for balanced production go into effect with creation of a Central Planning Committee in the Artillery Division.[110]

Production Techniques

Of all the new or refined production techniques employed in making artillery during World War II, two may be taken as major advances—cold-working and centrifugal casting of gun tubes. Their novelty, it should be added, was not so much in the processes themselves as in their application to cannon manufacture on a large scale for the first time.[111]

Cold-Working (Autofrettage)

In the nineteenth century Springfield Armory had adopted the practice of firing in each rifle barrel, before it was bored to final dimensions, a cartridge loaded far above normal pressure. The purpose was to discover defective barrels, but toward the end of the century it was discovered that, for some unknown reason, firing a high-pressure cartridge imparted greater elastic strength to the rifle barrel. At about the same time European designers were applying the principle to large gun tubes by use of hydraulic pressure. During World War I, American Ordnance officers brought back to the United States reports on the European experience. Engineers at Watertown achieved some success during the 1920's in applying the principle to big guns, using controlled hydraulic pressure up to 150,000 pounds per square inch within the bore. Tests established the fact that pressure high enough permanently to enlarge the bore strengthened the barrel by imprisoning internal compressions at the bore comparable to those created in a built-up gun when a heated jacket or hoop was slipped on the barrel or breech and allowed to cool, shrinking to a very tight fit.[112] As hydraulic pressure produced this effect without hoops it was sometimes described by the French term "autofrettage" meaning "self hooping." By subjecting gun tubes to pressures exceeding

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[109] (1) Review . . . Arty Div, 16 Dec 42; (2) Memo, USW for McCloy, 23 Dec 42, sub: Superheavy Arty, USW Guns, AT, Aircraft, and so on. See ch. 8 for description of industry integration committees.

[110] Mead Comm. *Report*, OHF.

[111] Both processes are described in "World Leader in Gun Making" by Brig. Gen. Rolland W. Case, *Army Ordnance*, XXII, No. 129 (November–December 1941), 359–61.

[112] Compare with Rodman guns cast around a water-cooled core in mid-19th century. See also Hayes, *op. cit.*, pp. 164–66, and Earl McFarland, *Textbook of Ordnance and Gunnery* (New York: J. W. Wiley and Son, 1929), pp. 180–84.

any they would experience in service, it further served as a proof test.[113] Both Watertown and Watervliet were producing cold-worked tubes in quantity long before Pearl Harbor and continued to do so throughout World War II.

Centrifugal Casting

Though the first patent on casting in a rotary mold was issued in England early in the nineteenth century before the Ordnance Department was created, application of the principle to gun production in the United States dates only from World War I and the years following. Long before 1918 the centrifugal process had been used for commercial manufacture of pipes, piston rings, gear blanks, and thin-walled metal tubing, but Ordnance did not begin serious experimentation with centrifugal casting of cannon until 1925. In 1918 an Ohio concern, the Paper and Textile Machinery Company of Sandusky, had submitted to Ordnance for examination three centrifugally cast steel cylinders and had been awarded a contract to build a machine large enough to cast the 155-mm. howitzer tube. In 1925, after delivery of the machine, its use was energetically pushed by Brig. Gen. Tracy C. Dickson, commanding officer at Watertown from 1918 to 1932. During the experimental stages in the mid-20's Watertown made large numbers of castings under different conditions and gave the resulting guns every known metallurgical test. The experimental casting cylinder used at Watertown was fitted with glass end pieces to permit observation of the molten metal after it was poured into the whirling cylinder.[114] By 1932, after years of experimental production, a member of the Watertown staff was able to report in a scientific journal that, "The manufacture of cannon from cast steel is an accomplished fact. Molten steel is poured into a revolving mold and shaped by centrifugal force to the shape of the mold. The result is a piece of ordnance superior in many ways to anything heretofore produced." [115] There were still many problems to be solved, and rejection rates remained high, but by 1940 the process was sufficiently developed to be ready for quantity production.

During World War II centrifugally cast guns made a substantial contribution, starting with the small sizes and eventually working up to medium sizes. On 20 June 1944 Watertown passed two landmarks in its production history: completion of its 100,000th centrifugally cast gun tube, and installation of a new machine for casting heavy cannon weighing up to 10 tons. The centrifugal process not only resulted in speedy production and economy of material but produced a gun that, unlike the forged gun which was stronger lengthwise than crosswise, had uniform directional properties. Centrifugal force tended to drive impurities toward the center where they could be eliminated when the gun was bored, and to increase the specific gravity of the product. Economy, simplicity of manufacture, speed of production,

[113] Hist, Watertown Arsenal, vol. 102. This reference contains an important technical paper, Design Data for Gun Tubes and High Pressure Vessels by Capt Donald H. Newhall, officer in charge of the Cold Work Section at Watertown before and during World War II. See also Hist, Watertown Arsenal, XV, pp. 6–7, and Hist, Watervliet Arsenal, I.

[114] History, Watertown Arsenal, vol. 102. This reference gives a detailed account of centrifugal casting experience at Watertown, including numerous photographs.

[115] "Whirling Molten Steel to Make Gun Castings" by 1st Lt Steven L. Conner, *Scientific American*, 147 (September 1932), 160.

and greater uniformity of product—all these were virtues of centrifugal casting.[116]

In December 1941 Ordnance placed contracts for two government-owned, contractor-operated plants to make gun tubes according to Watertown's centrifugal casting method. The Houston Tool Company built and operated the Dickson Gun Plant in Houston, Texas, and the Ohio Steel Foundry Company operated the Ohio Gun Plant at Lima, Ohio. The latter arrangement was terminated in September 1942 in view of the drastic reductions in the Army Supply Program, and the plant thereafter became the Lima Tank Depot. The Dickson plant continued in operation until the end of the war, turning out a total of more than 12,000 gun tubes, of which about half were for 105-mm. howitzers.[117]

The list of other new methods adopted for artillery production is almost endless. The work of the Firestone Company in redesigning the 40-mm. gun carriage has been noted above. The use on this carriage of welding to replace riveting was well in advance of the adoption of welding for tanks and proved to be the forerunner of a host of new applications for welding techniques. Employment of lathes that permitted simultaneous boring of the inside and machining of the outside of gun tubes saved valuable production time.[118] The use of seamless steel tubing for the smaller gun tubes and for recoil cylinders not only lightened the load on forging and casting plants but also saved time and material and gave a uniformly high quality product. With breech rings for the 90-mm. AA guns, casting instead of forging reduced machining time and doubled the rate of production.[119] To speed output of optical instruments a new method was developed for casting optical glass in rods and bars from which could be cut small circular blanks ready to go on the lens-grinding machines. Formerly optical glass had been cast in large chunks from which slabs were cut and then gradually reduced to small circular blanks. In the long list of such cost-cutting, production-speeding techniques lay part of the secret of American industry's high-speed quantity production in World War II.[120] The whole process was in line with General Campbell's admonition to the District chiefs in December 1944: "Make no compromise with quality and yet at the same time wherever we can let's cut out the monkey business." [121]

But there was another side of the picture, too, with defects in production causing much concern. When artillery weapons reached the proving ground for final test they often failed to pass. In spite of a vigorous campaign to tighten inspection, General Wells reported late in 1942 that "a lot of material is getting into the proving grounds that has various things wrong

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[116] Hist, Watertown Arsenal, vol. 102, including long extracts from Watertown Arsenal Rpts by Dickson, Capt Hugh C. Minton, Capt Scott B. Ritchie, and Lt Steven L. Conner during the 1920's and 1930's and personal notes of Dr. J. L. Martin, superintendent of production.

[117] (1) History, Dickson Gun Plant, OHF; (2) History, Ohio Gun Plant, OHF. The latter contains a lengthy memorandum by Maj. Tracy Dickson, Jr., to OCO Historical Section, 31 December 1943.

[118] William S. Knudsen, Lecture, Problems in War Production, 18 Jun 46, ICAF.

[119] (1) *The Ordnance Digest,* XXVII, No. 10 (October 1945), p. 3; (2) Ordnance Reports for ASF Report on Logistics in World War II, 28 Sep 45, SR 104, pp. 7–8, OHF.

[120] Artillery, 1 July 1940 to 31 August 1945, Ordnance historical monograph prepared under the direction of Brig Gen John K. Christmas by F. D. McHugh, C. B. Rosa and F. W. F. Gleason, pp. 74–80.

[121] Rpt Conf Dist Chiefs, Cleveland, 19 Dec 44, p. 105, OHF.

with it. It's a critical situation." [122] Pressure to get out production sometimes led to unwise shortcuts that caused no end of trouble, while material accepted without inspection on the basis of the manufacturer's certificate was sometimes found to be the source of defective parts. Constant efforts by Ordnance, under pressure from Army Service Forces, to reduce inspection forces probably also contributed to lowering of standards. The lack of inspection gage designs from which manufacturers could produce work gages and the necessity to find substitutes for critical or strategic materials and machine tools were the principal causes of the discrepancies.

Fire Control Instruments

Instruments for observing distant targets, measuring distances, and aiming weapons—collectively known as fire control instruments—contributed greatly to the effective employment of U.S. artillery in World War II, but they were among the most troublesome items for Ordnance to procure. Ranging from relatively simple binoculars, telescopes, and quadrants to more complex items such as periscopes, panoramic telescopes, height finders, and range finders, and finally to enormously complicated directors for antiaircraft guns, they covered a wide area of manufacturing problems. Compared to standard guns and howitzers, which were themselves not simple in construction, fire control instruments were generally more complicated, required more drawings, called for more different kinds of material, and demanded more exacting machining and more meticulous assembly operations. As the quantities required of the more complex instruments were relatively small, and the risks of production were great, manufacturers were usually reluctant to accept contracts for their production. Ordnance district representatives had to overcome this reluctance by meeting with industry executives and explaining to them the urgency of the Army's needs. The success of these efforts is indicated by the fact that from 1940 to 1945 the value of fire control instruments produced by industry under Ordnance contracts exceeded $1,000,000,000.[123]

Frankford Arsenal had been the Ordnance center for fire control research and procurement all during the interwar years and continued in that role throughout World War II. Because of lack of funds, progress in both research and procurement planning was slow during the peace years, but in 1939 the arsenal was enabled to place several educational orders with industry for height finders, gunner's quadrants, telescopes, and telescope mounts.[124] Before much was accomplished on these orders the arsenal was faced in the fall of 1940 with the need to replace them with quantity production contracts. Over-all direction of fire control procurement came from the Industrial Service in Washington, but the day-by-day work of placing contracts and expediting production was

[122] (1) Rpt Conf Dist Chiefs, Philadelphia, 8 Oct 43, pp. 17–18; (2) Rpt Conf Ord Dist Chiefs, Springfield, Mass., 28 Jul 43, pp. 12–13; (3) Rpt Conf Ord Dist Chiefs, New York, 18 Jan 44, p. 20.

[123] (1) Hist, New York Ord Dist, vol. I, pt. 4, p. 465; (2) Hist, Arty Div, Ind Serv, OCO, 1940–45, vol I, pt. 2, ch. VII. For the research and development aspect, see Green, Thomson, and Roots, *Planning Munitions for War*, pp. 333–45. For a description of the manufacturing and inspection problems with fire control instruments see Inspection and Quality Control, Problems and Solutions, PSP 13, Jun 45, vol. I, ch. 5, sec. 9 OHF. An excellent summary of the development of AA weapons and fire control may be found in Special Text 9–169, February 1953, The Ordnance School.

[124] For a list of these orders, see Hist, Arty Div, Ind Serv, OCO, 1940–45, vol. 3, ch. X, OHF.

handled by Frankford Arsenal. Except on matters of inspection, the arsenal bypassed the District offices and dealt directly with contractors, justifying this action on the ground that the Districts, which were just then building up their staffs, lacked specialized knowledge of the instruments and their production. As far back as 1930 the arsenal had stationed an officer, known as an Army Inspector of Ordnance, at the Sperry Gyroscope plant in Brooklyn, N.Y., and as time went on increased his jurisdiction to include contracts with Keuffel and Esser, Eastman Kodak, and other concerns. Soon after Pearl Harbor, as the District offices gained strength and as General Wesson moved to promote further decentralization of Ordnance procurement, a Fire Control Sub-Office was established at Frankford Arsenal with directions to transfer all Frankford Arsenal fire control contracts (then totaling about two hundred) to the appropriate districts for administration.[125] Production lagged far behind requirements during 1942, but the sharp cut in the Army Supply Program announced in November 1942 reduced the gap between production and requirements.[126] Meanwhile the quality of American fire control matériel came in for a good deal of criticism from British forces in North Africa, who were equipped in part with American tanks and artillery, criticism that was soon echoed by U.S. troops who landed in North Africa in November 1942.[127]

Of the three main categories of fire control instruments—binoculars and telescopes, range finders and height finders, and directors—the first was the least complicated and least subject to changes in design, but it nevertheless posed difficult procurement problems. Early in 1941, to meet an urgent requirement for 350,000 binoculars, Ordnance took the unusual step of standardizing for military use a commercial design of the Bausch and Lomb Optical Company. This design closely approximated the old World War I binocular, known as type EE, that was still standard. Other commercial models were also standardized and produced in quantity for shipment to allies. But this policy soon proved to be a costly mistake. Designed for normal civilian use, the commercial binoculars failed to stand up under combat service where they were subjected to rough handling, submersion in water, and exposure to extremes of temperature. Using them was, in the words of one field commander, "like looking through two dirty milk bottles." [128] The existence in the supply system of different types of binoculars with noninterchangeable parts also complicated spare parts supply and field maintenance. To remedy the situation a new military model was adopted early in 1943.[129]

With compasses, Ordnance followed the same policy with better luck. In 1941, while development of a more rugged instrument to replace the standard compass used in World War I was under way, Ordnance examined a commercial compass known as the Brunton Pocket Transit. It was adopted late in 1941 and, with minor modifications, remained the standard Army compass throughout the war.

When the Bausch and Lomb binocular was adopted in 1941 it was understood

[125] (1) ODO 231, 27 Jan 42; (2) Hist Arty Div, Ind Serv, OCO, vol. 3, ch. X.

[126] Review of Prod Plans, Arty Div, 16 Dec 42.

[127] PSP 13, ch. V, sec. 13.

[128] Interv with Maj Gen Orlando Ward, summer 1949.

[129] For details on this phase of the problem, see Encyclopedia of Army Ord Binoculars photolithographed at Frankford Arsenal, n.d., no author, copy in OHF.

that the Bausch and Lomb Company could not be counted on for large-scale production of binoculars because its resources were needed for more critical precision optical instruments. Ordnance therefore turned to the Nash-Kelvinator Company and the Mansfield, Ohio, works of the Westinghouse Electric and Manufacturing Company. Neither firm had any experience in making optical instruments, nor any facilities for manufacture of optical elements, but plant surveys had convinced Ordnance that the two concerns could readily adapt their equipment and buildings to binocular production. Optical elements—lenses, prisms, windows, reticles, and other parts made of optical glass—were to be procured from optical glass manufacturers and turned over to Nash-Kelvinator and Westinghouse as government free issue materials. Production was slow to start. "We were told by old line binocular manufacturers," Westinghouse later reported, "that they questioned if we would ever be able to produce satisfactory binoculars, let alone produce them in the quantities called for under our contract." But by the first anniversary of Pearl Harbor the two contractors were producing at the rate of 8,000 binoculars each per month. During 1943, the peak year for production, 245,672 were turned out, including both old and new models.[130]

Manufacture of panoramic telescopes by the camera works of the Mergenthaler-Linotype Company and the Eastman Kodak Company may be taken as a representative sample of this special field of Ordnance procurement. As used for artillery fire control, the panoramic telescope was a periscopic instrument with a head that could be rotated to permit the observer to look in any direction without moving the eye piece. It was also, in the words of the Eastman company, "a precision instrument manufactured to extremely close tolerances." [131] Frankford Arsenal had made small quantities of the panoramic telescope M1 during the 1930's but its maximum capacity was only about 10 per month. To develop an industrial source that might be called upon for quantity production in time of war, Ordnance placed an educational order in May 1940 with the Mergenthaler Company, which had signed an accepted schedule of production for panoramic telescopes in 1939. The company followed arsenal methods to the letter, obtained good results, and was soon asked to take on a quantity production order.[132] Meanwhile an improved model was adopted and a production contract placed with the Eastman Company, which soon became the leading producer.[133]

Production of directors, the heart of most antiaircraft fire control, was far more difficult than production of binoculars, telescopes, or height finders, but Ordnance was fortunate in its selection of contractors and made a good production record. The only director produced in large quantities was the M5, based on the British Kerrison predictor, for the 37-mm. and 40-mm. guns, and the great majority of M5's were made by the Singer Manufac-

[130] (1) *Ibid.;* (2) Whiting, Statistics; (3) Historical Data, Westinghouse Electric and Manufacturing Company, Mansfield, Ohio, in Hist, Cleveland Ord Dist, vol. 100, pt. 4.

[131] Hist, Rochester Ord Dist, vol. 100, pt. 4, Eastman Kodak Co., p. 42, OHF.

[132] (1) Hist, New York Ord Dist, vol. I, pt. 2 (1939–41), pp. 280–81, and vol. 100, pt. 2; (2) The Optical Industry by Capt Samuel M. Grafton, March 1945, in Hist, New York Ord Dist, vol. 100, pt. 1.

[133] Eastman Kodak Co. Rcd of War Prod Activities for the Rochester Ord Dist, 1945, Hist, Rochester Ord Dist, vol. 100, pt. 4.

turing Company of Elizabethport, N.J.[134] As early as December 1940 Singer engineers had come to Frankford Arsenal to see the Kerrison predictor and study the problem of manufacturing it. They found that it was a 500-pound mechanism built with the precision of a wrist watch, carefully assembled to make mathematical calculations that would show how the gun should be aimed to reach its target. Early in 1941, after the director had been standardized, Singer agreed to manufacture it at the rate of 1,700 per year, a rate that company officials then considered "overwhelming." [135] The company obtained drawings from Frankford, planned its work procedures, ordered over 1,300 new machine tools, and erected a new building, completely air-conditioned. As Singer could find no satisfactory source for large quantities of aluminum and bronze castings it decided to convert its foundry from the production of cast iron to aluminum and bronze. The company used its other plants and subsidiaries to make packing chests, motors, small parts, and subassemblies. Delivery of eight directors to the Ordnance inspector in February 1942 marked the end of the period of preparation and the beginning of the period of production. By mid-July 1942 the 1,000th director had been accepted, requirements were doubled and redoubled, and by 1944, when production was curtailed in view of Allied air supremacy, Singer had made some 23,000.

Procurement of optical elements, such as lenses, prisms, windows, reticles, and so forth, was one of the most difficult phases in the production of fire control instruments. The metal parts, known as optical components, posed far less difficult problems. As the United States had always imported optical elements, chiefly from Germany, it had very little capacity for home production. In the New York Ordnance District, for example, it was estimated in 1939 that total annual production of all optical element manufacturers in the district was less than $100,000. "The competition for optics," wrote one procurement officer, "almost resolved itself into a 'free for all' between the Army, Navy and Air Corps, with the British Purchasing Commission interfering with all three." [136]

Because of the shortage of optical elements, and the instrument makers' lack of experience in procuring them, Ordnance decided to procure optical elements from qualified producers and turn them over to instrument manufacturers as government free issue material. One of the most successful procurements under this policy flowed from a contract with the Optical Research Company of Long Island City. This concern produced most of the optical elements for the binoculars made by the Nash-Kelvinator Company and the Westinghouse Electric and Manufacturing Company. As requirements for optical elements mounted after Pearl Harbor and it became necessary to bring many small manufacturers into production, Frankford Arsenal and the New York Ordnance District arranged with the Mergenthaler-Linotype

[134] For description, see Catalog of Standard Ord Items, OHF. For the research and development background, see Green, Thomson, and Roots, *Planning Munitions for War,* pp. 416–21. Some 2,500 of the larger M7 and M9 directors for the 3-inch, 90-mm., and 4.7-inch guns were made by the Ford Motor Company and the Sperry Gyroscope Company.

[135] Fire Control Director, M5, A Report to Army Service Forces, New York Ord Dist, by the Singer Mfg Co., prepared by W. A. Davidson, asst. vice president, 9 Jul 45, copy in Hist, New York Ord Dist, vol. 100, pt. 3, OHF.

[136] Capt Samuel M. Grafton, The Optical Industry, Mar 45, Hist, New York Ord Dist, vol. 100, pt. 1.

Company to attempt an unusual experiment. Mergenthaler set up the U.S. Optical Supply Corporation, with an office in New York City, to provide central control of numerous contracts with small producers. Its officers were also officers of Mergenthaler, the parent company, and received no compensation for their services. Operating on a cost-plus-fixed-fee contract with the government, the company placed subcontracts with many small producers, helped them get into production, provided storage space for optical pressings, and eventually delivered some $4 million of material. It supplied nearly all the optical elements used by the Bulova Watch Company in manufacturing tank telescopes.[137]

The Fire Control Sub-Office encouraged the optical glass industry by arranging for government financing of plant expansion and administering an optical machinery pool which procured some 1,000 machines for use by optical glass producers. It arranged for the Corning Glass Works to build a government-owned, contractor-operated plant at Parkersburg, W.Va., and to operate a glass depot there. In October 1943, when the coating of optics to improve the performance of instruments under poor lighting conditions was made mandatory, the Fire Control Sub-Office supervised the procurement of equipment and provided technical instruction to contractors on this difficult project. Similar action was taken after the introduction in December 1943 of thermosetting cements that increased the resistance of instruments to failure under extreme heat or cold.[138]

Changing Requirements and Types, 1943–45

During 1943, the peak year for artillery production, Ordnance arsenals and contractors produced something over 150,000 weapons, of which roughly half were aircraft guns. The one item that bulked largest in 1943 output, nearly equal to all other artillery weapons combined, was the 20-mm. aircraft gun, which reached a production figure of 70,000 for the year. The next largest item on the list was the 75-mm. tank gun with a total of something over 20,000.

An analysis of the production figures for 1943–44–45 reveals sharp fluctuations in requirements and the emergence of many new types as Allied forces pushed forward against the enemy on many fronts, employing novel tactics and weapons. Aircraft and AA guns, which held the highest priority at the start of the war, were cut back in 1944, and their manufacture virtually came to a standstill early in 1945. Large-scale procurement of plastic 4.5-inch rocket launchers in 3-tube clusters began in February 1944 when contracts were placed with General Electric and Firestone.[139] The 37-mm. AA gun dropped out of the picture in 1944 and output of the 40-mm. declined sharply. Production of the 90-mm. AA gun, after reaching a peak of over 4,000 in 1943, dropped to 300 in 1944, and stopped altogether by 1945. Meanwhile a new and more powerful AA weapon, the 120-mm. "Stratosphere" gun, came into production on a small scale—550 all told. Because it was extremely heavy and complex it saw little service overseas, and with the enemy on the de-

[137] (1) Grafton, *op. cit.*; (2) U.S. Optical Supply Corporation by A. J. Mackay, president of U.S. Optical Supply Corporation, 6 July 1945, copy in Hist, New York Ord Dist, vol. 100, pt. 1.

[138] History of Industrial Service, Artillery Division, vol. I, pt. 3, ch. X.

[139] Design, Development and Production of Launchers, Rocket, 3-Tube 4.5-inch, A.C. [Aircraft], M10, M14, and M15, OHF.

fensive in 1944–45, virtually no demands were heard for additional AA guns.[140] As Allied planes were armed primarily with .50-caliber machine guns—and a few with 75-mm. cannon—output of intermediate aircraft weapons, 20-mm. and 37-mm., came to a standstill in 1944–45. All told, output of aircraft guns dropped from over 78,000 in 1943 to only 1,000 in 1945.

In other categories the story was much the same with steadily declining output of tank guns, self-propelled weapons, and field guns. But within each category new or improved weapons forged ahead of older types. For tank armament the 90-mm. gun and the 105-mm. howitzer came into production in 1943 and rose to more than 2,000 each in 1945, while the 76-mm. tank gun took first place on the list with more than 12,000 produced in 1944–45.[141] The 37-mm. AT gun went out of production in 1943 followed by the 3-inch in 1944. The 4.5-inch gun which had been adopted in May 1942 as corps artillery was dropped in 1945, after 426 had been produced, because field commanders reported it could do nothing the 155-mm. howitzer could not do.[142] Self-propelled weapons did not come into production until 1942 but soon rose to a peak of over 13,000 in 1943. They dropped off to about 3,000 for 1944, and in 1945 new, larger types came on the scene, the 8-inch howitzer and 155-mm. gun, but all in very small numbers. Although the foregoing fluctuations in output were apparent in the individual categories of artillery, production of all types of artillery for the 1940–45 period totaled 519,031. (*Table 10*)

Heavy Artillery

From the very start of World War II most Ordnance officers were advocates of heavy artillery, a term that generally included weapons ranging from the 155-mm. gun (or the medium 155-mm. howitzer) to the 240-mm. howitzer, but their views were not shared by responsible Army planners.[143] The General Staff and field commanders felt that big guns, like heavy tanks, were not sufficiently mobile to counter German fighting tactics and imposed a disproportionate burden on the nation's limited shipping resources. Though a few big guns were listed in the early estimates of Army needs, they carried a low priority and their manufacture proceeded at a snail's pace.[144] Then, during the winter of 1942–43, even these small requirements were sharply cut in successive revisions of the Army Supply Program, partly because of the desire to conserve steel and partly because of the belief that heavy equipment, however valuable in Europe, would be altogether useless in jungle warfare in the Pacific.[145] Late in 1942 Lt. Gen. Lesley J. McNair, Commander of the Army

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[140] (1) Memo, Maj Gen Barnes to Maj Gen Russell L. Maxwell, ACofS G–4, 8 Jan 45, G–4 vol. II; (2) PSP 29.

[141] PSP 105-mm. Howitzer M4, Design, Development and Production.

[142] Memo, CofOrd to Col Scott B. Ritchie, OCO, 13 Feb 45, ExecO file. On development and production of the 4.5, and its obsolescence, see PSP 80.

[143] For a detailed account, see The Design, Development and Production of Heavy Mobile Artillery Weapons and Ammunition, Oct 44, OHF. See also Millett, *Organization of the Army Service Forces*, p. 117, and comments by Gen George C. Marshall in interview with Dr. Sidney T. Mathews and others, 25 July 1949, p. 5, extract in OHF.

[144] For an artilleryman's complaint, see Capt. Trevor N. Dupuy, "For Men Only," in *Field Artillery Journal*, 32 (Sep 42), 708–12.

[145] (1) ASF Ann Rpt FY 1944, p. 96; (2) Memo, USW for McCloy, 23 Dec 42, sub: Superheavy Arty, USW 104 Guns, AT, aircraft, and so on.

TABLE 10—SUMMARY OF ARTILLERY PRODUCTION, 1940–1945

Item	Amount
Total	519,031
Heavy field artillery	7,803
Light field and AT weapons	56,616
Tank guns and howitzers	116,114
SP guns and howitzers	27,082
Aircraft guns	156,587
Antiaircraft guns	49,775
Mortars	105,054

Source: From Whiting, Statistics, Table PR-8.

Ground Forces, unsuccessfully urged production of 16-inch howitzers on railway gun mounts to supply the need for "superheavy" artillery and in April 1943 criticized the Troop Basis for its lack of sufficient heavy artillery units.[146] In the spring of 1943 General Campbell made a strong plea for immediate approval of more heavy artillery, asserting that powerful guns would be needed to blast heavy concrete fortifications on the continent. "The bigger the weapon," he warned, "the longer it takes to get into production." [147] A small increase was authorized on 1 July 1943, but the gain was only temporary. In January 1944, in February, and again in March, General Campbell protested against proposed new cuts, contending that once production was stopped it could not be resumed speedily at a later date if the need for heavy artillery should arise again.[148] But he meanwhile proceeded as directed to terminate contracts, and gave increased attention to manufacture of spare gun tubes and reworking of worn out tubes returned from overseas.[149]

Just as the curtailment orders were being carried out they were suddenly rescinded. Early in April ASF headquarters ordered that production of heavy artillery weapons

[146] Memo, McCloy for USW, 20 Dec 42, USW 104 Guns, AT, aircraft, and so on. See also Greenfield, Wiley, and Palmer, *Organization of Ground Combat Troops*, pp. 178 and 233.

[147] Quoted in The Design, Development and Production of Heavy Mobile Artillery Weapons and Ammunition, p. 17.

[148] (1) Memo, CofOrd for CG ASF, 8 Jan 44, sub: Reduction in Heavy Arty Program, and 1st Indorsement, 12 Feb 44, OO 400.12/11812; (2) Memo, CofOrd for CG ASF, 14 Feb 44, copy in ASF Contl Div, 020 Ord; (3) Memo, CofOrd for CG ASF, 10 Mar 44, sub: Prod Capacity for Heavy Arty Matériel, and 1st Indorsement CG ASF to ACofS G–4, 12 Mar 44, in folder marked 6–Class V Supply in ASF Plng Div, Theater Br, Box 393, NA; (4) Memo, CofOrd for ASW, 26 Mar 44, sub: Status of Heavy Field Arty, OO 475/19588.

[149] Ann Rpt CofOrd FY 1944, p. 6. For the heavy artillery ammunition side of the story, see next chapter.

and ammunition be expedited, describing the project as of "high operational urgency." [150] The experience of the Italian campaign, where German artillery outranged that of the Allies, had proved the need for big guns.[151] In mid-May G–4 issued the specific requirements, all adding up to enough weapons for 66 new battalions of medium and heavy artillery.[152] Capacity that had been laboriously built up over a long period of time and then dismantled had now to be built up again. But to resume production took time, six months or more, depending on the circumstances. One of the chief difficulties was that plant capacity released following the cutbacks had been taken over by the Navy and was no longer available to Ordnance. Further, contractors who had released their subcontractors could not win them back overnight. As a result, some artillery contracts had to be placed with firms that had never before made big guns for the Army.[153] Others had to be placed in labor shortage areas because of the lack elsewhere of forging and machining capacity.[154] Meanwhile, as Allied troops fought their way inland after the 6 June 1944 landings in France, General Eisenhower sent back an urgent request for more powerful antitank ammunition, more tanks with 90-mm. guns, and more 90-mm. self-propelled guns.[155] This request was given special priority and was merged with the intensive drive for heavy artillery production.[156] At the same time the demand for spare gun tubes and recoil mechanisms rose steadily. The tremendously increased rate of fire after the invasion pushed the requirement for spare tubes in 1944 to nearly 4,000 as compared with actual delivery of only 323 in 1943.[157]

Output lagged behind requirements all during the winter of 1944–45. Then, just as it was about to catch up, the defeat of Germany brought an end to the need. Testifying before the Truman Committee in April 1945, Donald Nelson reported that, "the heavy artillery is going along as well as could possibly be expected." Then followed this interesting colloquy that may serve as a conclusion for one chapter:

Mr. Nelson: On artillery, there are tremendously increased requirements.

Senator Ferguson: Due mostly to changes in plan?

Senator Truman: Due mostly to the fact

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[150] Memo, Director ASF Prod Div for Br chiefs, 6 Apr 44, sub: Expediting . . . Heavy Arty. . ., ASF Prod Div 472 Guns. See also Greenfield, Palmer, and Wiley, *Organization of Ground Combat Troops,* p. 235; Memo, ASF Director of Matériel for CG ASF, 1 Apr 44, sub: Heavy FA Program, OHF; and Memo, CG ASF for CofOrd, 2 Apr 44, same sub, OHF.

[151] Ltr, Col John G. Detwiler to Campbell, 4 June 1945, OHF.

[152] (1) Memo, ACofS G–4 for CG ASF, 15 May 44, sub: Proc . . . Arty, OO 400/12103; (2) Memo, CG ASF for CofOrd, 19 May 44, same sub, OO 400/12103. See also Robert R. Palmer, Bell I. Wiley, and William R. Keast, *The Procurement and Training of Ground Combat Troops,* UNITED STATES ARMY IN WORLD WAR II (Washington, 1948), p. 541.

[153] Memo, Col Ward E. Becker, WDGS G–4, for ACofS G–4, 29 May 44, sub: Rpt of Visit to Chicago. . . , G–4 file 472.2 vol. II.

[154] ASF Urgency Cir, 28 Aug 44, sub: Heavy Arty. . . , 300.5 ASF Urgency Cirs, ASF Prod Div, G1987.

[155] (1) Cable, Eisenhower for Marshall, 5 Jul 44, ASF Prod Div 472 Guns; (2) Memo for record by Lt Col John A. Sargent, ASF Prod Serv Br, 8 Jul 44, same file.

[156] (1) WPB Joint Operating Instruction No. 5, 14 Jul 44, copy in ASF Prod Div 473 Gun Carriages; (2) Memo, CG ASF for CofOrd, 10 Jul 44, sub: Prod of Carriage, Motor, 90-mm. Gun, M36. . ., OO 400.12/12944; (3) Ltr, CofOrd to Arty Contractors, 18 Jul 44, OO 472/6157; (4) ASF Urgency Cir, 28 Aug 44, sub: Heavy Arty, ASF Prod Div, 300.5 ASF Urgency Cir, G1987.

[157] Hiland G. Batcheller, Critical Programs, a Report to the WPB, 14 Nov 44, WPB Doc. 315, p. 6, WPB file 210.3, NA.

that they found out aircraft bombing could not take the place of artillery.

Mr. Nelson: That is very true.

Senator Hatch: This is one of the lessons of war.

Senator Ferguson: In other words, the dropping of the bomb didn't have the same effect as the shooting of the shell.

Mr. Nelson: The Ordnance Department knew that from the very start.

Senator Ferguson: And contended for it?

Mr. Nelson: Contended for it; proved it mathematically in every way, shape, and form.

Senator Truman: But you couldn't convince them except by experience.[158]

[158] *Hearings,* Truman Comm., S., 78th Cong., 2d sess., pt. 25, p. 10,884.

CHAPTER VI

Artillery Ammunition: Preparation

The settled doctrine of U.S. Army field commanders in World War II was to pave the way for advancing foot soldiers by massed artillery fire and aerial bombing. Whenever possible, stubbornly held positions were reduced at long range with steel and high explosives, not with frontal attacks by infantry columns. In the first two days of the March 1944 attack on Cassino, for example, U.S. artillery units fired something like eleven thousand tons of shells, accompanied by a hailstorm of bombs dropped by the Air Force. Similarly, landings on islands in the Pacific were regularly preceded by hours of methodical pounding from planes and surface vessels to destroy the enemy's strong points and drive him back from the beaches. During the attack on Iwo Jima close to forty thousand tons of shells and bombs fell on its 8-square-mile area. In the European theater, in the single month of December 1944, the total quantity of 105-mm. howitzer ammunition fired exceeded three million rounds. In his diary kept during the Italian campaign Maj. Gen. John P. Lucas quoted a captured German medical officer as raving against the German command and saying, "You people expend artillery ammunition but mine expend only the bodies of men." [1] U.S. Army tactics helped achieve the all important goal of sure victory at minimum cost in American lives, but they ate up ammunition at a rate never before considered feasible.[2]

Massed fire power on the scale employed during World War II was utterly beyond the capability of the U.S. Army in the summer of 1940, or even as late as the summer of 1941. The stocks of ammunition on hand in 1940 were so meager that, in the words of Secretary of War Stimson, "We didn't have enough powder in the whole United States to last the men we now [1943] have overseas for anything like a day's fighting." [3] Worse still, only a

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[1] Maj Gen John P. Lucas, Diary, vol. II, Italy, 5 Sep 43–1 Jan 44, OCMH.

[2] For ammunition statistics, see Ammunition Supply for the European and Mediterranean Theaters, 15 Aug 45, by ASF Contl Div, OHF. On the effect of artillery fire on U.S. casualties see Rpt, Director of Intelligence, ASF, n.d., sub: Report From AGF Board Report, 26 Nov 43, ASF Plng Div. Theater Br, Gen File 17, Lessons Learned, NA.

[3] *Army Ordnance*, XXIV, No. 137 (March–April, 1943), 275. For smokeless powder, the total capacity of the country in July 1940 was 60,000 pounds per day, and for TNT, 25,000 pounds per day. Report re SR 71 in papers of Brig Gen John W. N. Schulz, Chief of Proc Br, OASW, 1940–41. See also detailed figures in Report on Explosives Capacity vs. Requirements, incl to Memo of Cof-Ord for USW, 2 Feb 43, no file number, carbon in OHF file, pp. 10–11. For earlier history, see Dorothy B. Howard, Disposition of Five DuPont Munitions Plants World War I, 1918–26, Historical Study No. 77, U.S. Dept of Labor, Dec 44, OHF.

handful of small plants were making propellent powder and high explosives, and there were virtually no facilities for the mass loading and assembling of heavy ammunition. American industry was just beginning, through educational orders, to learn techniques for forging and machining shells and producing intricate fuze mechanisms. The only sources for new artillery ammunition were Frankford and Picatinny Arsenals, while a few Ordnance depots were equipped to renovate old ammunition. Private ammunition plants did not exist, and, because of the specialized nature of the process, there were no commercial plants that could be converted to ammunition production.[4]

A Government-Owned Ammunition Industry

To meet this situation the Ordnance Department took steps in the summer of 1940 to create something new in American economic life—a vast interlocking network of ammunition plants owned by the government and operated by private industry. More than 60 of these GOCO (government-owned, contractor-operated) plants were built between June 1940 and December 1942. Representing a capital investment of about $3 billion they produced a wide range of military chemicals, and they loaded millions of shells, bombs, grenades, rockets, and mines. The plants employed nearly a quarter of a million workers and covered a total land area equalling that of New York, Chicago, and Philadelphia combined. Their annual operating expense amounted to about $1 billion.[5]

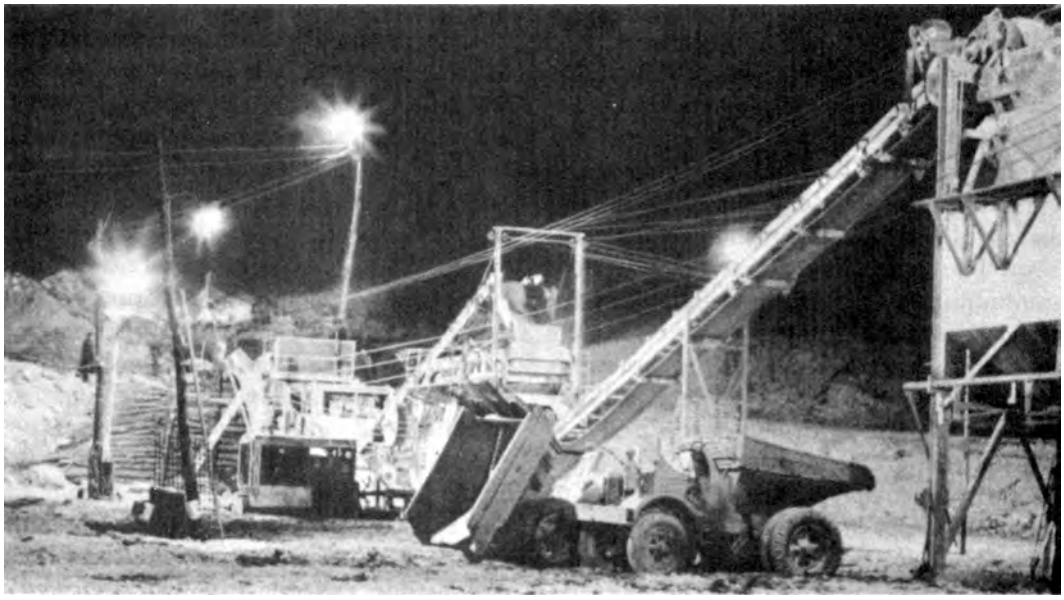
It was this ammunition industry, spread widely throughout the Mississippi Valley, that accounted for the spectacular growth of the U.S. Army's fire power between 1940 and 1943. From some of these quietly efficient plants, operated by competent industrial firms, came smokeless powder and death-dealing high explosives. From countless other privately owned plants—some as far away as New England—came shells, cartridge cases, fuzes, and related metal components. At still other government-owned plants, managed by concerns that in peacetime handled such products as soap, soft drinks, rubber tires, or breakfast food, the ammunition was loaded and assembled into complete rounds for shipment overseas. All along the line, inspectors checked each step in the process to assure high quality production. Total output for the 1940–45 period reached astronomical figures. The 105-mm. shells alone, if placed end to end, would have extended twice around the earth at the equator. The total for all types and sizes amounted to nearly one billion rounds, ranging from 20-mm. to 240-mm., not counting over one hundred million grenades and mines, and over thirty-three million bombs and bomb clusters.[6]

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[4] For a listing of plants in existence in 1939–40 for producing TNT, ammonium picrate, lead azide, mercury fulminate, and smokeless powder, see Ilsley, Facilities Program of the Ammo Div, Oct 44, vol. I, pp. 25–26, OHF, and Rpt of Comm. headed by Col Rutherford to ASW, 24 Jun 40, sub: Proposed WD Program for Increasing Production Capacity. . . , Gen Burns' personal file. Ammunition procurement policy is outlined in PSP 1, Contract Negotiation and Administration, Ord Dept, May 45, ch. 5a.

[5] (1) PSP 73, St. Louis Suboffice, Office of the Field Director of Ammunition Plants, Jul 45, by Ammo Div, Ind Serv, OCO, pp. 3–4, OHF; (2) Maj Edwin J. Grayson, PSP 18, The Establishment of the Artillery Ammunition Loading Program for World War II, Oct 45, OHF; (3) Historical Rpt by FDAP, vol. I, Gen Hist, 1 Aug 42 to 30 Sep 45, p. 4, OHF; (4) Maj Gen Levin H. Campbell, Jr., Address before The Mile High Club, Denver, Colo., 2 Nov 43, OHF.

[6] Whiting, Statistics, Proc sec., pp. 48–52.



NIGHT CONSTRUCTION OPERATIONS *in 1941 at Weldon Spring Ordnance Works, built for manufacture of high explosives.*

In terms of dollar value, artillery ammunition, bombs, and related items constituted the largest single element in the Ordnance procurement program. Ordnance not only filled the ammunition needs of the Army, including the Air Force, but it supplied large quantities of bulk explosives and complete rounds to the Navy and to lend-lease recipients. The value of artillery ammunition produced between Pearl Harbor and V–J Day was nearly $7 billion at 1945 prices, and the value of bombs, mines, grenades, and pyrotechnics brought the total up to about $10 billion, or nearly one-third of all Ordnance procurement during World War II. The value of artillery ammunition procured by Ordnance exceeded the combined total of all procurement by four of the other technical services—Signal Corps, Transportation Corps, Chemical Warfare Service, and the Medical Department. It was over five times the total sales volume of General Motors Corporation in 1940.[7]

The complexity of ammunition procurement increased in geometric proportion to the number of weapons and the types of ammunition employed by each. There were only twenty different sizes of artillery shell used in World War II, but there were more than a dozen types of shell for each caliber. Artillery weapons were supplied not only with high explosive and armor piercing ammunition, but also with smoke, illuminating, and phosphorous shells. Some ammunition was stuffed with propaganda leaflets. All told, Ordnance produced 270 types of artillery shell, and seventy different types and sizes of bombs.

[7] (1) Statistical Review, World War II, a Summary of ASF Activities prepared by the Stat Br, Contl Div, ASF, n.d., p. 2; (2) *Moody's Industrial Manuals,* annuals published by Moody's Investors Service.

The Anatomy of Ammunition Production

To see the process of artillery ammunition production in proper perspective it is necessary to take a round of ammunition apart and inspect its composition. There are five major elements in a complete round of high-explosive ammunition: the cartridge case, the projectile, the propellent powder, the high explosive, and the fuze mechanism. For bombs the principal elements are the bomb body, explosive, fin, and fuze. In addition, there are many other small parts, such as the primer, booster, and adapter, all of which are essential but of lesser importance in terms of production volume. From the procurement point of view, all parts of a bomb or round of artillery ammunition naturally fall into two groups—metal components, and powder and explosives. In general, the metal components were procured from private industry, through the district offices, using existing plant capacity; powder and explosives were produced in the main by the new GOCO plants under the direction of the Ammunition Division of Industrial Service. After the elements of a shell had been produced there still remained the task of loading and assembling them into complete rounds at the loading plants, and inspecting them with care. A complete round of ammunition did not spring full-born from any one plant. It was, rather, the end product of a whole series of interrelated manufacturing operations in a host of different plants. The TNT came from one source, the smokeless powder from another, and the metal components from scores of widely separated factories. With the 105-mm. howitzer high-explosive shell, for example, it has been estimated that the metal parts traveled over 10,000 miles from twelve Ordnance plants and works.[8]

Two additional features of ammunition production merit special note: the precision work required on the metal components, and the hazardous nature of powder-making and ammunition loading. An artillery shell is a delicate and complicated mechanism packed with two death-dealing powder charges—smokeless powder in the case, and TNT or other high explosives in the shell. Both the brass case and the steel projectile must be formed to meet exact specifications. The fuze must be built with the precision of a fine watch and yet be strong enough to withstand violent shocks —and sure to function with split-second accuracy. Its sensitive detonator and booster charge must be assembled by skilled operators. Propellants and highly sensitive percussion primers must pass rigid inspection tests to assure safety for the gun crew and uniformity in the flight of the projectiles round after round. The TNT or other high explosive must be loaded with extreme care, must remain safe to handle and store for long periods of time, and then must explode with terrific shattering effect at precisely the right moment.

This type of work was obviously not for amateurs. Yet in 1940 there were only a half-dozen companies in the United States familiar with explosives manufacture, and their experienced personnel were few in number. These companies had but recently come through the "Merchants of Death" era when everyone connected with the

[8] (1) Lewis and Rosa, Ammo, pp. 56–57; (2) Memo, Col Francis H. Miles. Jr., for Chief Ind Serv, 31 Jan 41, sub: Monthly Progress Rpt of the Ammo Div. . . , filed as ex. 49, PSP 6, 7, 12, Ordnance Requirements and the Control of Production, Aug 45, by Maj Paul D. Olejar; (3) Testimony by Wesson and Col Rutherford, 25 Jul 40, *WDAB*, H.R., 76th Cong., 3d sess., 2d Supplemental Appropriation Bill for 1941, pp. 192–212.

manufacture of munitions had been publicly castigated. Nor did the Ordnance Department itself, with only 375 Regular Army officers in the summer of 1940, have very many officers or civilian engineers with more than elementary knowledge of ammunition production. Notable among these was Maj. John P. Harris, who in 1937 had established the Wilmington, Del., suboffice to draw up plans for ammunition production and take counsel with the explosives firms that had home offices in Wilmington.[9]

The Period of Plant Expansion, 1940–42

Site Selection

The selection of sites for new ammunition plants was complicated by a variety of factors. At the outset, the policy of avoiding coastal areas in favor of the less vulnerable interior regions set certain broad limits, as did the need for avoiding, on grounds of safety, large centers of population. Next came a whole series of interrelated considerations, such as availability of water, manpower, electricity, railroads, and highways. There were strong political pressures always at work, and they sometimes decided the issue in favor of the less desirable sites.[10] Mistakes were sometimes made in selecting sites as, for example, the choice of land in Illinois that had oil pipes under it.[11] Huge tracts of land were needed for both the explosives plants and the loading plants, not because the buildings were large but because safety demanded wide open areas between production lines and between storage areas. The Illinois Ordnance Plant, for example, with eight loading lines, covered an area of twenty-four thousand acres—about one and a half times the size of Manhattan Island. Within the Wolf Creek plant and its adjoining depot there were seventy-five miles of railroad track and 130 miles of highway. Whenever possible, plants were built on land that was not well suited for farming and could be purchased at reasonable cost.[12] Finally, Ordnance was required to spread its new plants widely for reasons of security, with resultant increase in freight hauls between plants. "If we were a private concern," commented General Wesson in the spring of 1941, "we would have concentrated our plants so as to reduce transportation but it has been necessary to yield to the demand to spread them out." [13]

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[9] (1) Ilsley, Facilities Program of the Ammo Div, Oct 44, vol. I, p. 27; (2) Intervs with Brig Gen Merle H. Davis and Col John P. Harris during the summer of 1953; (3) Dir, Lt. Col. Alfred B. Quinton, Jr., High Explosives Manufacturing Plants, 20 Sep 39, copy in OHF.

[10] Interv with Col John P. Harris at Picatinny Arsenal, 19 Jun 53. Colonel Harris' testimony is borne out by History of Ohio River Ordnance Plant and History of Oklahoma Ordnance Plant. See also draft MS., Jesse A. Remington and Lenore Fine, The Corps of Engineers: Construction in the United States, a volume in preparation in the series UNITED STATES ARMY IN WORLD WAR II, ch. VIII.

[11] Min of Second Mtg in Brig Gen Charles T. Harris, Jr.'s office. . . , 12 Feb 41, p. 12. OUSW Prod Div 185.6 Munitions Ord Plant Comm.

[12] (1) Lt. Col. Robert Ginsburgh, "Inland Sites for New Ammo Plants," *American Machinist*, 85 (10 December 1941), 1281–82; (2) *Hearings*, Truman Comm., 17 Nov 41, pt. 9, p. 2906, 77th Cong., 1st sess. For figures on land costs, see Quarterly Inventory of WD Owned, Sponsored and Leased Facilities, 31 Mar 45. For data on site selection and acquisition of land for loading plants, see PSP 18. Verbatim minutes of two conferences in February 1941 on sites may be found in OUSW Prod Div, 185.6 Munitions Ord Plant Comm. See also Maj John F. Joorfetz, Site Rpt, Mar 44, History of Ammunition Division, Ind Serv, OCO.

[13] (1) Min of Conf in Wesson's Office, 1 Apr 41, relative to SR 71, OHF; (2) Testimony by Wesson and Col Rutherford, *WDAB*, H.R., 2d Supplemental Appropriation Bill for 1941, 76th

The decision to avoid areas within two hundred miles of the nation's borders forced Ordnance to modify its mobilization plans for loading plants. In the 1930's the accepted plan for an emergency was to construct two different types known as First Phase and Second Phase plants. The former were to be built at existing Ordnance depots such as Delaware, Nansemond, Raritan, Charleston, Savanna, and others.[14] It was believed that, on the approach of a crisis, shipment of ammunition from these depots to troops in the field would release buildings that could readily be converted into ammunition loading plants in ninety days. These plants would supply the Initial Protective Force during the first stages of the emergency while Second Phase plants—large, newly constructed plants—were being built.[15] This plan had to be abandoned in 1939–40 because most of the depots were along the seacoast and were considered too vulnerable to air or sea attack. Further, some were near large cities such as Baltimore and Charleston. Another factor practically completed the wiping out of all plans for First Phase loading plants. This was the desire to minimize the effect of enemy air attacks by spreading plants out over very large areas, with such great distances between lines that a bomb dropped on one line would not destroy the entire plant. The effect of this decision was to double the distances previously planned between loading lines, and increase the total area and total cost of all plants. It also contributed materially to the remarkable safety record made by Ordnance in World War II.[16]

The location of ammonia plants demands at least brief mention, for it introduced a permanent shift in the geographic center of the ammonia industry. Before the war, when ammonia was made chiefly from coal, the plants were built in coal-producing areas, generally near the coke ovens. Some industrial chemists and Ordnance officers, particularly Maj. John P. Harris, were convinced that in time of war enough ammonia for the mass production of explosives and smokeless powder could never be produced from coal.[17] The pre-1940 Ordnance plans therefore called for the production of ammonia from natural gas and the location of new ammonia plants in the Southwest rather than in the Pennsylvania–West Virginia–Kentucky coal region. "People told me I was crazy

Cong., 3d sess., pp. 192–212. For a readable and informing story of site selection and plant construction, see William P. Vogel, Jr., *Kingsbury: A Venture in Teamwork* (New York: Todd and Brown, 1946).

[14] A list of proposed plants appears in Memo, Col Lucian D. Booth, Ammo Div, 3 Jan 39, sub: General Data Regarding . . . Plans for Ammo in an Emergency, copy in OHF. The background planning is described in PSP 18.

[15] Dir, War Plans for Loading Ammunition, WDPMP 1939 Augmented, 21 Mar 40, by Brig Gen Charles T. Harris, Jr., OHF.

[16] Revised Requirements for Sites for Second-Phase Ammo Loading Plants, 15 Jun 40, copy in OHF. An excellent and authoritative presentation of this whole phase of the history of loading plants is to be found in part II of a report, Powder, Explosives, and Loading Capacity vs. Requirements, inclosure to ltr, CofOrd to USW, 18 Feb 43, sub: Report on Powder, Explosives and Loading Capacity, pt. II, 18 Feb 43, copy in OO 675/889 Misc Incl file. See also PSP 18. In 1939–40, two loading lines were built at Savanna Ordnance Depot in Illinois and proved valuable in correcting faults in design and construction. Two minor caliber lines were also built on land adjacent to the Ogden Ordnance Depot in Utah. See also Gen Rpt on Bag and Shell Loading, 4 Jan 44, in files of War Projects Unit, Bureau of the Budget, ExecO of the President, copy in OHF.

[17] (1) Interv with Col John P. Harris, 19 Jun 53; (2) History, Dixie Ordnance Works, vol I, OHF. The latter reference tells of the early interest of the Commercial Solvents Corporation in this matter.

when I proposed the idea," Harris declared, "but it succeeded and today all the ammonia producers use natural gas." [18] Four ammonia works—Cactus (Tex.), Dixie (La.), Missouri (Mo.) and Ozark (Ark.)—were built to utilize natural gas as their basic raw material. Three other ammonia works—Buckeye (Ohio), Jayhawk (Kans.), and Morgantown (W.Va.)—continued to make ammonia from coal.

The Construction Phase

Construction of new plants was managed by the Quartermaster Corps until 16 December 1941 when this responsibility was transferred to the Corps of Engineers. War Department plans provided that the service responsible for plant construction should select the construction contractor while Ordnance would choose the operating contractor. In most cases the operating firm helped design the plant, and in some instances served also as the construction contractor. To speed work and avoid protracted negotiations that would be required for fixed-price contracts, the Quartermaster Corps and Corps of Engineers used cost-plus-fixed-fee contracts with results that led to sharp criticism by committees of Congress.[19] The criticism may have been unwarranted, as the Quartermaster Corps and Corps of Engineers contended, but its publication left many people with the erroneous impression that the Ordnance Department was at fault.[20]

The expansion program began on a rather modest scale in the summer of 1940 when contracts were left for two smokeless powder plants (Radford and Indiana), one TNT plant (Kankakee), and one shell and bomb loading plant (Ravenna).[21] A few weeks later another loading plant (Elwood) for shells and bombs was added. Twice during the latter part of 1940 the capacity of the Indiana plant was raised, bringing the total up to three times the original plan and boosting the cost to more than one hundred million. In October construction started on the Baytown Ordnance Works in Texas for the production of toluene, basic chemical needed for TNT, using a process recently developed by industry with Ordnance support and encouragement.[22] The British meanwhile (August 1940) contracted with the DuPont Company to build a large smokeless powder plant (later named Chickasaw Ordnance Works) at Millington, Tennessee, and Ordnance in October 1940 signed a contract with the Lansdowne Steel and

[18] Interv with Col John P. Harris, 19 Jun 53. See also Campbell, *The Industry-Ordnance Team*, pp. 259–60.

[19] (1) Interim Gen Rpt, Comm. on Mil Affairs, H.R., 77th Cong., 2d Sess., H.R. Rpt 2272, 23 Jun 42, pp. 5–6; (2) S. Rpt No. 480, pt. 5, 15 Jan 42, pp. 232–74, 77th Cong., 2d sess. For Campbell's personal account of the plant construction phase, see *The Industry-Ordnance Team*, ch. 7. For a frank discussion of the matter within Ordnance, see Min of Conf in Wesson's Office, 1 Apr 41, Relative to SR 71, OHF. The legal background for GOCO plants is sketched by Col. Irving A. Duffy in Memo for CofOrd, 24 Mar 42, sub: Background and Status of New GOCO Facilities. . . , OHF. The official history of each plant gives detailed information on a wide range of topics.

[20] Smith, *Army and Economic Mobilization*, ch. XII. For the viewpoint of the Corps of Engineers historians, see Remington and Fine, Construction in the United States, Chapter VIII.

[21] For Ordnance plans for new facilities as they existed in the spring of 1940, see Memo, CofOrd for ASW, 6 May 40, sub: Additional Facilities. . . , OO 381/35763 ASW. See also Rpt on Explosives Capacity vs. Rqmts, and Memo, ASW for SW, 29 Aug 40, sub: Time Schedule of Munitions Prod. . . , Gen Burns' personal file.

[22] For a detailed account of this project, see Toluene for War, OHF. Baytown was built near the Gulf Coast because it had to be near the Humble Oil Company refinery.

Iron Company to build a plant in Alabama for forging and machining 105-mm. shells. The Gadsden Ordnance plant, as it was known, was the only GOCO plant that produced metal components for ammunition.

During 1941 the expansion program rapidly gained momentum as work on twenty-five new plants began and the capacity of existing plants was greatly increased. Broadly speaking, these plants were intended to raise production capacity to the level required for a 4,000,000-man Army.[23] Thirteen of the new plants were designed for loading operations—eight for bomb and shell loading, four for bag loading, and one for loading fuzes and boosters. Five of the new plants produced ammonia, three TNT, two smokeless powder, one oleum, and one ammonium picrate. In addition, Ordnance took over the British smokeless powder plant at Millington, Tennessee, following enactment of the Lend-Lease Act in March 1941, but output of the plant continued to go to the British. After Pearl Harbor the program was doubled, with construction starting on 25 new plants between January and August 1942. Ten were for loading bombs, shells, fuzes, boosters, detonators, and primers. Six were for TNT, two for a newer and more powerful explosive known as RDX, two for smokeless powder, and the remaining five for ammonia, magnesium, and ammonium picrate.[24]

Erection of the new facilities is sometimes described as coming in a series of waves, each wave forming a balanced array of lines for producing smokeless powder, TNT, and auxiliary chemicals, and for loading and assembling complete rounds. But the actual construction of the plants did not fall into any such neat pattern. The expansion moved forward rather unevenly along a wide front, beginning with Indiana and Radford in the fall of 1940 and ending in the late summer of 1942 with Holston and Sunflower. The goal was always to achieve balanced production as soon as possible, but the task of keeping production in balance was never easy, though it was simplified somewhat by construction of multiple-purpose plants.

In most cases, Ordnance plants turned out more than one product or performed more than one function. The Badger Ordnance Works, for example, was originally intended to provide only three smokeless powder lines, but the contract was revised to add double-base powder and TNT. The Illinois Ordnance Plant went into operation in June 1942 with production of percussion primers, but it was soon producing detonators, assembling fuzes, and loading boosters for 155-mm. shells. The use of such multiple-purpose facilities gave the program a flexibility it would otherwise have lacked. Flexibility was essential, for the situation was never static. As requirements rose or fell, or shifted from one type of ammunition to another, production lines had to be shut down, new lines

[23] The Ordnance plan for 17 of these plants may be found in Memo, CofOrd for ASW, 28 Dec 40, sub: Funds Required for Additional Facilities, OO 381/15444 ASW. See also Memo, Col. Miles, for Chief of Ind Serv, 31 Jan 41, sub: Monthly Progress Rpt of the Ammo Div. The early plants were designed to last for many years, but the later plants were of less durable construction.

[24] The complexity of the Ordnance powder and explosives program is suggested by the fact that 30 chemicals, including raw materials, intermediate materials, and end products were manufactured at Ordnance works. For detailed information, see PSP 15, Chemicals Used in the Powder and Explosives Program in World War II, 1945, OHF. For the new plants proposed by Secretary Patterson on 2 Jan 42, see Incl to Memo of that date for Knudsen, OUSW Madigan file (Ord Gen).

added, or entire plants taken out of production. For example, because of a drop in requirements, the large bag-loading plant at Flora, Mississippi, was not needed in the summer of 1942, when it was nearing completion; it was converted into a Unit Training Center until 1945 when need for it arose in the heavy ammunition program.[25]

For many reasons, precision in planning plant expansion in 1941–42 proved to be impossible. Requirements fluctuated from month to month. No one could predict exactly how long it would take to build a new plant, for it depended on such factors as weather, labor supply, and deliveries of materials and production equipment. Improvements in techniques boosted the rate of production in many plants and completely invalidated the original estimates of plant capacity. Construction of a number of plants and new operating lines authorized after Pearl Harbor were canceled late in 1942 as requirements dropped and existing plants reached unexpectedly high production levels.[26]

New facilities were never created as fast as Ordnance officers thought they should be. Of twenty-three new loading plants built in the 1940–42 period, the average time required for construction was nine months.[27] A constant source of delay was the interval between the time the need for new capacity was foreseen and the time funds became available. After that, approval by higher authorities of both sites and projects was often slow in coming, for it demanded co-ordination with The Quartermaster General, the Judge Advocate General, the Site Board appointed by the Assistant Secretary of War, the National Defense Advisory Commission, the Bureau of the Budget, and the President himself. Aggressive action was necessary to push urgent projects through this labyrinth of offices in anything like reasonable time. The division of authority between Ordnance and the QMC on construction came in for particularly vehement criticism by Ordnance officers.[28]

The Operating Contractors

To meet the 1940 emergency Ordnance adopted the policy of placing contracts for operation of new TNT and smokeless powder plants with established explosives manufacturers, chiefly the DuPont, Atlas, Hercules, and Trojan companies. Their staffs were "stretched to the breaking point" to man the new plants.[29] For auxiliary chemicals such as anhydrous ammonia, toluene, oleum, and ammonium picrate, contracts were made with industrial chemical firms and with oil refining companies. To operate the loading plants it was necessary to bring in companies

[25] For a list of specific cancellations, see Ilsley, Facilities Program of the Ammo Div, Oct 44, vol. I, pp. 158–59.

[26] (1) Rpt on Explosives Capacity vs. Rqmts, pp. 13–44; (2) Memo, Maj Gen Lucius D. Clay, ASF Director of Matériel, for USW, 10 Jul 43, sub: Ord Plant Data for the H.R. Mil Affairs Comm., printed in Second Gen Rpt of H.R. Comm. on Mil Affairs, 78th Cong., 2d sess., H.R. Rpt No. 1903 ex. F.

[27] Table No. 1 in Gen Rpt on Bag and Shell Loading, 4 Jan 44.

[28] (1) For an outline of approval procedures, see Campbell, *op. cit.*, pp. 105–106. See also (2) Memo, CofOrd for ASW, 12 Aug 40, OO 400.-12/234; (3) Rpt on Explosives Capacity vs. Rqmts, *op. cit.*, and (4) Ilsley, Facilities Program of the Ammo Div, Oct 44, vol. I, p. 24. (5) See Remington and Fine, Construction, ch. 8.

[29] Development of Production Capacity in the Ordnance Department, PSP 8 [1945], pp. 2–3. For a good, brief description of the expansion, see Rpt on Explosives Capacity vs. Requirements. These reports have been supplemented by numerous interviews with officers and civilians who were in charge of the expansion program.

with no previous experience in handling explosives or related chemicals. The Quaker Oats Company took over management of a bomb-loading plant in Nebraska; the Sherwin-Williams Paint Company operated a shell and bomb-loading plant in Illinois; and the Procter and Gamble Soap Company operated the Wolf Creek Ordnance Plant in Tennessee for loading shells.[30] Todd and Brown, Inc., which had helped build Rockefeller Center in New York and had directed the colonial restoration of Williamsburg, built and operated the Kingsbury Ordnance Plant. In selecting such contractors the Ordnance Department did not attach any great importance to the nature of their peacetime functions, but gave first consideration to their managerial ability, reputation for efficient operation, integrity, and financial stability. The idea was that such firms knew the fundamentals of mass production and good business management, had competent plant managers on their staff, and could soon learn all they needed to know about the special problems of loading shells and bombs.[31] "One of the lessons Ordnance learned in the Second World War," wrote General Campbell, "was that any up-to-date, alert manufacturing company with a strong executive, engineering, and operating staff could take an ammunition plant and operate it effectively, even though the plant was of a character entirely foreign to the previous activity of the company." [32]

With all of these companies, known as "agent operators," Ordnance signed cost-plus-fixed-fee (CPFF) contracts with rather liberal provisions. Each company was reimbursed at regular intervals for approved expenses in operating the plant, and in addition was paid a fee based on the number or rounds of ammunition or pounds of explosive produced. Under this arrangement the contractors ran no risk of failing to make a profit. To protect the government's interest, teams of auditors at each plant checked the company's accounts and approved or disallowed every item of expense in accordance with policies established in Washington. As the CPFF contract had never before been used by the Army on such a scale, it raised many knotty legal and fiscal problems for both government and contractor. There was some criticism that the fees allowed the contractors were excessive, but the Ordnance contracts for plant operation encountered little of the public criticism directed against the CPFF construction contracts.[33]

Metal Components

While new powder, explosives, and loading plants were being built and put into operation the Ammunition Division also launched a tremendous program for procurement of the metal components of ammunition. The magnitude of this phase of ammunition procurement is indicated by the fact that in the single year 1943 it used four million tons of steel, second only to the tank-automotive program, which ate

[30] For detailed testimony on Wolf Creek, see *Hearings,* Truman Comm., 17 Nov 41, pt. 9, pp. 2905ff, 77th Cong., 1st sess. See also Interim Gen Rpt, Comm. on Mil Affairs, H.R. 77th Cong., 2d sess., H.R. Rpt No. 2272.

[31] (1) Statement prepared by Wesson for the Truman Comm., Jun 41, OHF; (2) PSP 8, pp. 2–3.

[32] Campbell, *op. cit.,* p. 72.

[33] For a comprehensive tabulation of operating costs and fixed fees earned, see Hist, Ammo Div, Ind Serv, OCO, vol. 100, Relationship of Actual Costs and Fees. . . , 31 May 45, OHF. For criticism of fees, see reports of inspections of the plants and of the Office Field Director of Ammunition plants by representatives of The Inspector General's Department.

up seven million tons of steel. Procurement of metal components was not only a big but also a highly complex operation, requiring the co-ordination of literally hundreds of widely scattered producers. For each type of ammunition, cartridge cases might be procured from one source and shell forgings from another, while a third source machined shells, and still other firms produced primers, fuzes, adapters, and boosters. Contracts were negotiated and administered by the arsenals and district offices with delivery direct to loading plants. Generally speaking, the prewar planning by the districts for procurement of metal components was not adequate and was thrown overboard when war came.[34]

Production of all components had to be carefully planned in advance, and then schedules had to be adjusted from month to month to meet changes in over-all requirements. All items had to conform exactly to specifications so the products of many separate plants could be speedily assembled on a mass-production basis. Because of the great variety of shell sizes and types, constant efforts were made to reduce the number of components and to adapt each part to fit different types of shell. This resulted in a great number of interchangeable parts that helped to simplify procurement but required close central control of production scheduling. Although the Ammunition Division procured several hundred different small parts for all kinds of ammunition, the story of procurement of metal components may be told in broad outline under four headings —shot and shell, cartridge cases, bomb bodies, and fuzes.[35]

Shot and Shell

In the literal meaning of the term, an artillery shell is a *shell,* i.e., it is not solid but hollow. This distinguishes it from shot, which is solid (or has only a small cavity) and is most widely used in the smaller sizes for penetrating armor plate. Most World War II shells, and a large proportion of bombs, contained a high explosive such as TNT or RDX and achieved their effect either by blast or by scattering steel fragments. Driven from gun barrels at supersonic speed, shot and shell carried death and destruction directly to the enemy. They formed, in the words of General Harris, "the fist of our fighting forces."

There were two main processes involved in shell production—forging and machining—and at the outset separate contracts were made for each. The importance of these two processes had been recognized by Ordnance procurement officers for many years before World War II and both had been included in the educational orders program of 1939. Forging of the 75-mm. high-explosive shell was one of the six production processes on the first educational orders list, and machining of the same shell was added a short time later. In the late 1930's Frankford Arsenal established a modern shell-machining pilot line capable of making three thousand 75-mm. shells per 8-hour day with only forty-one machine operators. During the emergency period it was available as a model for private industry. But in spite of all these efforts, shell producers ran into a lot of trouble in getting quantity production in 1940 and 1941.[36]

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[34] (1) Interv with Col John P. Harris; (2) Interv with Dr. Ralph Ilsley, 9 Jun 53.

[35] For detailed data on number of items and number of components in the program in 1941, see draft memo from Ammo Div to Dist Contl Div, 18 Sep 41, Sub: Plans for Current Proc, OHF.

[36] This section is based on many interviews with Ordnance officers during the summer of 1953, and

Only one government-owned facility, the Gadsden Ordnance Plant, was built to produce shells. All other production came from privately owned plants. Operations at Gadsden, where both forging and machining of 105-mm. shells took place, were fairly typical of the process of shell manufacture, and may be cited to illustrate the techniques employed. After the plant received a shipment of 1,000-pound steel billets from steel mills, the billets were nicked and broken into slugs on a hydraulic press. These slugs, each about the size and shape of a loaf of bread, were then heated, run through a roller, and placed upright in a die pot. Powerful presses then performed piercing and drawing operations that formed the deep cavity for holding the high explosive. After further shaping and cleaning, the rough forging went to the machine shop where it was finished on a variety of lathes and grinders, and heat treated in hardening furnaces.[37]

Most manufacturers, when shown an artillery shell and asked if they could make it, promptly answered, "Of course." A shell appeared to be a comparatively simple object, but making thousands of them to exact measurement proved far harder than it at first appeared.[38] A shell had to meet exacting specifications, particularly on outside measurements, over-all weight, and uniformity of wall thickness. These specifications were not needlessly precise, as some harried producers were inclined to think, but were the products of long years of experimental production and test firing. Slight variations in wall thickness, for example, appeared trivial to the manufacturer, but Ordnance ammunition men knew that they would throw the shell off balance and shorten its range.[39] Ordnance engineers responsible for the performance of ammunition were reluctant to approve any deviations from tried and proved specifications, for they could not be sure, without prolonged tests, what effect such deviations might have. And if an engineering change were authorized for one contractor it had to be authorized for all, with the corollary need to revise all contracts pertaining to the item.[40] "We are not going to abrogate inspection drawings or specification requirements for quality," General Campbell told the District chiefs in the spring of 1943. "I don't care if he is Judas Priest himself he is not going to get it because we saw some of that in

on the numerous histories in the Ordnance files bearing on procurement of metal components. On the Frankford line, see Charles Grazioso, "How to Machine 75-mm. Shell," in *Artillery and Small Arms Ammunition* (New York: McGraw Hill Publishing Company, 1942) compiled by the editors of *American Machinist,* and Lt. Col. Levin Campbell, Jr., "Artillery Ammunition Production," *Army Ordnance,* XIX, No. 113 (March–April, 1939), 273.

[37] (1) History, Gadsden Ordnance Plant, OHF; (2) A. F. MacConnochie "Forging 105-mm. HE Shell at Gadsden Ordnance Plant," *Steel,* vol. 113, No. 4 (26 Jul 43), pp. 72–76; (3) History of 155-mm. Shell Forging Production, by Tennessee Coal, Iron and Railroad Co., in Hist, Birmingham Dist, vol. 100, pt. 4. For comparison of pierce-and-draw method with upsetter method, see J. B. Nealey, "Notes on Shell Forging," *American Machinist,* 86 (26 November 1943), 1383.

[38] See recognition of this fact in *The Armed Forces of A.C.F.,* p. 40, a booklet put out by American Car and Foundry Co. at the end of the war, in OHF.

[39] As an example, see, Col. Herman U. Wagner, "The Projectile in Flight—Effects of Eccentric Wall Thickness on Shell Behavior," *Ordnance,* XXXVII, No. 194 (September–October 1952), 339–45. For similar comments on this theme, see address, The Time Is Now, by Maj Gen Gladeon M. Barnes, 4 Sep 44, Weirton, W.Va., OHF.

[40] Documentation of a specific case in the explosives field when Ordnance was accused of showing bad management may be found in Hist, FDAP, IV, app. IV–15 to IV–22, and IV–30.

the last war. Once you lose control of drawings, God help the Ordnance Department." [41]

The history of the Pittsburgh District, largest steel-producing area in the nation, reveals some of the difficulties in shell procurement. Small-scale production began early in 1940 when educational orders for forging 75-mm. shells were placed with the Pressed Steel Car Company and the Pittsburgh Forgings Company. A short time later another educational order, for forging the 81-mm. shell, was awarded the Dresser Manufacturing Company of Bradford, producer of oil well equipment. In June 1940 an educational order for the 105-mm. shell was placed with the Pullman-Standard Car Manufacturing Company, and was soon followed by a production contract. At the same time, a $34 million contract was awarded the National Tube Company for forging a wide variety of shell sizes, from 75-mm. through 155-mm. In peacetime the manufacturer of seamless steel tubing and pressure cylinders, National Tube served in war both as a shell forger and as a laboratory for developing new production methods. National Tube and Pullman-Standard also signed contracts during the defense period for shell machining, as did the Armstrong Cork Company. But there were not many contracts of this kind because the Pittsburgh area was not well supplied with firms capable of machining shells to close tolerances.[42]

An analysis of fourteen contracts for forging artillery shells in the Pittsburgh district shows that they averaged a little over four months in coming into production. Even then, contractors encountered repeated difficulties in getting quality production. The rate of rejection by inspectors was so high that Ordnance was forced to widen certain tolerances and relax some of its inspection requirements.[43] This step did not lower the quality of finished shells but simply placed a greater burden on the firms that machined the shells to final dimensions. The record on shell machining is more difficult to measure, for machining could not begin until forgings were available. Pullman-Standard's educational order for machining 105-mm. shells did not get into production until August 1941, almost a year after the award. The delay resulted chiefly from difficulties the company had with its order for forging the same shell. In July 1941, when the company took a production contract for forging and machining the 105-mm. shell, it profited from the earlier experience and completed the job three months ahead of schedule.

Probably the most important improvement in shell-forging technique adopted by American industry during the war was a method for more exact forging of the interior of a shell. Adoption of this improved technique for piercing and drawing enabled the Pullman-Standard Company, which used it effectively, to produce 155-mm. shells from billets weighing only 126 pounds instead of the standard 150 pounds. The new process not only saved steel but, what was even more important, it also cut down on the man-hours and machine time needed to finish the shell.[44]

Beginning in midsummer 1942 with the 155-mm. shell, Ordnance canceled all its

[41] Rpt, Conf Dist Chiefs, Rochester, 19 May 43, p. 18, OHF.

[42] Hist, Pittsburgh Ord Dist, I, pt. 3, ch. 5 and pt. 4, ch. 6.

[43] *Ibid.*, pt. 3, ch. 4. Critical comments on arsenal methods by a San Francisco district engineer appear in History, San Francisco Ordnance District, I, pt. 2, ch. 6.

[44] Hist, Pittsburgh Ord Dist, I, pt. 4, pp. 778–79, and vol. 100, sec. 10.

contracts for shell forgings and inaugurated a new procedure for ammunition procurement. Originally the Department had made separate contracts, usually with different companies, for forging and machining shells, and had assumed responsibility for delivering forgings to the machiners as required. This arrangement enabled the Ammunition Division to keep close control over forging operations during the early phase when the forgers encountered many difficulties in meeting specifications. After these difficulties were surmounted Ordnance told the companies holding contracts for machining that it would no longer supply them with forgings but would expect them to buy directly from the forging companies. One advantage of this move for Ordnance was that it freed the Department of a rather demanding job and thus simplified its procurement process. The new procedure was welcomed by industry because it left more room for the free play of normal business forces. As shell forgings varied slightly in outside dimensions, depending on the technique and skill of the producer, and thus required different amounts of machining, the forgers and machiners could now work out between themselves whatever adjustments were required on each order.[45]

During the early months of 1942 the production of shells used such a high percentage of steel output that measures had to be taken to relieve the situation. Ordnance revised the prevailing specification of steel with a high manganese content to permit use of lower grade steel and more scrap metal. But use of this steel required heat treating by the shell machiners to retain the desired physical properties. Every shell-machining plant had therefore to install hardening furnaces, oil quench systems, and draw furnaces. There were, of course, other factors to be considered in this move. Manganese steel had been specified originally because of its free-machining quality, but in 1941 metallurgists became alarmed at the prospect of polluting the nation's steel scrap pile with sulfur from the manganese steel.[46]

Producers of shot encountered many of the same problems as did the shell manufacturers. When contracts for shot were let in large volume, few producers had sufficient machines to get into production. Lack of centerless grinders, which were not extensively used in peacetime industry, presented the most serious problem and blocked many contractors from starting production. Next in importance was the great need for heat-treating equipment, and, for the smaller shot, automatic screw machines. Stepped up production schedules posed problems with cutting tools as "round-the-clock" operation of machines at higher-than-normal speeds reduced the life of all tools. Use of carbide-tipped tools proved helpful as did liberal use of coolants.[47]

One of the most striking contrasts between procurement plans and actual output in 1941 and 1942 appears in records of 75-mm. and 105-mm. shell production in the Pittsburgh district. Before 1940, when the 75-mm. gun was the main weapon of the Field Artillery, its ammunition topped the requirements list with nearly five million scheduled for the Pittsburgh district in the first year of war. In comparison, only 598,000 shells for the

[45] Hist, Pittsburgh Ord Dist, I, pt. 3, ch. 5, pp. 630–32.

[46] (1) Hist, Chicago Ord Dist, I, pt. 1, pp. 48–49; (2) Interv with Brig Gen Merle H. Davis, 27 May 53.

[47] (1) Hist, Chicago Ord Dist, I, pt. 1, pp. 55–56; (2) Memo, Miles for Chief Ind Serv, 31 Jan 41.



A 500-POUND DEMOLITION BOMB *ready for shipment to a loading plant to be filled with high explosives. (Fins are attached for photographic purposes.)*

105-mm. gun were scheduled. Actual production in 1942 reversed this proportion, with only about one million of the smaller shell and nearly five million of the larger type accepted. In spite of these variations in specific items, total planned production for the first year of war was quite close to total actual production.[48]

Artillery Cartridge Cases

Unlike shot and shell, which were generally made of steel, cartridge cases were normally made of brass. These cases not only contained the propellent charge, usually smokeless powder, but also held the percussion primer and gripped the base of the projectile. They expanded when the gun was fired to form a tight-fitting valve that helped prevent escape of gases to the rear, and then instantly contracted to permit easy extraction from the breech. Like shells, brass cases, which resembled big tin cans, looked easy to make. They were certainly easier to make than fuzes, but their manufacture was not without its problems. It required special machinery and full knowledge of time-tested procedures for which Frankford Arsenal served as the development center. Although many other techniques had been tried over the years, the only successful method was deep drawing the entire case from a single disc.[49]

In the fall of 1940 the Bridgeport Brass Company surveyed existing brass-making capacity in terms of planned production for military use and reported that more plants were urgently needed. Early in 1941 the War Department approved an Ordnance proposal to build a new government-owned brass plant in the Midwest to be operated by the Bridgeport Brass Company of Bridgeport, Connecticut. Designed to turn out twenty million pounds of brass strip per month, and also fabricate light and medium cartridge cases, the new plant was built at Indianapolis and was formally opened on 15 May 1942.

Just as the production of brass cases was moving into high gear in the closing

[48] Hist, Pittsburgh Ord Dist, I, pt. 4, pp. 764–65 and ex. B.

[49] Detailed information on the new machines installed at Frankford, and new processes adopted, in the late 1930's, may be found in History Frankford Arsenal, Artillery Ammunition, volume I, OHF. The technique of cartridge case manufacture as practiced in 1940 is described by F. J. Lerro, foreman of the artillery cartridge case shop at Frankford, in *American Machinist,* 84, (2 October 1940), 761. See also Hist, Chicago Ord Dist, I, pp. 82ff.

months of 1941, a severe shortage of copper and its alloys developed. Sea transport was not available to bring in copper from Chile. The demands of the Maritime Commission and the Navy for copper were huge, and there was no apparent substitute for the copper needed in ocean-going vessels. Ordnance was therefore faced with the problem of substituting some other metal for brass in ammunition if production schedules were to be met. The choice fell upon steel, and the widespread efforts to make acceptable steel cases dominated the scene for the next two years. As the manufacture of steel cases has been described in detail in the preceding volume, we need mention only at this point that the results were never altogether satisfactory. The progress was an industrial miracle, General Hayes once observed, but "not a big enough miracle. It has to be a more resplendent miracle." [50] The ambitious goals set for the steel-case project early in 1942 were not attained, and the project became, in the words of one high-ranking officer, "a pain in the neck." [51] Solution of the steel-case problem had to await a renewed attack, in which Army and Navy co-operated, in the postwar years.[52]



A 22,000-POUND SEMI-ARMOR-PIERCING BOMB *compared with a 2,000-pound one produced by the A. O. Smith Corporation, Milwaukee, Wis.*

Bombs

The sharply rising curve of bomb procurement in 1942 represented the biggest single increase in ammunition production during World War II. After a sudden drop in the summer of 1943 it rose again in 1944 and resulted in the total production of something over thirty-three million bombs and bomb clusters. The bombs ranged in size from 4-pound "Butterflies," usually dropped in clusters, to 4,000-pound block busters.[53] Ordnance procured a few 10,000-pound bombs for test by the AAF, but they were not used in combat. Small quantities of 12,000-pound "Tall Boy" bombs and 22,000-pound "Grand Slam" bombs were produced in the United

[50] Rpt of Conf Ord Dist Chiefs, 28 Jul 43, Springfield, Mass., p. 7, OHF.

[51] Rpt of Conf Ord Dist Chiefs, Rochester, 19 May 43, p. 13.

[52] (1) Green, Thomson, and Roots, *Planning Munitions for War*, ch. 18; (2) William F. Stevens, "Steel Cartridge Cases Advance Toward Standardization," *Steel*, 129, No. 2 (1951), 72; (3) Lt. Col. Harold R. Turner, "Steel Cartridge Cases," Army Ord Rpt No. 5, 1 Jul 44, published by Army Ordnance Association.

[53] (1) Ammunition Supply in European and Mediterranean Theaters, p. 74; (2) Harry S. Beckman, "High Explosive Bombs," *Ordnance*, XXXII, No. 64 (September–October 1947), 98–99; (3) Ann Rpt ASF Rqmts Div FY 44, p. 18.

States for the British, but the bulk of American production was in the smaller sizes with the 500-pound bomb accounting for nearly half of all general-purpose bombs produced in the United States. Through the medium of the bombing plane, this production contributed in a spectacular way to weakening the enemy on the battlefield and on the home front.[54]

Before 1940 there had been very little production of bombs in the United States. Aside from some work on small fragmentation bombs at Frankford, no Ordnance arsenal had produced bombs. The educational orders for bombs in 1939 were too small to be of much value, and it was not until the emergency had arrived that production problems were tackled in earnest. Even then, progress was hindered somewhat by uncertainty as to the most desirable types and sizes. Sharp differences of opinion developed as to the relative merits of high-explosive bombs with great blasting effect and fragmentation bombs that filled the air with flying particles of steel.[55] Policy on this and other matters for all the services was determined by a subcommittee of the Joint Aircraft Committee. Ordnance handled the biggest share of bomb procurement, the Chemical Warfare Service filled chemical bombs, and the Navy procured depth bombs for attacking submarines and armor-piercing bombs for use against ships with thick deck armor.

Specifications for bombs to be dropped from airplanes were less exacting than for shells to be fired from guns, but they nevertheless caused some manufacturing difficulties. The old method of bomb production was to start with a solid steel billet, machine it down the outside, gouge out the inside, and then fill it with TNT or amatol. "They were pretty good bombs," wrote one contemporary observer, "but they cost too much, took too much machine work and time. . . ." [56] The answer was to use short lengths of thick-walled, large-diameter tube or pipe of the type used by the oil industry in peacetime. One end of the pipe was put into a furnace, brought to a white heat, and then forced into proper shape for the tail. The nose was formed in the same fashion, and was then cut and threaded to receive the fuze. After sandblasting to remove all scale, and heat treating to harden the steel, the bombs were ready to be painted and inspected before shipment to loading plants.

Ordnance did not prescribe the method of fabrication to be followed by bomb producers, but permitted each company to work out the method best suited to its equipment and past experience. Shops that had produced steel bottles in peacetime by spinning used the same process to produce bombs; hammer shops used the swaging method; and in factories where wobbling dies had been used to form flanges on pipes the same type of die was used to make bombs.[57] The largest bombs were made of rolled plate because there was no seamless

[54] On bomb research and development, see Green, Thomson, and Roots, *Planning Munitions for War,* Chapter XVII.

[55] For detailed consideration of this topic, see Green, Thomson, and Roots, *Planning Munitions for War,* Chapter XVII.

[56] *Steel,* 24 May 43, p. 76, quoted in Hist, Cleveland Ord Dist, III, p. 112.

[57] (1) Harry S. Beckman, "High Explosive Bombs," *Ordnance,* XXXII, No. 64 (September-October 1947), 98–99; (2) J. B. Nealey, "Seamless Bombs from Steel Plate," *American Machinist* vol. 86 (October 1, 1942), 1117ff; (3) Interv with Beckman and Otto C. Pototschnik, 6 Jul 53. Among the most prominent bomb-producing firms were A. O. Smith Corporation of Milwaukee; Harrisburg Steel Corporation; and National Tube Company and Jones and Laughlin Steel Company, both of Pittsburgh, Pa.

tube made of sufficiently large diameter. Armor-piercing bombs were generally made from billets by the pierce-and-draw method. General-purpose and semi-armor-piercing bombs were made from welded or seamless tubes.[58]

Bomb production suffered from changes in requirements more than did any other aspect of the ammunition program. At the beginning of the war, requirements for demolition bombs were based on airplane production schedules and the estimated number of sorties per airplane. Production facilities were contracted for on this basis. But a year or so of experience demonstrated that these figures were far too high because planes did not fly immediately from factory to combat theater. Some were held in this country for training, and a large proportion of all planes produced was needed to fill the supply pipelines. A drastic cutback in bomb procurement was therefore ordered in April 1943.[59] So great was the reduction of bomb requirements for 1943-44 that General Somervell wrote to General Henry H. Arnold that the effect of this reduction on established production lines would be "tremendous" and would cause cancellation of contracts at sixteen metal-working plants, the complete shutdown of one ammonia plant, and elimination of thirty-five TNT lines.[60] The machines and facilities released in the spring of 1943 could not be held in cold storage for the future because they were badly needed in other programs. In 1944, when bombs requirements mounted and production was resumed, lines had to be set up all over again. According to one estimate, it took seven months to reach 75 percent production on bomb bodies, and at least nine months for full production. "Requirements varied to such an extent," wrote one observer, "that nothing but the patriotism of the manufacturers kept them cooperating." [61]

Fuzes

Of all the metal components of ammunition, fuzes were by far the most difficult to manufacture and use, and were sometimes compared to the Army mule as "ornery but necessary." Not only were they complicated mechanisms but they had to meet the most exacting standards of performance. The mechanical time fuze used on 75-mm. field artillery and 3-inch anti-aircraft shells, for example, consisted of 106 parts, many of which had tolerances of less than one thousandth of an inch.[62] All the time and money spent on manufacturing a round of ammunition and all the effort expended by combat troops in getting it into position for firing were completely wasted if the fuze failed to function properly. For this reason, Ordnance had spent a portion of its limited research funds on fuzes during the interwar years, and on making plans for their manufacture. Plans of this nature were particularly

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[58] Report on the Manufacture of Demolition Bomb Bodies by the American Society of Mechanical Engineers, 1 Jun 45, copy in files of Bomb and Pyrotechnic Sec., R & D Div, OCO. This report describes and illustrates the different production methods used during the war.

[59] Ltr, CG AAF to CofOrd, 4 Apr 43, sub: Reduction in Bomb Rqmts, OO 400.12/5164, copy in Demolition Bombs, 1 Aug 44, vol. I, OHF. For an excellent brief analysis of this problem, see Rpt of WD Proc Review Bd, 31 Aug 43, ASF 334 (WD Proc Review Bd), 020 CofS, USA. See also Maj. Berkeley R. Lewis, Project Paper, PP 19, Bombs—Research, Development, Production and Performance, 1919-45, Jul 45.

[60] Memo, CG ASF for CG AAF, not dated, sub: Reduction in AAF Bomb Rqmts, copy in Demolition Bombs, 1 Aug 44, vol. I, OHF.

[61] Lewis, PP 19.

[62] Hist, Chicago Ord Dist, I, pt. 1, ch. 6.

important because, with more than 150 types of fuzes required, the need to establish a system of common contours and weights was imperative. Minor variations in the contours and weights of point-detonating fuzes would affect the ballistics of the projectile and would require readjustment of the weapon when changing from one type of fuze to another.[63]

Picatinny had been the center of this work for many years before 1940, and in the late 1930's Frankford installed modern machinery for small-scale production of primers and mechanical time fuzes. When war production orders were placed, practically every fuze manufacturer received drawings from Picatinny or Frankford of the required tools, jigs, and fixtures. Fuze contractors sent their production men to Picatinny for training in arsenal methods. Specialists from Picatinny visited most of the commercial plants to assist them in setting up equipment and starting production. There was a remarkably fruitful interchange of information and ideas between industry and Ordnance, resulting in early production by industry and a constant stream of new fuze-making machines and improved production methods. For point-detonating fuzes some of the early contracts went to companies that normally produced electrical equipment, automobile accessories, fountain pens, pressure cookers, gasoline engines, and sewing machines. The earliest contracts for mechanical time fuzes, containing clockwork mechanisms, went to established watch and clock manufacturers. To speed delivery, all these firms set up temporary production lines with secondary equipment that bridged the gap until new machines arrived. Use of such equipment, including single-spindle drill presses and hand milling machines, intensified the problem of meeting the exacting tolerances required by Ordnance.[64]

Because mechanical time fuzes were among the most troublesome items in the ammunition program, their manufacture demanded some means of systematic cooperation among contractors. In the spring of 1942, when huge new requirements for the mechanical time fuze M43 were announced, General Campbell and a successful fuze contractor, Mr. Roy T. Hurley of the Bendix Aviation Corporation, set out to form an industry integration committee for this purpose. At the end of April they called a meeting of representatives from the six companies holding contracts for the M43 fuze, plus Frankford Arsenal, to discuss ways of sharing the experience of the four firms that were already in production with the two that were just getting started.[65] Within four months the newly formed M43 Mechanical Time Fuze Committee not only increased production by about 100 percent but also introduced improved manufacturing techniques that greatly reduced the cost of the fuze.[66]

As noted in Chapter III, Ordnance had formed many engineering and research ad-

[63] (1) Green, Thomson, and Roots, *Planning Munitions for War;* (2) Barnes, *Weapons of World War II* (New York: D. Van Nostrand Company, 1947), pp. 83–84.

[64] Hist, Chicago Ord Dist, I, p. 60ff. For a description of fuze manufacturing methods, see J. B. Nealey, "Artillery Fuzes," *Army Ordnance,* XXII, No. 132 (May–June 1942) 961–64.

[65] Min, Wesson Confs, 27 Apr 42.

[66] Integration with Industry, PP No. 14, OHF. The six companies on this committee were Eastman Kodak, National Cash Register, Elgin Watch, Hamilton Watch, the Eclipse Machine Division of Bendix Aviation Corporation, and the Thomas B. Gibbs Division of Borg Products Corporation. For an account of the Smokeless Powder Integration Committee, see H. LaTourette, Propellants—Smokeless Powder During World War II, Feb 46, pp. 47–50, OHF.

visory committees in 1941 to help with design and production problems, but it was not until formation of the M43 fuze committee (and nearly simultaneous formation of the carbine committee) that cooperation between contractors came to cover nearly every aspect of production. "In the integration of the mechanical time fuze industry," General Campbell wrote to Frankford Arsenal and the six fuze contractors in April 1942, "parts, material, engineering information, production information, tools, equipment, and, in fact, all elements—both material and personnel—will be placed by the chairman of the committee at the disposition of any and all manufacturers in the mechanical time fuze industry without let or hindrance." [67] Described as "the cross-weave in the fabric of America's wartime Ordnance production program," these committees brought together representatives of firms that were business competitors in time of peace and enabled them freely to share their knowledge and skills in the interests of national defense. At committee meetings these representatives exchanged new production ideas and arranged for the transfer from one company to another of scarce materials, badly needed machine tools, or even skilled workmen and production engineers. The companies were assured in 1942, as their predecessors had been in 1941, by a letter from the Attorney General that their committee action would not be regarded as violations of the antitrust laws. Each integration committee was headed by an Ordnance officer, usually the chief of the branch having jurisdiction, with the title of chairman. It also included another Ordnance officer as deputy chairman, an industrial member as assistant chairman, and an Ordnance officer on duty at the plant where the committee had its headquarters. By June 1943 there were 131 such committees in existence, 75 of them dealing with ammunition (both small arms and artillery).[68]

The most remarkable new type of fuze developed during World War II was the VT[69] or proximity fuze containing a miniature radio transmitting and receiving oscillator that caused the shell to detonate when it came within a certain range of its target. Not only was development of VT fuzes one of the top-ranking scientific achievements of the war; its mass production was a triumph of production engineering. "Never, perhaps, in the history of assembly-line methods," wrote the author of *Scientists Against Time,* "have the standards of performance been more difficult to meet." [70] Procurement of VT fuzes

[67] Quoted in Campbell, *Industry-Ordnance Team,* p. 123.

[68] For the official Ordnance statement outlining the functions of the committees, see letter from General Campbell to Donald M. Nelson, 29 Apr 42, in History of Carbine Industry Integration Committee and Prior Carbine Committees, Part III, OHF, and Ordnance Fiscal Circular 105, 22 August 1942. For discussion of problems in administration, see Report, Conference Ordnance District Chiefs, Rochester, 19 May 1943, Pages 6–16. For an excellent brief account of integration in production of the M48 fuze, see Report, Conference Ordnance District Chiefs, 22 April 1944, Pages 12–13, in History, Detroit Ordnance District, Volume 117, OHF. The whole subject of Industry Integration Committees is discussed by Richard F. McMullen in Industry Integration Committees, OHF, and by General Campbell in *The Industry-Ordnance Team,* Chapter 8. The former reference includes a list of committees and their members.

[69] A code designation with no significance.

[70] James P. Baxter, *Scientists Against Time* (Boston; Little, Brown and Company, 1946), p. 227. Baxter also describes the development of the fuze, as does Green, Thomson, and Roots, *Planning Munitions for War,* and Ordnance Development Division, National Bureau of Standards, *The Radio Proximity Fuzes for Bombs, Rockets and Mortars* (Washington, 1945).

was a co-operative enterprise in which Ordnance was but one of many partners.

As the Navy Bureau of Ordnance, with NDRC, had taken an early interest in the use of VT fuzes with antiaircraft guns, while Army Ordnance and the National Bureau of Standards concentrated their first attention on fuzes for bombs, rockets, and mortars, a broad division of responsibility for procurement was made between the two services in March 1942. The Navy was to procure the rotating type, used chiefly with rifled-bore artillery, and the Army was to procure the nonrotating type used on bombs, rockets, and mortar shell. Because the delicate electronic elements of the fuze fell naturally within the Signal Corps field, procurement of those parts was assigned to the Signal Corps which supplied the parts to Ordnance for final assembly. As it eventually turned out, most of the Navy-procured fuzes were used by the Army, and most of the Army-procured fuzes went to the Navy. But the cooperation between the two services proved so effective that the division of labor was continued throughout the war and into the postwar years. The less satisfactory arrangement with the Signal Corps was terminated in 1944 after production got under way and Ordnance assumed full responsibility for parts procurement.[71]

Manufacture of the battery-powered fuzes (both radio and photoelectric) was started in the latter part of 1942 by Westinghouse Electric and Manufacturing Company, Philco Radio and Television Corporation, General Electric Company, Emerson Radio and Phonograph Corporation, Julien P. Friez and Sons, Western Electric Company, and Rudolph Wurlitzer Company. Production of this type totaled 780,000. Approximately a million bomb fuzes of a later generator-powered type were produced by Westinghouse, Emerson, Philco, General Electric, and Zenith Radio Corporation.[72]

By the summer of 1943 sufficient experience had been gained with VT fuzes for large projectiles to suggest that development of much smaller fuzes for trench mortars was possible, and in November 1943 the Office of Scientific Research and Development (OSRD) was requested to undertake the job. By the winter of 1944–45 interest began to grow in the possibility of getting VT mortar fuzes into large-scale production before the war ended. In March 1945, Dr. Vannevar Bush of OSRD wrote that the project could be carried through successfully only if the Army put the full weight of its influence on the scale. Within two weeks a meeting of OSRD and Ordnance representatives was held to discuss the goal of 400,000 fuzes per month by January 1946. By the end of July the design was complete and tooling for large-scale production had started, but the project was canceled when the war ended the following month.[73]

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[71] (1) Interv with Hoyt W. Sisco, Chief VT Fuze Sec, R&D OCO, 14 Jul 53; (2) OCM 31683, 7 Aug 47, citing the early documents; (3) Baxter, *op. cit.*, ch. XV; (4) Joseph C. Boyce, ed., *New Weapons for Air Warfare* (Boston: Little, Brown and Company, 1947), pp. 194 and 207; (5) Telecon with W. S. Hinman, Jr., Asst Director of Ord National Bureau of Standards, 15 Jul 53. For an account of Signal Corps procurement, see History, Signal Corps Research and Development in World War II, vol. 4, Project 453–C, Signal Corps historical files.

[72] Ord Development Div, Nat Bur of Standards, Radio Proximity Fuzes for Bombs, Rockets and Mortars pp. 30–31.

[73] Boyce, *op. cit.*, ch. XXIII.

CHAPTER VII

Artillery Ammunition: Production

By the summer of 1942 the period of plant expansion for artillery ammunition had to come to an end, and the period of intensive production was beginning. In the history of the ammunition program the transition from expansion to production is conveniently marked by the creation on 5 August 1942 of the Office of the Field Director of Ammunition Plants (FDAP) in St. Louis.[1] Headed by Col. Theodore C. Gerber, an Ordnance officer with experience as commander of a government - owned, contractor - operated (GOCO) plant, this office administered all the ammunition plants, most of which were within an overnight train ride from St. Louis. The new headquarters was staffed by transferring from Washington the lawyers, contract negotiators, and administrators who had piloted the plants through the expansion period.

Operations of FDAP

At the outset it was assumed that FDAP would be primarily an administrative and legal office and that most technical problems would be referred to Washington or to Picatinny Arsenal. General Campbell, who had launched the GOCO plants while assistant chief for new facilities, knew that legal and administrative problems were inevitable because of the novelty of the GOCO arrangement whereby private concerns produced war materials on government property, using government-owned machinery, and received payment under a cost-plus-fixed-fee formula. In the beginning FDAP had no authority over inspection, packaging, renovation, or scheduling, but as time went on these responsibilities were delegated to it. By 1945 FDAP had, in the words of the official memorandum, "complete control, administration, coordination, and direction" of the GOCO plants under the Ammunition Division.[2] But it never had as full control of the ammunition program as OCO–Detroit had of tank-automotive procurement. Broad control of scheduling of production remained in Washington, as did authority to approve engineering changes. St. Louis was not granted as much authority as was Detroit, primarily because of the marked procurement differences between ammunition and vehicles. Ordnance did not contract for a complete round of ammunition as it contracted for a complete truck or tank. The division into

[1] FDAP was authorized by ODO Number 305, 16 July 1942. Its creation is described in Green, Thomson, and Roots, *Planning Munitions for War*, Chapter IV.

[2] History, FDAP, Aug 42–Sep 45, vol. I, p. 7. This history contains a copy of Ammunition Branch Memorandum 48–42, 31 July 1942 and Ammunition Division Memorandum no. 2–45, 2 March 1945. See also Mead Comm. *Report*, Aug 46.

three distinct operations—procurement of metal components from industry, production of powder and explosives at GOCO plants, and assembly and loading at GOCO plants—made wholesale decentralization to St. Louis far more difficult than was decentralization of tank-automobile procurement to Detroit.

The administrative problems handled by FDAP covered a wide range. Most of them centered around the interpretation of contracts, auditing expenses, and applying specifications. There were questions, for example, about the propriety of charging to government expense the cost of certain activities such as plant newspapers and charitable contributions that were normal business practice for the contracting firms. There were more important problems in recruiting personnel and obtaining draft deferments for essential workers. Difficulties in production, or in satisfying inspection demands, were also brought to the attention of FDAP, which served as a "home office" for all the plants.[3]

There were many obvious advantages in the GOCO arrangement, but the dual control required by the government-industry partnership in the ammunition plants caused certain difficulties. There was inevitably some duplication of function between contractor and government and many opportunities for friction developed. When emergency production first began, all available talent had to be used in the process of training new personnel. Contractors who knew little or nothing about handling ammunition had to depend upon Ordnance officers and civilian technicians. During the construction period, government representatives at each plant site handled payrolls, timekeeping, and inspection of all incoming material. After the plants reached the operating stage the contracting firms took over most of these duties, with government auditors checking the accounts only on a selective basis. As all the sites on which Ordnance facilities were located were designated as military reservations, a commanding officer was assigned to each with responsibility for the activities of the government auditors and inspectors, and for protecting government property. This system of dual control was not only wasteful of personnel but annoying to both sides and administratively unsound because it tended to divide responsibility for performance. Frequent changes in the Ordnance commanders at the plants caused further difficulty. One plant, for example, had seven different commanding officers during three years, each new commander "coming in to get the plant running right."[4] Most of the contracting firms directed their representatives at the plant sites to work in co-operation with the government representatives and to reach practical solutions on the spot rather than to refer every problem to the home office. With some firms, particularly those with no experience in munitions making, there was criticism that the safety provisions required by Ordnance were too elaborate, that labor-saving machinery was not used enough, and that "many decisions forced upon the contractor by directive were uneconomical and unsound. . . ."[5]

[3] Hist, FDAP, vol. II, pt. 1, Oct 45.

[4] Key Pers Rpts from Lone Star Ord Plant, OHF. Criticism of dual control was made by a representative of the Bureau of the Budget in the General Report on Bag and Shell Loading, 4 January 1944. For an illustration of difficulties during the construction period, see History, Wolf Creek Ordnance Plant, I. This plant was cited by the Truman Committee as an example of unduly high-cost construction. See S. Rpt 480, pt. 5, 15 Jan 42, 77th Cong., 2d sess., pp. 125–66.

[5] See, for example, History, Cornhusker Ordnance Plant, I, pp. 11–12.

On 3 October 1942 the Chief of Ordnance issued a directive to clarify the situation at the GOCO plants. His purpose was to put a stop to duplication of effort between contractors and Ordnance field staffs, to reduce the Ordnance payroll by transferring to the contractor responsibility for property records, production planning, motor pools, and in-process inspection.[6] As a result of this directive, the number of Ordnance officers and civilian employees at the plants dropped sharply. At the Arkansas Ordnance Plant, for example, there were 424 civilians on the government payroll in September 1942 but only 255 at the end of December, and during the same period the number of officers dropped from 15 to 9.[7] Nevertheless, a study of loading plants completed in January 1944 showed that some Ordnance employees were duplicating work done by contractor employees.[8] Between January 1943 and June 1944 the number of civilian employees at all GOCO ammunition facilities was cut in half.[9] The October 1942 directive not only conserved manpower and reduced duplication but it also promoted greater understanding and confidence between the contractor and the government.[10]

Competition among Plants

Perhaps the most noteworthy achievement of FDAP was the use of standard methods to measure the efficiency and economy of plant operations. The need for such methods was obvious. The CPFF contracts under which the plants operated provided an incentive for quantity production but not for efficiency and economy. As the contracting firms received a certain fee per unit of production their prime objective was speed of production, not economy or efficiency. Colonel Gerber and his superiors in Washington decided to attack this problem by recording and analyzing the cost of operation for each plant. They believed that once this was done—and the results distributed—a spirit of competition would develop, with every plant manager eager to make a good showing in the eyes of his home office and in view of the other plant managers. Pride was to take the place of profit as an incentive to efficient low-cost production.[11]

The success of this plan cannot be measured accurately, but there is some indication that it worked well. A record of improved efficiency under the system does not of itself prove the point, for efficiency

[6] Ltr, CofOrd to CO's Ord plants, 3 Oct 42, sub: Clarification of Functions of Ord Dept Field Staff at New Ord Facilities, copy in Hist, Cornhusker Ord Plant, vol. II, app. See also comments on the "substantial progress" made by Ordnance in Memo of Director SOS, Contl Div, for CG SOS, 22 Nov 42, sub: GOCO Ord Plants, in ASF Contl Div file, folder marked Orgn of Ord Dept 1943–44.

[7] History, Arkansas Ordnance Plant, I, pp. 6–7. This history describes in some detail the specific duties performed by government employees at the plant. For an excellent account by an Ordnance plant commander, see Lt. Col. John K. Willard, Key Personnel Report, 31 October 1945, Pennsylvania Ordnance Works, OHF.

[8] Gen Rpt on Bag and Shell Loading, 4 Jan 44.

[9] Performance Analysis . . . FDAP, By Statistics and Progress Unit, FDAP, 1 Jun 45, copy in Hist FDAP.

[10] For testimony on this point from one Ordnance officer with wide experience, see Final Report of Maj Vernon L. Keldsen, 22 October 1945, Key Pers Rpts, Alabama Ord Works, OHF.

[11] Hist, FDAP, vol. II, pt. III, and vol. VIII. Reports on the comparative standing of the loading plants in August 1943 are conveniently assembled in General Report on Bag and Shell Loading. For an account of the work done by the contractors in compiling cost data, see La Tourette, PSP 17, Propellants–Smokeless Powder During World War II, quoting final report of the Smokeless Powder Industry Committee, pp. 46–50.

would probably have risen steadily under any circumstances as both management and worker gained experience and as new machines or techniques were introduced on the production lines.[12] But the record of the GOCO plants was so good that the FDAP administration must be credited with having inspired performance far above normal. The record was one of steadily increasing production, lowering costs, rising labor productivity, and substantial savings in the use of raw materials. The cost of TNT, for example, was cut in half while the rate of production was doubled. The amount of alcohol required per 100 pounds of smokeless powder was cut from 7 gallons to 2 gallons, a saving of over 4,000,000 gallons per month. It cost over 27 dollars and took nearly 10 manhours to load a 1000-pound bomb in January 1943; the same bomb was loaded a year later at a cost of about 16 dollars and in less than 5 manhours.[13]

In the spring of 1944, Representative Albert J. Engel, a member of the War Department Subcommittee of the House Appropriations Committee, personally inspected twenty-two ammunition plants and summarized his findings in a report printed in *The Congressional Record,* 21 June 1944. After citing many specific examples of the remarkable savings achieved by Ordnance and its ammunition contractors, Representative Engel offered the following comments, which still stand as the best brief explanation of the factors behind the FDAP accomplishment:

> Reduction of cost and conservation of manpower has been outstanding. It has been due, in my judgment, in a large measure to: (1) The excellent quality of the responsible and experienced contractors selected. (2) The creation of integrating committees and the meeting of those committees periodically to exchange information between plants. (3) Continuous analysis and comparison of unit costs and cost of operation of respective plants by the Field Director of Ammunition Plants. This policy created a competitive spirit, each plant trying not only to increase efficiency but also to reduce their costs to the level of the plant which had the lowest unit-cost level. (4) The high quality of the technical knowledge available in loading units of the Field Director of Ammunition Plants. (5) The establishment of manpower standards by skilled industrial engineers working through administrative units aided by industrial representatives. (6) Last, and certainly of great importance, was the close and effective cooperation between industry and the War Department in the operation of these plants, making available, without reservation, information of every kind and quality which industry possessed.[14]

Shortcomings

There was also much that was not accomplished by FDAP and industry before the war ended. No fully satisfactory method of comparing the operating efficiency of plants was devised. Cost statements alone were not adequate, for there were many uncontrollable factors in the

[12] By way of comparison, see the discussion of steadily rising efficiency in British plants for shell loading (called "filling" by the British) in Postan, *British War Production,* pp. 174–183. During the 18 months preceding Pearl Harbor the efficiency of "filling labour" increased by 40 percent.

[13] For a broad summary, see Performance Analysis of . . . Ammo Plants, 1 Jun 45, ex. XXII in Hist, FDAP, VIII.

[14] Hon Albert J. Engel, Ordnance Ammunition Production, Army Ord Rpt, No. 6, 21 Aug 44, AOA, Army Ordnance Association, OHF. See also the generally favorable report submitted in January 1944 by a representative of the Bureau of the Budget, General Report on Bag and Shell Loading. Inspecting officers in 1945 praised the FDAP staff for its competence and efficiency. See ltr, Col J. B. Jones and Maj C. F. Heney to Acting TIG, 4 Mar 45, sub: Spec Inspection of OFDAP. . ., NA.

total cost. The labor rate at each plant was geared to the prevailing rates in the locality, and costs of raw materials varied from month to month and plant to plant. In January 1945 a proposed plan for evaluating the performance of TNT works was prepared, assigning a percentage value to each basic cost factor and expressing overall ratings by a single index number. But the proposal did not proceed beyond the discussion stage before the end of the war was in sight.[15]

Few of the plants under FDAP supervision ever had a chance to achieve peak efficiency by operating at capacity over a long period. In most cases, as soon as a plant came into production and completed a few months of shakedown operations, it received notice to curtail production. By the fall of 1943 the tendency throughout the War Department was to feel that adequate supplies were on hand and that Ordnance was producing too much ammunition.[16] In January 1944 Ordnance was forced to practice extremely short-range scheduling of plant operations, few schedules running for more than one month ahead. Changes in types of ammunition also had an effect on plant efficiency, for it required the plants to shut down a line for loading bombs, for example, and convert to a shell-loading line, or switch from small to large calibers. Changes often had to be made suddenly, without advance preparation for management or workers, and the effect on morale was, to say the least, disconcerting. Because of the lack of firm, long-range forecasts of requirements, it was not possible to concentrate production in the most efficient plants and operate them full time. Instead, particularly in late 1943, the production load was spread out among many plants in order to keep them in operation as a reserve against unexpected demands in the future. But during the winter of 1943–44 many plants were closed as the War Department emphasized the curtailment of production.[17]

As noted in the preceding chapter, the Ordnance Department's management of the ammunition program was subject to criticism on one score—the terms of its contracts with the plant operators. No generalization applies with equal force to all the contracts, but it may be said that in many cases the contractors received fees that were generous if not excessive. The contractors were as free of business risk as any businessman could hope to be. They had no capital invested in the plants; they contributed no operating funds; they oftentimes utilized government free-issue materials; they had an assured market for their products; and they were reimbursed for all costs. Officers of The Inspector General's Department who made a special inspection of FDAP in March 1945 expressed the view that the terms of contracts with the operating firms were "extremely liberal." [18] Though in many cases

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[15] See draft letter, entitled Index of Operating Performance—TNT Industry, 3 Jan 45, in Hist, FDAP, IV, app. III–1. For a report on loading plants, see General Report on Bag and Shell Loading.

[16] (1) Report of WD Equipment Review Board, 31 Aug 43, ASF, 334, 020 CofS USA; (2) Gen Rpt on Bag and Shell Loading. The author of this report concluded that "the condition most affecting use of manpower and economy in loading is the reported frequent changes in operating schedules." See Chapter IV.

[17] The resumption of full production in 1944 is discussed below. For data on the closing of plants, see reports in OO 334.

[18] Ltr, Jones and Heney to Acting TIG, 4 Mar 45. Reports by other IG officers who made inspections of the administration of CPFF contracts at artillery ammunition and small arms ammunition plants reached the same conclusion.

the fees originally agreed upon had been substantially reduced during the preceding two years, the inspecting officers felt that further reductions were in order. They pointed out that one company, operator of a loading plant, had contributed very little "know-how"; it had not contributed trained employees from its own staff but had trained all its workers for the plant at government expense. Yet, in spite of its modest contribution the company had received to date over $470,000 in fees. Neither the Chief of Ordnance nor the director of FDAP agreed with these conclusions. They insisted that, all things considered, the fees were not excessive and pointed to the fact that FDAP was constantly reviewing contracts to keep fees down to the proper level.

Cost-plus-fixed-fee supply contracts differed from CPFF construction contracts in one important respect: the fixed fee was not really fixed. It was not a single lump-sum payment for the whole operation but a fee for each unit produced, such as a pound of TNT or round of small arms ammunition. The fees were originally set without full knowledge of production costs or of economies that might be achieved. Volume production usually resulted in high fees. One small arms producer, for example, received a total of $12,801,620.16 in fees during thirty-two months of operations. In 1943, when output was at its peak, the firm averaged over $600,000 per month in fees. Though the fixed fees had been reduced three times, an inspecting officer in October 1944 still considered them to be out of line.[19]

Safety

No account of ammunition production would be complete without a word about safety. The operations at ammunition plants, where huge quantities of TNT, RDX, and smokeless powder were handled by relatively inexperienced workers, were potentially the most hazardous in the world. But Ordnance and its industrial contractors took such effective safety precautions that the ammunition industry proved to be one of the safest in wartime America. These safety measures have a particular relevance to the preceding paragraphs on efficiency and cost of production, for, in the minds of Ordnance officers, safety was more important than either efficiency or economy. Speaking at a meeting of plant managers in the summer of 1944 Colonel Gerber declared: "I cannot overemphasize safety. . . . Safety comes first, quality comes second, and efficiency comes later." At the same meeting Brig. Gen. Roswell E. Hardy, Chief of the Ammunition Division, said: "I don't care how much it costs or how much time it takes, I want safety and quality."[20] This attitude was supported by many coldly practical considerations as well as by the ever present desire to safeguard the lives of employees. Fires and explosions were to be avoided because they destroyed badly needed facilities, stopped production, and cost a great deal of money. Older Ordnance officers remembered the disastrous explosion at the T. A. Gillespie Company plant at Perth Amboy in World War I that took the lives of scores of workmen and destroyed over three hundred buildings. Furthermore, in a tight labor market the danger of explosions was a serious handi-

[19] This subject is discussed in Smith, *Army and Economic Mobilization*, Chapter XII.

[20] Admin Cir 142, FDAP, 10 Aug 44, sub: Notes Taken at the Joint Conf. . . , copy in Hist, FDAP, VIII.

cap to the recruitment of needed workers.[21]

From the very beginning, safety was built into the ammunition plants. The explosion in the late summer of 1940 at the privately owned Hercules Powder Company plant at Kenvil, New Jersey, served as a dramatic and timely warning to the whole industry. It revealed the hitherto unknown fact that small-grain smokeless powder would explode if the depth of the mixture exceeded a certain critical point. The layouts of the Radford and Indiana plants then under construction were immediately revised to incorporate additional safety features. Operations were thereafter more widely separated so that a blast in one unit would not set off another unit. Workers were trained to be safety conscious and were required to observe rigid safety rules. Elemental good housekeeping, including sweeping and scrubbing, was stressed constantly. Ordnance sought the aid of the Surgeon General's Office and the U.S. Public Health Service to protect the health of workers. As a safeguard against the toxic effects of TNT a special soap was developed that turned violet until a worker had washed all traces of TNT from his body. Whenever an explosion occurred, its cause and prevention were studied by a flying team of experts and warnings were immediately sent to all other plants.

During the early months of the war the safety record left much to be desired. Between December 1941 and June 1942 there were three explosions that killed a total of 83 persons and caused property damage of more than one million dollars. Two of these three incidents occurred at the Iowa Ordnance Plant where an explosion in December 1941 caused 13 deaths, and another in March 1942 took 22 lives. The worst disaster in an Ordnance plant during World War II occurred at the Elwood Plant on 5 June 1942 when an explosion occurred in a building where antitank mines were being loaded. Forty-eight persons were killed, and property damage amounted to $489,000. To see these explosions in perspective we need to view them in relation to other wartime disasters. Each of the worst Ordnance explosions was comparable, in terms of lives lost and property damaged, to the crash of a single commercial airliner. When compared to the Navy's Port Chicago explosion in July 1944, when 250 persons were killed, and over 1,000 injured, or to the disasters of World War I, the accidents at Ordnance plants appear small.

To strengthen the Ordnance safety organization, General Campbell established an Explosives Safety Branch (later renamed the Safety and Security Branch) in Chicago in July 1942. The new office was headed at first by Col. Francis H. Miles, Jr., and later by Colonel Gerber who was at the same time head of FDAP.[22] This office reviewed the design of new plants before their construction, prepared safety manuals and bulletins, investigated fires and explosions, and kept the Chief of Ordnance informed on matters of safety. It launched an intensive program for training "safety auditors" who inspected plants, and it outlined plans for training foremen and workers in safety

[21] For an account of disastrous explosions in the United States and elsewhere before 1930, see Ralph Assheton, *History of Explosions on Which the American Table of Distances Was Based, Including Other Explosions of Large Quantities of Explosives,* (Wilmington, Del.: The Press of the Charles L. Story Company, 1930).

[22] History, Safety and Security Branch, OCO, I, pp. 12–15 and appended documents, OHF.



BOX OF BULK TNT *being processed in the melt unit is handled by a workman wearing nonsparking safety shoes made without nails.*

methods. This latter type of training was considered the one most important means of preventing accidents. In its early days the branch received helpful advice and assistance from civilian agencies such as the National Safety Council, Underwriters' Laboratories, Illinois Institute of Technology, and metropolitan fire and police departments.[23]

In the twelve months following establishment of the safety office in Chicago the accident frequency rate at GOCO plants was cut by more than half. It declined further in 1944, and in 1945 the ammunition industry had the best safety record of all manufacturing industries in the United States, surpassing even the traditional leader, the ladies' garment industry. Congressman Engel termed the Ordnance safety achievement "one of the most amazing records made in the history of any industry." [24] The Morgantown Ordnance Works, to cite one outstanding example, operated for nearly four years, accumulating approximately nine million manhours, without a single lost-time injury. A note-

[23] Memo of Col Crosby Field to Miles, 19 Nov 42, sub: Progress Rpt, copy in History Safety and Security Branch, OCO, OHF. For an account of the training and duties of "safety auditors," see the progress report attached to Colonel Field's memo. For a published volume of lectures delivered in the fall of 1943 at the Chicago office of the Safety and Security Branch, see Clark S. Robinson, *Explosions, Their Anatomy and Destructiveness* (New York: McGraw Hill, 1944).

[24] Engel, *op. cit.*



INSPECTOR AT VOLUNTEER ORDNANCE WORKS *taking a sample of TNT for testing at an ordnance laboratory.*

worthy feature of the World War II record is that more than 95 percent of all disabling injuries at ammunition plants were not due to explosives but to run-of-the-mill accidents such as falling off a ladder or being hit by a truck.[25]

Technological Advances

Some of the most remarkable technological advances of World War II occurred in the ammunition industry. The field was wide open for the development of new processes and new machinery, for there had been virtually no mass production of military ammunition in the United States for over two decades. Small-scale production of powder and explosives by Picatinny Arsenal and by several commercial firms had served to keep alive some knowledge of production methods and to make important advances in certain areas. Pilot production lines at Frankford Arsenal served a similar purpose for metal components. But small-scale production does not justify construction of the costly and intricate machines suitable for mass

[25] (1) Hist Rpt, FDAP, I, Gen Hist Aug 42–Sep 45, p. 39; (2) Engel, *op. cit.;* (3) "Shot, Shell and Bombs," *Fortune* (September 1945) pp. 131–36, 260. (4) Rpt on Safety, Incl to Memo, Gerber for Campbell, 7 May 45, in Safety and Security Br files; (5) Stat Review World War II, issued by ASF Contl Div, p. 165. This last reference covers all Ordnance installations and shows that the accident frequency rate in Ordnance was far lower than at all other ASF installations.

production, nor does it always clearly reveal the problems of the high-speed production line. Ordnance officers were well aware of these limitations during the peace years but were unable to do much about them until 1938–40. Long before the beginning of the emergency period Ordnance experts had seen the need for automatic machines to load detonators, for example, but the problems involved in designing them were so baffling, and the prospects of profit so dim, that few machine designers could be persuaded to take any interest in the matter. The whole list of World War II technological advances made under pressure of war would fill a volume; only a few may be mentioned here. Reverse nitration of TNT, toluene from petroleum, mechanization of loading, and the development and use of wood pulp, RDX, and rocket powder—these have been selected because of their intrinsic importance and illustrative value.[26]

Reverse Nitration of TNT

During the 1941–42 period the inadequate supply of TNT for high-explosive bombs and shells was a major problem for Ordnance. Because the shortage had been foreseen, plans were made to use a substitute explosive known as amatol (a mixture of TNT and ammonium nitrate) for shell or bomb loading until new TNT plants came into full production.[27] Quantities of ammonium nitrate were imported from Canada and maximum use was made of commercial ammonium nitrate facilities in the United States to stretch available supplies of TNT as far as possible. Admiral Blandy reported that the TNT shortage was so acute he had to dole TNT out to the Navy "with a teaspoon."[28] But the shortage suddenly disappeared when a new process appeared on the scene almost by accident. For many years before the emergency, the method used by TNT makers, and the only method considered safe, had been to add the nitric acid to the toluene. But in 1941 Lt. Col. John P. Harris visited a small Canadian TNT plant at Beloeil, near Montreal. His visit to this plant had not been planned in advance but was added at the end of his itinerary to fill in the time before his train left. To his surprise, he found the plant was "doing things backward" by putting toluene into the acid instead of putting acid into the toluene, thereby making TNT much faster. When Colonel Harris reported what he had seen at the Canadian plant, American TNT makers were skeptical. They were reluctant to change tried and proven methods, but a successful trial run of the new process at the partly built Keystone Plant at Meadville, Pennsylvania, convinced them. Soon the reverse nitration process was adopted for all TNT production in the United States. The result was a trebling of TNT output. Lines designed

[26] (1) Campbell, "Artillery Ammunition Production," *Army Ordnance,* XIX, No. 113 (March–April 1939), 273; (2) Col William E. Larned, "Mechanized Ammunition Manufacture," *Army Ordnance,* XXIV, No. 138, (May–June 1943) 504–10. For an account of improved techniques in smokeless powder production, see the study by H. LaTourette, Historical Report on Smokeless Powder Program of the Ordnance Department in World War II, PSP 17, OHF. The official histories of Frankford and Picatinny provide further detailed information on prewar conditions.

[27] Amatol was developed in England during World War I because of the shortage of TNT. History, Picatinny Arsenal, Manufacturing Group, vol. I, pt. 1, pp. 68–72.

[28] Quoted in Memo, Brig Gen Campbell for M. J. Madigan, OUSW, 14 Nov 41, OUSW Madigan files (Ord Gen).

to turn out 33,000 pounds a day produced more than 100,000 pounds a day. The need for TNT substitutes vanished and the price dropped from twelve cents a pound to six cents.[29]

Toluene from Petroleum

Development of a new means of producing toluene,[30] the basic raw material from which TNT is made, was another highly significant technological advance of World War II. The importance of this chemical stems from the fact that nearly half of every pound of TNT—trinitrotoluene—must come from toluene. In World War I toluene was derived from coal as a by-product of coke ovens, and some was extracted from illuminating gas. But the supply was so limited that the Assistant Secretary of War, Benedict Crowell, later called it "the greatest and most pressing of all the problems in regard to the existing raw materials." [31] In contrast, during World War II, high-explosives production was never seriously hampered by lack of toluene. Production of toluene by Ordnance-sponsored facilities reached such a high level in 1943 that large quantities were diverted from ammunition to aviation gasoline.[32]

The groundwork for this achievement was laid during the 1930's by Picatinny Arsenal, Maj. John P. Harris, and the Standard Oil Company of New Jersey. As early as 1927 Standard had obtained patent rights from a German firm to use a process for producing toluene from petroleum. Tests were made on small samples at Picatinny during the 1930's, and in 1939 Major Harris began negotiations with Standard to prepare for the day when the striking power of the nation's military forces would depend on abundant supplies of TNT. In June 1940 Ordnance placed a contract with Standard for two tank cars of toluene to be produced in the several refineries owned by the company and its affiliates. The raw material had to travel to three widely separated plants in Texas, Louisiana, and New Jersey before the process was completed and the first tank car of synthetic toluene ever made was delivered to Ordnance. After test at DuPont's TNT plant in Wisconsin, Ordnance signed a contract with the Humble Oil and Refining Company, Standard's affiliate in Texas, for the specific purpose of building a toluene plant, the Baytown Ordnance Works, on a site adjacent to its Baytown refinery in Texas. By October 1942 this plant was producing toluene at the rate of 65 million gallons per year—compared with less than 9 million gallons total toluene production in the United States in 1918.[33]

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[29] (1) Interv with Col John P. Harris, 19 Jan 53; (2) Report on Explosives Capacity vs. Requirements, *op. cit.*, pp. 13–14; (3) "Shot, Shell and Bombs," *Fortune,* (September 1945), p. 260. (4) Campbell, *op. cit.*, p. 271; (5) Barnes, *Weapons of World War II,* p. 76; (6) Engel, *op. cit.;* (7) Hist, FDAP, Aug 42–Sep 45, vol. I, app. 10, p. 25.

[30] The words "toluene" and "toluol" are virtually interchangeable. Toluene is the chemical name for the compound C_7H_8 which, when nitrated, produces TNT. Toluol is commonly used to designate a coal-tar product high in toluene content.

[31] Crowell, *America's Munitions 1917–18,* p. 106.

[32] Capt Vern C. Whitman, Toluene for War, 1940–45, Nov 45, OHF. This history of over two hundred typed pages, plus documents, treats the entire toluene program in considerable detail.

[33] (1) *Ibid;* (2) History of Baytown Ord Works, vol. I, OHF; (3) *18 Dates With Destiny,* a pamphlet published by the Standard Oil Company, New Jersey, copy attached as exhibit to Toluene for War 1940–45.

RDX

The superexplosive known as RDX (Research Department Explosive) or cyclonite, with 30 percent more power than TNT, was not new at the outbreak of World War II.[34] It had been known for many years but had never been produced commercially in this country. It was considered too sensitive for use as a bursting charge and no more effective than tetryl as a booster. Ordnance was reluctant to embark upon large-scale production of RDX, a new and untried endeavor, in view of the existing capacity for production of TNT.[35] But in May 1941, when the British Purchasing Commission requested the United States to produce 6,500 tons and the U.S. Navy expressed a desire for 20 tons per day, Ordnance constructed a completely new RDX plant, the Wabash Ordnance Works, at a cost of $70 million. Starting production in November 1942, Wabash attained a monthly capacity of over five million pounds of RDX which was converted into various compositions.[36]

As demands for RDX skyrocketed after Pearl Harbor, Ordnance built another facility, Holston Ordnance Works, to use a more economical process than the British nitration method used at Wabash. This new process, developed by Canadian and American investigators through the National Defense Research Committee (NDRC), enabled Holston by May 1945 to reach a monthly capacity of 27 million pounds and cut the estimated cost in half. Holston was operated by the Tennessee Eastman Corporation, which had taken a leading part in the development work. The support auxiliary facilities that provided raw material for Holston were the Morgantown Ordnance Works that produced ammonia, methanol, formaldehyde, and hexamine, and the Cherokee Ordnance Works that made formaldehyde and hexamine.[37]

Wood Pulp and Cotton Linters

Before the war the standard practice for making smokeless powder called for the treatment of bleached cotton linters[38] with a mixture of nitric and sulfuric acid.

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[34] The Ordnance historical file contains a detailed and authoritative 3-volume study on the subject by Dr. Robert O. Bengis, Super Explosive Program, RDX and Its Components A, B, and C, Nov 45, PSP 16.

[35] In *Scientists Against Time,* Pages 256–57, Baxter criticized Ordnance for its lack of interest in creating new facilities for RDX production. Ordnance men contended that the civilian scientists in NDRC did not fully realize the problems involved in shifting a big production program from one commodity to another when both time and materials were at a premium. Interv with Bengis, Ammo Div, OCO, 17 Jul 53.

[36] Beside its pure form, RDX was produced in three compositions. Composition "A," a mixture of 90 percent RDX and 10 percent desensitizing agent, was used for press loading. Composition "B," about 60 percent RDX and 40 percent TNT, was used for bombs and other ammunition where cast loading was required. Composition "C," about 88 percent RDX and 12 percent plasticizer, was used to form demolition charges. Lewis and Rosa, Ammo, 1 Jul 40–31 Aug 45, p. 39.

[37] For details on the development of the new process and construction of Holston see Bengis, *op. cit.,* and History, Holston Ordnance Works, Volume I, OHF. The latter volume contains a fascinating narrative by Maj. Karl P. Doerr concerning the removal from the Holston plant site of buried explosive materials left over from World War I. The NDRC contribution is described in Preparation and Testing of Explosives, Summary Technical Report of Division 8, NDRC, in Ordnance R&D Reports Section, dtd 1946. This report also contains an extensive bibliography.

[38] "Cotton linters" are the lint or fuzz remaining on cotton seeds after the cotton has been removed. For a more detailed account of their use, see Cotton Linters and Wood Pulp Uses in Smokeless Powder Program, November 1945, OHF. This study provides a bibliography and an appendix containing significant documents. See also Smokeless Powder During World War II, pp. 9ff, OHF.

In the summer of 1941 it became apparent to Ordnance that, even with a good cotton linters crop and capacity operation of bleacheries, the supply of linters for powder would fall short of requirements. Ordnance therefore turned to the use of a special type of wood pulp that was available in quantity, was suitable for most kinds of powder, and was cheaper than cotton linters. The Hercules Powder Company had made smokeless powder from wood pulp for a number of years, and Ordnance had found the product fully acceptable. Use of wood pulp as a supplement to, but not a replacement for, cotton linters was approved promptly except for rifle powder, Navy rocket powder, and certain other uses. New machinery was installed first at Indiana and Radford, and then at other plants. Soon most plants had one or two lines for nitrating cotton, an equal number for nitrating wood pulp, and several "swing lines" adaptable to the use of either material.

From January 1942 to the end of the war, Ordnance plants used roughly equal quantities of cotton linters and wood pulp. There was never a concurrent shortage of both materials, although there were times when the supply of one ran low or was expected to run low. At such times Ordnance drew upon its inventories while it converted the "swing lines" to meet the situation. The use of wood pulp doubled the existing supply of cellulose for powder and eliminated a serious potential bottleneck in ammunition production.

Rocket Powder

When development of military rockets was undertaken in the United States in 1940–41, one of the most troublesome problems was the manufacture of suitable propellants. Double-base smokeless powder[39] was a satisfactory rocket propellant but its production in the large, long-burning, thick-web sticks or "grains" needed for rockets was a difficult undertaking. The accepted method of producing smokeless powder in this country in 1940 was by the solvent-extrusion process in which the nitrocellulose and nitroglycerine were mixed with a volatile solvent (alcohol or acetone) to form a doughlike substance that could be pressed into grains of the desired shape. The solvent was then removed by evaporation. As solvent powder was used for the 2.36-inch bazooka rocket and for the 4.5-inch rocket, lines for its production were built at the Radford and Sunflower Works. For the small, thin-web powder this production method proved satisfactory, but when it was employed for large, thick-web grains two difficulties arose—the long time required for the sticks to dry out, and the distortions in the sticks that occurred during the drying period. The obvious answer was to turn from solvent powder to solventless or dry-extruded powder, but American producers lacked both the experience and the heavy equipment needed for producing solventless rocket powder. British firms made large thick-web grains of cordite, the standard British smokeless powder, by rolling the powder into a sheet, winding the sheet into a roll, and then placing the roll, still dry, into a press that extruded it at moderate temperature and high pressure.

[39] The term "smokeless powder" is misleading, for it is neither smokeless nor a powder. The individual "grains" in conventional artillery ammunition may be an inch or more in length while the grains or sticks of rocket powder may be several feet long. The large sticks are perforated, and the term "web thickness" refers to the thickness of the wall between perforations.

In 1941 the National Defense Research Committee undertook study of dry-extrusion processes, as did the Hercules Powder Company under contract with Ordnance. By December 1941 the dry-extrusion press set up by NDRC representatives at the California Institute of Technology produced sticks nearly an inch in diameter, and by the early months of 1942 a larger press was extruding sticks up to three inches in diameter. In February 1942, Hercules was authorized to establish a pilot plant with a capacity of twelve hundred pounds per day at the Radford Works. Soon the Soviet Union requested thirty-six thousand long tons of solventless rocket powder to augment its own production, and authority was granted Ordnance to build an addition to the Sunflower Ordnance Works in Kansas to fill the Russian request. By the middle of 1943 the U.S. rocket program had reached the point where large new requirements for solventless powder were placed on Ordnance, and thereafter the requirements steadily increased. In January 1945 the over-all requirements reached a peak of more than eighteen million pounds per month, and plans were made to expand facilities at the Sunflower, Badger, and Indiana Works. Without the dry-extrusion process developed for making solventless rocket powder the extensive employment of rockets by U.S. military forces in 1944–45 would not have been possible.[40]

Mechanization of Loading Operations

In the tedious process of loading and assembling complete rounds of ammunition, industry and Ordnance made countless improvements. The simple hand fixtures and machines in use at Picatinny Arsenal in 1939 gave way to high-speed mechanisms that operated as nearly automatically as possible. One striking example was the detonator-loading machine developed under contract with Picatinny by R. A. Jones and Company, an Ohio manufacturer of automatic machines. As several detonators, each containing a sensitive explosive, were needed in a single fuze, and fuzes were needed by the millions, the demand for speedy production was great. After many failures, R. A. Jones and Company finally developed a detonator-loading machine with which 6 operators could load 8,000 detonators in one 8-hour shift, as compared with 7,500 formerly loaded in the same time by from seventeen to twenty operators.[41]

Ordnance introduced a new method of loading TNT that was considered to be one of the greatest developments in the shell-loading industry, resulting in great savings in time, money, and manpower. In the older process, molten TNT was poured into the shell where it cooled and solidified. Because the TNT contracted as it cooled, and left a hollow in the center, the pouring was done in layers, the hollow in each layer being opened up by hand to permit molten TNT to flow into it when the next layer was poured. Each shell was thus practically tailor-made as each was loaded individually and by hand. In the new

[40] (1) Dr. E. H. Hemingway and E. N. Smith, Historical Rpt on Solventless Rocket Powder Program, Jul 45, OHF; (2) Baxter, *Scientists Against Time*, pp. 202–05; (3) John E. Burchard, *Rockets, Guns, and Targets* (Boston: Little, Brown and Company, 1948); (4) Notes on Rockets and Rocket Powder, a collection of documents in OHF.

[41] (1) Col. William E. Larned, "Mechanized Ammunition Manufacture," *Army Ordnance*, XXIV, No. 138 (May–June 1943), 504–10; (2) Hist, Picatinny Arsenal, Mfg Gp, II, pt. 2. The Picatinny history contains many excellent photographs of machines and processes.



WORKMEN POURING MOLTEN TNT INTO 155-MM. SHELLS *at Charleston Ordnance Depot, October 1941.*

method the shells were loaded in groups by a multiple volumetric loading machine and were then transferred to another machine, a multiple core melter, which forced a heated probe into the center of each shell to melt out all porosity and crystals. As these probes were withdrawn, molten TNT was quickly poured into the cavity. The Chief of Ordnance reported late in 1944 that this new procedure would save nearly five million man-hours during the year ahead.[42]

In making ammunition, minute quantities of sensitive explosives, such as tetryl, must be placed in small cups or cavities in primers, detonators, boosters, and other components. To permit their speedy handling, the explosives are pressed into pellets by using the same type of machinery employed in making pills or candy. In cooperation with Picatinny Arsenal, the F. J. Stokes Machine Company of Pennsylvania developed rotary presses that poured out pellets in any size or shape in a continuous stream. After the pellets were made they had to be placed in small booster cups by hand. Not only was it slow and tedious work, but handling the pellets presented a health hazard. This phase of the problem was finally solved when the Stokes Company produced a rotary pelleting press that automatically inserted pellets into booster cups at a speed of 75 units per minute. When machines of this type were put to use throughout the ammunition industry the dividends in terms of increased output, reduced costs, saving in floor space, and

[42] (1) Rpt of CofOrd for SW on Ord Dept Activities, 1 Nov 44, and 20 Dec 44, Barnes file, OHF.

reduction of personnel requirements were tremendous.[43]

At the bag loading plants, where powder for large-caliber separate loading ammunition was put into cloth bags, there were equally important improvements in machines and equipment. Instead of wrapping the powder charges by hand, as was the standard practice, machines that were almost entirely automatic were introduced, with resultant saving of manpower and increase of production by over 50 percent. Changes in design of propelling charges were introduced to permit application of mass production principles in cutting the cloth and assembling the powder bags.[44]

There was no end to the improvements that could be made in the loading of ammunition, nor was there any lack of engineering skill and imagination among the World War II producers. The ceiling on technological advances was set by the demand for production, the funds available, and requirements of other programs for machines and materials. The end of the war in 1945 momentarily stopped the intense drive for increased mechanization of bomb and shell loading, but the process continued on into the postwar years.[45]

Speeding production and conserving manpower were highly important considerations throughout World War II, but they were not the only considerations in the minds of Ordnance ammunition officers. In commenting on the trend toward more and more mechanization of operations at the loading plants, Brig. Gen. Merle H. Davis, postwar chief of the Ammunition Division, observed that the most important result was not increased output nor reduction in the number of employees, great as those considerations were. "The most important dividend," he wrote, "is a better and more uniform product, with a reduction in the errors that can be made by human beings." [46]

With reduction of errors and elimination of imperfections its constant goals, the Ammunition Division set up elaborate inspection procedures for metal components, powder, and explosives, and stood firm against manufacturers' requests for waivers of inspection standards. Inspection of ammunition was rigid but was not intended to be arbitrary. Throughout the production phase, efforts were made to keep quality high even if it meant holding up production. The Ordnance philosophy was well expressed by General Hardy when he advised the district chiefs that, "We don't save anybody any expense and we cause plenty of trouble when we let anything of an inferior nature get into the hands of troops." [47]

Balancing Production, 1941–43

In theory, the procurement of all chemicals and metal components should have

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[43] (1) Larned, *op. cit.*, (2) Hist, Picatinny Arsenal, Mfg Gp, I, pt. 2.

[44] Report on Powder, Explosives, and Loading Capacity, pt. II, 18 Feb 43, copy in OO 675/889 Misc Incl file.

[45] German munitions-makers also made rapid technological advances and in some cases were more successful than British and American producers. For examples, see PSP 17, Propellants–Smokeless Powder during World War II, pp. 57–72. For a statement of the problems encountered in England in mechanizing these operations, see Postan, *British War Production*, pp. 174–83. The Royal Ordnance Factories were planned very largely as "manufactories" where large numbers of unskilled workers would perform the operations by hand or with small tools. For reasons of safety, individual units were kept small and much dispersed, thus making impractical the use of conveyor belts and heavy machinery.

[46] Brig. Gen. Merle H. Davis, "Explosive Ammunition Production," *Ordnance*, XXXVI, No. 192 (May–June 1952), 934–36.

[47] Rpt of Conf Ord Dist Chiefs, Philadelphia, 8 Oct 43, p. 19, OHF.

been kept in balance so that the number or quantity of each exactly matched the needs of the loading plants. But such theoretical exactness was impossible to attain in practice. As some components were easier for industry to produce than were others, production of the easy-to-manufacture items surged ahead and got out of line. Shells, bomb bodies, and cartridge cases, for example, came into quantity production during 1941 well ahead of powder, explosives, and fuzes. After Pearl Harbor the unbalance grew worse because of the public statements by high-ranking government officials urging every war plant to speed production to the maximum. To arrest the trend toward unbalance, the Industrial Service issued in December 1941 a directive to the districts and other field installations to expedite only those items appearing on a "Short List" to be issued weekly.[48]

The "Short List" helped, but it did not work miracles. It was not possible to achieve exact mathematical balance of all components by curtailing or stopping completely the production of fast items, for that would have resulted in complete loss of facilities through their conversion to other work, loss of labor force, or, in the case of smaller plants, bankruptcy. There were also many other factors that entered the picture—changing requirements, slow deliveries on machine tools, lack of raw materials, technical difficulties in production of certain components, and occasional plant shutdowns due to strikes, fires, or explosions. Use of the "Short List" brought criticism on Ordnance because some of its contractors were working only half their maximum capacity at a time when the whole nation was being mobilized for war. These were contractors producing fast items and they had to be held back until plants making slow items caught up with them. Ordnance reported that about 10 percent of its contractors were responsible for items on the "Short List" and that half of these were still tooling-up and were not yet in production. Other plants had unbalanced production lines because the tools needed for some items had not been delivered; others reported interruptions in their raw materials supply as the source of their troubles.[49]

During the 1941–42 period the Ammunition Division was not at all satisfied with the means at its disposal for balancing production. One of the chief difficulties lay in the lack of flexibility in dealing with industry. The Division could institute procurement only on programs for which funds were available, and these programs often bore no relation to the needs of industry or to production potential. With ammunition, as with other types of matériel, Ordnance could not forecast its requirements long in advance and take the steps necessary to prepare industry for production, to eliminate bottlenecks, or smooth out uneven spots in the schedule. Contractors already engaged in production were sometimes faced with interruption in production, and potential contractors requiring some preparation or additional equipment were often unable to proceed until an order was available under a specific program. Savings on one fund

[48] (1) Memo, Brig Gen Lewis for all districts. . . , 13 Dec 41, sub: Acceleration of Prod. . . ; (2) Memo, Brig Gen Lewis for all districts . . . , 22 Dec 41, sub: Expediting Prod. Both in History, Production Service Branch, OHF.

[49] (1) Memo, Milo J. Marsh for Brig Gen Hermon F. Safford, 21 Nov 42, sub: Balancing of Ord Prod, Ord ExecO file. This memo cites the complaint made by Mr. Donald Nelson to General Somervell on 28 April 1942 and the Ordnance comment of 13 May 1942.

could be applied to another fund only by going through the cumbersome process of getting approval from higher authority. The result was a long lag in getting new production started. Deliveries against new requirements were always behind schedule. In 1941 the chief of the Ammunition Division summarized the situation as follows:

> A proper description of our present situation is that we are trying to run an arsenal the size of the United States without the flexibility of existing government arsenal procedure. We are trying to operate a mass production job involving numerous production changes without any anticipatory action regarding procurement until the funds are available and the requirements are announced in the form of an official program specifying delivery schedules. To put it another way, we are in the position of an automobile company which takes no action as regards the procurement and production of new equipment, raw materials, and parts in planning the coming year's production, when the standard practice in that industry is to start such activity 18 to 24 months before the model is announced.[50]

With adoption of the Army Supply Program early in 1942 an effort was made by ASF to provide long-range procurement forecasts for all types of ordnance. The emphasis shifted from monthly capacity objectives to yearly quantity objectives. At the same time, fiscal regulations were relaxed so that the necessity for earmarking each increase for a specific production order was no longer necessary. In the summer of 1942 the Ammunition Division under General Hardy set machinery in motion to improve procedures for keeping ammunition production in balance. The former practice of forecasting production by adding together all theoretical maximum monthly capacities, and multiplying the total by the number of months in the period, was abandoned. Production forecasts for each component were made in terms of realistic capacity figures, not theoretical maximums, and in terms of orders actually placed. Production of complete rounds was then scheduled in terms of planned delivery of components to the loading plants, with the components in shortest supply setting the pace for all the others.

The new procedure centered around use of "preliminary work plan sheets" issued each month by the Ammunition Division. These planning sheets showed the status of all metal components in terms of realistic production forecasts and were used to determine feasible loading schedules. They placed on one sheet of paper all procurement data concerning a single component by district, by manufacturer, and by quantities expected in the months ahead. Although used at first only for analyzing and planning procurement the sheets were soon given the status of legal documents authorizing the districts to procure.[51] The value of the PWP sheets is attested to by the fact that they were not only used during the rest of the war but were continued into the postwar years. At the same time that the new scheduling procedures were being put into effect in the latter half of 1942, Industry Integration Committees

[50] Memo, Chief of Ammo Div for Chief of Ind Serv, 9 Jul 41, sub: Proc Procedure, quoted in full in draft of Contract Negotiation and Administration, Ord Dept, ASF, pp. 51–54 OHF. Many other memos dealing with the same subject are also quoted in this study.

[51] (1) Statement by Hardy quoted in Contr Negotiation and Admin, pp. 88–95; (2) Lewis and Rosa, Ammo, 1 Jul 40–31 Aug 45, pp. 95–96; (3) Interv with Nathan Nachamkin, Chief, Opns Sec, Ammo Br, OCO, 3 Aug 53. See also folder marked Original Army Supply Program, Feb 24, 1942.

were formed to help balance production by raising the output of plants working on problem items.

Along with the PWP sheets for components the Ammunition Division drew up forecast sheets for end items showing the quantity of complete rounds of ammunition expected to be available each month for distribution to troops. They were based on known production capacity and were kept within the requirements set by the Army Supply Program. They constituted the basic control documents for the FDAP in regulating activities at the loading plants and were used by the military high command to plan the allocation of ammunition to the Ground Forces, Air Forces, Navy, Marines, and lend-lease recipients. Even before the new system was put in operation the emphasis switched from maximum production at any cost to curtailment and leveling off of production in terms of combat experience and existing stock levels. Downward revision of the Army Supply Program was so substantial in the latter half of 1942 that the Chief of Ordnance appointed a special board of officers to review all matters relating to the readjustment of production schedules.[52]

A drastic reduction of bomb requirements was made early in 1943 with consequent reduction in the demand for TNT, ammonium nitrate, metal components, and loading capacity. Some plants that were still under construction were dropped from the program, and in many other plants individual lines not needed to meet the new requirements were eliminated.[53] Several factors other than requirements were taken into account in deciding which plants were to close and which were to stay open. Cost of production, flexibility, labor supply, location with respect to other plants, and the variety of items produced—all these were considered.[54] Cutbacks in certain items made it impossible to keep metal components in balance. Ordnance reported in September 1942 that its powder and explosives production was in balance with the loading schedule but that for some metal components there was no stock on hand and with others there was a 2-year supply in stock. The former were new items that were in great demand but were not yet in full production. The latter were supplies made surplus by sudden and drastic cuts in requirements.[55]

The cutback policy was reinforced in the fall of 1943 when the War Department Procurement Review Board, headed by Maj. Gen. Frank R. McCoy, urged curtailment of production on the ground that excessive stocks of many kinds had been built up both in the ZI and in overseas theaters.[56] Ordnance contended that ammunition stocks were not excessive, and

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[52] This board was composed of Brig. Gen. Hermon F. Safford, Col Herbert R. White, and Col. John C. Raaen. See Ilsley, Facilities Program of the Ammo Div, Oct 44, pt. 2, pp. 175ff.

[53] The details of this program cover many closely typed pages in Ilsley, Ammo Div, Oct 44. A total of twenty-two TNT lines at the Keystone, Pennsylvania, Volunteer, Weldon Springs, and West Virginia works were closed. The New River and Mississippi bag loading plants were shut down as well as the Cactus plant that produced ammonia, the Pilgrim plant for grinding magnesium, and many others.

[54] Memo, Maj Gen Clay for USW, 10 Jul 43, sub: Ord Plant Data for H.R. Mil Affairs Comm., copy in OHF. See statement on cutback policy by General Clay at ASF staff conf, 14 Mar 44, quoted in Ilsley, Facilities Program of the Ammo Div, Oct 44, pt. 2, pp. 256–61, and reports on specific plants described in the first 100 pages of the same reference.

[55] For ASF policies see Memo, Director Matériel Div ASF for CofOrd, 20 Jun 43, sub: Prod Information on Components, copy in folder marked Dirs, Basic Data . . . ASP.

[56] Rpt of WD Proc Review Bd, 31 Aug 43, ASF file 334 WD Proc Rev Bd, 020 CofS USA.

declared that expenditure rates for the North African campaign, a war of movement allowing for little artillery fire, should not be accepted as a guide to expenditure rates during an invasion of western Europe.

In spite of Ordnance objections, the ASF policy announced in January 1944 was directed toward continued retrenchment and avoidance of overproduction in the year ahead. All down the line the technical services were told to procure during the calendar year 1944 only the matériel specifically required by the Army Supply Program. Production of any items in excess of requirements for the purpose of retaining labor or facilities was expressly forbidden.[57] In conformity with this policy, work at some Ordnance facilities was stopped altogether in January 1944. In other cases, facilities not currently needed for Ordnance production were diverted to other programs, notably fertilizers, synthetic rubber, and aviation gasoline.

The Crisis of 1944–45

The year 1944 was a year of trial and tribulation for the Ammunition Division. At the start the emphasis was on slowing down the mounting tide of production as the defeat of Germany appeared more and more imminent, but at the end there was an almost frantic drive for more production at any cost. As late as the last week in March 1944 Ordnance, in line with recent ASF directives, was reviewing the need for existing plants and recommending that three bomb- and shell-loading plants —Illinois, Pantex, and Gulf—be closed within the next sixty to ninety days and put in stand-by condition. Illinois had always been a high-cost plant while Pantex and Gulf were both small plants with only three or four lines. But by the time the Ordnance recommendation reached ASF it encountered a reversal of the cutback policy and was not approved.[58]

Early in 1944 Ordnance officers were convinced that the Army's neglect of heavy artillery and its ammunition was a mistake, but they felt they had nearly exhausted their powers of persuasion in presenting the argument to higher authorities. At the end of February, and again in mid-March, Ordnance called to the attention of ASF the low stocks of 240-mm. ammunition and the high expenditure rates reported from overseas theaters. "This type ammunition is so large," wrote General Hardy, "that facilities for its manufacture are very limited in extent, and the time required to reach production amounts to about eight months." He warned that, if authority were not granted him to expand facilities immediately, it would be impossible to meet increased requirements during 1944 or early 1945.[59] This appeal broke the log jam. Ordnance was authorized on 27 March to expedite production with a view to attaining as soon as possible a monthly production rate of forty thousand rounds of 240-mm.

[57] Memo, CG ASF for CofOrd and others, 29 Jan 44, sub: 1944 ASP—Policies Affecting Prod, ASF Contl Div files, folder marked Supplemental Rpt on Implementation of Dir to Deputy CofS, 1 Jan 44. . . .

[58] Memo, CofOrd for CG ASF, 25 Mar 44, sub: Proposal to Close . . . Loading Plants, and Incls, OO 334/8206 Misc.

[59] Memo, Hardy for CG ASF, 18 Mar 44, sub: Rqmts for 240-mm. Ammo, OO 471/3074. Two memos dated 28 February 1944 are quoted in Dr. Ralph Ilsley, $700,000,000 Facilities Program, Ammunition Division, May 1945, OHF, pages 10–11. See also Brig. Gen. Roswell E. Hardy, "Heavy Artillery Ammunition," *Army Ordnance,* XXVII, No. 147 (November–December 1944), 442.

ammunition. Similar increases in ammunition for the 8-inch gun and howitzer, the 155-mm. gun and howitzer, and the 4.5-inch gun were authorized on 2 April. By far the largest quantity in this directive was for the 155-mm. howitzer—1,303,000 rounds per month.[60]

The next step was taken in mid-May when G–4 and ASF, concluding that the cutback policy had been a mistake, ordered a major increase in production of medium artillery and ammunition, and added to the heavy artillery program. The campaign in Italy, where artillery ammunition and bombs were used in huge quantities against strongly fortified mountain positions, had forced a change in Army plans. The new directives required Ordnance to double its monthly rate of heavy artillery ammunition production in seven months and triple it in thirteen months. In June and July substantial increases in bomb requirements were added. Here, at last, was the procurement authority Ordnance had repeatedly requested earlier, but it came so late in the war that it had to be handled on a "blitz" basis.[61]

Creation of additional production capacity for heavy artillery ammunition was a big job comparable to the expansion undertaken by Ordnance after Pearl Harbor. Some of the government-owned plants, such as Gopher, Keystone, and Weldon Springs, that had been shut down a few weeks or months before, had to be speedily reopened and re-equipped, and new contracts for metal components had to be placed with industry under very unfavorable conditions. Enormous forging presses had to be built and countless gages, jigs, fixtures, and machine tools assembled; production of explosives and smokeless powder had to be increased; new lines had to be set up at the loading plants; and increased capacity had to be found for forging and machining shells, machining cartridge cases, and producing fuzes. General Campbell reported that the facilities for production of shells for the 240-mm. howitzer and the 8-inch gun and 8-inch howitzer called for one thousand heavy-duty lathes, nineteen 1,000-ton piercing presses, seventeen 300-ton draw presses, twelve 600-ton billet-breaking presses, and twenty-seven 500-ton nosing presses. All this equipment required motors, hydraulic pumps, and other accessories. The expansion program for heavy artillery ammunition as of April and May 1944 required the building of new facilities costing $203 million, divided in roughly equal parts between production of metal components and the manufacture and loading of explosives and propellants. A heartbreaking feature of the situation for Ordnance was that production capacity for part of this load had been laboriously built up in

[60] (1) 1st Indorsement to above Memo, ASF to CofOrd, 27 Mar 44; (2) Memo, CG, ASF for CofOrd, 2 Apr 44, sub: Heavy FA Program, OO 381/12117 Misc, copy in Ilsley, $700,000,000 Facilities Program. For background of these decisions, see Memo, ASF Director of Matériel for CG ASF, 1 Apr 44, sub: Heavy FA Program, OHF. The Troyer Anderson file at OCMH also includes notes on this subject in Folder 15, Heavy Ammo Crisis.

[61] Memo, CG ASF for CofOrd, 19 May 44, sub: Heavy and Medium Arty and Ammo Program, OO 400/12103. For a detailed account of this process, with supporting documents, see Ilsley, The Facilities Program of the Ammunition Division, a 3-volume study, and Ilsley, $700,000,000 Facilities Program of April 1944. For a brief summary, see Ammunition Division Annual Report, 30 Jun 45, OHF. See also Hardy, "Heavy Artillery Ammunition," *Army Ordnance*, XXVII, No. 147 (November–December 1944), 442–43, and The Production Story–Heavy Artillery Ammunition by ASF Prod Div, 20 Dec 49, copy in OHF.

1941–1942, only to be lost during the 1943 cutback era.[62]

Every facility of the Ordnance Department was placed at the disposal of the heavy ammunition contractors to expedite delivery of equipment and help with technical problems of manufacture. Industry integration committees disseminated information among contractors and provided a common pool of knowledge and experience. Col. Simpson R. Stribling was sent on a mission to England, France, and Italy to survey production facilities in those countries and to arrange for shipment of available machine tools to the United States. In August 1944 Ordnance reported to the Secretary of War that manpower was "the greatest single problem facing the expanding heavy artillery ammunition program." [63] Labor recruiting caravans toured the country to help overcome the shortage, and women were employed for many positions formerly held by men.[64] When requirements were further increased at the end of the year provision was made for furloughing enlisted men having skills as machinists, toolmakers, or machine operators to work in ammunition plants. The furlough program reached its peak in March 1945 when 3,066 enlisted men were at work in plants and several thousand requisitions for additional men were on file with ASF.[65]

On 1 December 1944 Ordnance was directed to step up its production of light and medium artillery ammunition. The monthly rate of production for ammunition for the 155-mm. gun was to be increased by 50 percent, from four hundred thousand per month to six hundred thousand; similar increases for the 57-mm. and 90-mm. guns, 105-mm. howitzer, and the 60-mm. and 81-mm. mortars were included.[66] Knowing in advance that these increases were coming, the Ammunition Division worked night and day to prepare its plans. General Campbell then called a conference attended by Robert P. Patterson, Bernard Baruch, General Clay of ASF, and representatives of the War Production Board, War Manpower Commission, and other government agencies, at which the chief of the Ammunition Division outlined a program of expansion that called for expenditure of about $300 million for producing mortar and medium artillery ammunition, in addition to the $329 million earlier allotted for heavy ammunition expansion. He provided the conferees with a complete set of planning sheets showing all the facilities selected for increased capacity and detailed information about each plant's management, previous work on ammunition, available machine tools,

[62] A detailed description of this process is given by General Campbell in a memorandum for General Somervell, 29 Sep 44, sub: Heavy Arty Ammo, OO 471/3834. See also Ann Rpt of Ammo Div, 30 Jun 45, OHF, and folder marked Heavy Arty and Ammo Ord ExecO file; and brief summary in Hiland G. Batcheller, Critical Programs, a Report to the WPB, 14 Nov 44, WPB Doc. 315, p. 6, WPB file 210.3, NA.

[63] Rpt for SW on Ord Dept Activities, 16 Aug 44, Barnes file.

[64] In smokeless powder plants the percentage of women increased from 18.43 percent in October 1943 to 34.71 percent in May 1945, and in some plants more than half the employees were women. PSP 17, Propellants–Smokeless Powder during World War II, p. 49, OHF.

[65] This subject is treated in detail in PSP 59, Manpower and Its Utilization, Contractor and Ordnance Personnel, June 1945, Volume I, OHF. The second volume contains copies of pertinent documents. See also Byron Fairchild and Jonathan Grossman, *The Army and Industrial Manpower*, UNITED STATES ARMY IN WORLD WAR II (Washington, 1959).

[66] (1) Memo, CG ASF for CofOrd, 1 Dec 44, sub: Rates of Prod Required for Ammo for 90-mm. and 155-mm. guns, OO 400.12/13638; (2) Memo, CG ASF for CofOrd, 1 Dec 44, sub: Rates of Prod Required for Ammo, OO 400.12/13639.

floor space, and requirements for manpower, fuel, and electricity. In the course of one day it was possible for Ordnance to obtain co-ordinated approval for the greater part of its planned expansion, and by the end of the month contracts for the entire program had been placed.[67] In January 1945 came new directives for increased production of ammunition for the 75-mm. howitzer, the 75-mm. field gun, and the 37-mm. antitank gun, followed by a demand for 355,300 rounds of armor-piercing ammunition with tungsten carbide cores for guns ranging from the 75-mm. to the 155-mm. When these comparatively small January 1945 additions were made, the total program called for the expenditure of $682 million on facilities alone, divided on roughly even proportions between metal components on the one hand and powder, explosives and loading, on the other.[68]

Production of 105-mm. high explosive (HE) howitzer ammunition in December 1944 reached a record high of 3,600,000 rounds and put this item at the top of the Ordnance list in terms of dollar value of procurement, just ahead of the medium tank. By the end of January 1945 Ordnance reported that it had procured a little over fifty million rounds of this type since 1940. Deliveries on some other rounds, mostly the heavy types, did not come up to expectations in December 1944. One of the chief causes of failure to meet production forecasts was the high rate of absenteeism at loading plants because of unusually heavy snowstorms during the month. Labor and machine-tool shortages retarded production of smoke shells for the 155-mm. gun early in 1945, but by April rates of production for nearly all types were so high that cutbacks were being talked about.[69]

During the first four months of 1945 expenditures for heavy artillery ammunition reached record levels—more than four times those of the first four months of 1944—and then declined sharply after Germany's surrender in May. (*Table 11*) At the end of June the chief of the Ammunition Division reported that his office had supervised the procurement of more than $5 billion worth of ammunition weighing over seven million tons during the fiscal year 1945. Procurement was roughly 50 percent greater, in both dollar value and weight, than in fiscal year 1944. Over two hundred new items, representing more than one-third of the average number of ammunition items under procurement, were brought into production. The new items included various calibers of recoilless ammunition, and the "Tall Boy" and "Grand Slam" bombs for the British. A new rocket propellant went into production at Longhorn, a new RDX composition at Wabash, and a new explosive, tritonal, was used to load British bombs. TNT production increased so much that a shortage of nitric acid developed, necessitating expansion of acid-making capacity.[70]

These events naturally raise the question, "Were the frantic efforts to boost production necessary?" The answer seems to be "yes" if we base our analysis on the situation as it existed in the winter of 1944–45.

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[67] Ann Rpt of Ammo Div, 30 Jun 45, p. 7.

[68] (1) Ilsley, $700,000,000 Facilities Program, pp. 27–29; (2) Memo, CG ASF for CofOrd, 27 Jan 45, sub: Rates of Prod. . ., OO 400.12/13827.

[69] Ammo Supply for European and Mediterranean Theaters, 15 Aug 45, pp. 25ff.

[70] Ann Rpt, Ammo Div, OCO, Ind Serv, FY 1945, OHF.

TABLE 11—EXPENDITURES FOR HEAVY FIELD ARTILLERY AMMUNITION, JANUARY 1944–AUGUST 1945

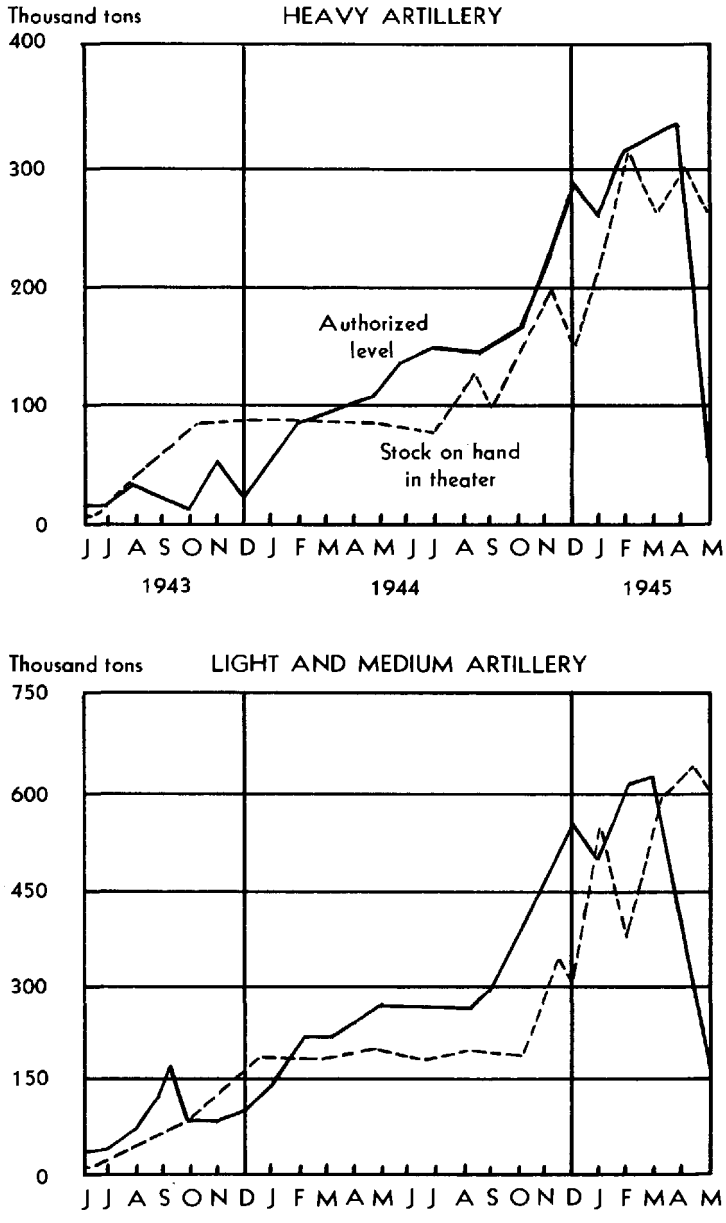
Period	Amount
1944	
January	$10,312,000
February	12,327,000
March	17,888,000
April	24,708,000
May	26,643,000
June	32,999,000
July	32,938,000
August	36,515,000
September	40,534,000
October	43,006,000
November	53,120,000
December	53,931,000
1945	
January	65,289,000
February	67,939,000
March	77,038,000
April	82,573,000
May	78,073,000
June	53,065,000
July	37,189,000
August	16,535,000

Source: Stat Review World War II, app. A, p. 75, by ASF Contl Div, OHF.

Chart 1 shows that stocks of artillery ammunition on hand in the European Theater of Operations ran well below the authorized level from the summer of 1944 to early 1945. An urgent cable from the ETO to the War Department on 23 September 1944 declared bluntly, "There is a serious shortage of heavy artillery ammunition for current operations." [71] As Table 12 reveals, ammunition was shipped in increasingly large quantities during these months, but did not catch up with the rise in authorized levels resulting from deployment of additional weapons. Vigorous efforts were made to speed the flow of ammunition from England and from the European beaches and ports to the front lines. Ammunition was rationed, and the armies were unable to fire at the desired rate. The fact that the campaign was a success does not prove that the ammunition supply was adequate, for the fighting

[71] Quoted in Ordnance Service in ETO, Ammunition Supply, pp. 120–23, OHF. See also cable from Eisenhower to Marshall quoted on p. 154, *ibid.* For statistics, see Ammunition Supply for European and Mediterranean Theaters, 15 Aug 45, p. 69, and Memo, Director of Supply, ASF, for Contl Div, ASF, 21 Dec 44, sub: Critical Items, copy in black binder in Somervell files, Box 48, NA. The subject is covered in some detail by Roland G. Ruppenthal in *Logistical Support of the Armies, Volume I,* UNITED STATES ARMY IN WORLD WAR II, (Washington, 1953), and in Ammunition Supply for European and Mediterranean Theaters, pp. 25ff.

CHART 1—ETO AUTHORIZED LEVELS AND THEATER STOCKS—GROUND AMMUNITION



Ammunition Supply for European and Mediterranean Theaters Control Division, Hdqrs, ASF, War Department–15 August 1945–p. 3.

TABLE 12—SHIPMENTS OF SELECTED TYPES OF ARTILLERY AMMUNITION TO THE EUROPEAN THEATER, DECEMBER 1944–MARCH 1945

[IN ROUNDS]

Type	Quantity			
	December	January	February	March
Total	1,239,356	2,268,486	3,087,372	4,227,884
155-mm. howitzer	937,881	1,531,414	2,052,000	2,672,571
155-mm. gun	220,217	438,826	555,043	786,073
8-inch gun	8,432	27,522	42,185	54,180
8-inch howitzer	58,131	238,196	382,181	629,752
240-mm. howitzer	9,695	32,528	55,963	85,308

Source: Ammo Supply for European and Mediterranean Theaters, ASF Contl Div, 15 Aug 45, p. 13., OHF.

might have ended sooner and with fewer casualties had more ammunition been fired. The conclusion seems to be inescapable that strenuous efforts to increase production and to speed distribution were called for in the critical months following 6 June 1944. The statistics showing that output more than doubled between June 1944 and June 1945 suggest that the production part of the program achieved a fair degree of success.

After Germany surrendered there were, of course, large quantities of all types of ammunition on hand, surplus to the needs of a campaign that was ended. How great was the surplus? It was large in all calibers and in some calibers it was unreasonably large. Table 13 shows that the 3.8 million rounds on hand at the end of May 1945 constituted a 3-month supply for the 155-mm. gun, based on the experience of the preceding three months (February, March, April). For the 155-mm. howitzer the supply was nearly four months, and for the other calibers it was roughly six months.

In June and July 1945 procurement was scaled down to the level of the one-front war against Japan, and requirements were far less than during the early months of the year. Then in mid-August the surrender of Japan put a stop to further production. On 14 August the FDAP sent telegrams to all its ammunition plants to halt production on all except a few types of matériel, and the district offices took similar action with respect to their contractors. These events suddenly ushered in a new era for which Ordnance had been making plans for many months, an era of demobilization and postwar planning.

In Conclusion: Quality and Quantity

Ammunition has been called the unsung hero of wars. When a gun fires straight and true the user is likely to remark that it is a fine weapon. When the gun fails to function properly the comment is likely to be, "There's something wrong with the ammunition." Realizing that ammunition which failed to function properly might have disastrous consequences, Ordnance went to extreme lengths to maintain quality at the highest possible level. Every

TABLE 13—HEAVY ARTILLERY AMMUNITION STOCKS ON HAND IN ETO, 31 MAY 1945

[IN ROUNDS]

Type	Quantity
Total	3,834,492
240-mm. Howitzer	65,428
8-inch Gun	46,832
8-inch Howitzer	435,509
155-mm. Gun	574,284
155-mm. Howitzer	2,712,439

Source: Prepared from data found in Ammo Supply for Eurpoean and Mediterranean Theaters, ASF Contl Div, 15 Aug 45, OHF.

newly designed shell, fuze, or cartridge case was subjected to the most severe tests before it was standardized for issue to troops. In the manufacturing process an unbelievable number of inspections were made to screen out defective elements. And in the overseas theaters Ordnance officers followed up on every reported instance of malfunction to determine its cause and root out the source of the trouble. General Merle H. Davis, who had wide experience in ammunition procurement and as a theater Ordnance officer, estimated that during World War II the Chief of Ordnance received information on 95 percent of the serious malfunctions that occurred in combat.[72] Early in the war, reports of premature explosions of shells came in from time to time, but by mid-1944 the rate of such malfunctions dropped to something less than one in 100,000 rounds fired. For certain rounds it was less than one per million.[73] "Based on performance," wrote Maj. Gen. Henry B. Sayler, chief Ordnance officer in ETOUSA, "American artillery ammunition was far superior [to German]. Whether because of sabotage or poor workmanship, the percentage of German duds was exceedingly high as compared with that of American performance." [74]

If combat troops seldom had cause to complain of the quality of their ammunition, they sometimes cursed its inadequate supply. This is not the time or place to analyze the intricacies of overseas ammunition supply, but the observation may be made here that lack of ammunition has been a perennial complaint of combat troops since the invention of gunpowder. In American history, from the defeat of the colonial forces on Bunker Hill to the war in Korea, field forces have occasionally run short of ammunition, sometimes at critical moments in the tide of battle. Ammunition is one of the most unpredictable items in the military supply catalog. Food, clothing, guns, tanks—the need for all these can be predicted with fair accuracy, but the supply of ammunition depends upon such incalculables as the success of an attack or the stubbornness of enemy resistance. It is not enough to have at overseas bases a large supply of ammunition in general. What the fighting forces need and demand are the particular types

[72] Davis, "Explosive Ammunition Production," *Ordnance,* XXXVI, No. 192 (May–June 1952), 934–36.

[73] Lewis and Rosa, Ammo, 1 Jul 40–31 Aug 45, p. 67.

[74] *Ibid.*, p. 67.

TABLE 14—MAJOR TYPES OF AMMUNITION PROCURED, 1 JULY 1940–31 AUGUST 1945

[IN ROUNDS]

Type	Rounds
Total for types listed	1,087,083,000
Total rounds for guns, howitzers, and mortars[a]	942,037,000
20-mm. gun (aircraft)	411,302,000
37-mm. gun (aircraft)	11,451,000
37-mm. gun (antiaircraft)	12,152,000
37-mm. gun (tank, antitank, and canister)	78,093,000
40-mm. gun (antiaircraft)	60,747,000
57-mm. gun	12,321,000
57-mm. recoilless rifle	203,000
75-mm. gun (aircraft)	656,000
75-mm. gun (tank and antitank)	48,405,000
75-mm. howitzer	26,872,000
75-mm. recoilless rifle	398,000
76-mm. gun	13,083,000
3-inch gun (tank and antitank)	13,795,000
3-inch gun (antiaircraft)	2,266,000
90-mm. gun (antiaircraft)	8,719,000
90-mm. gun (tank and antitank)	7,981,000
105-mm. howitzer	93,434,000
4.5-inch gun	1,969,000
155-mm. gun	7,168,000
155-mm. howitzer	20,800,000
8-inch gun	187,000
8-inch howitzer	2,531,000
240-mm. howitzer	409,000
60-mm. mortar	51,756,000
81-mm. mortar	37,043,000
Rockets, 2.36-inch (bazooka)	15,603,000
Rockets, 4.5-inch	2,537,000
Rockets, 7.2-inch	156,000
Total bombs, mines, and grenades	145,001,000
Bombs[b]	33,279,000
Mines	24,402,000
Grenades	87,320,000

[a] Not including a few minor types such as the 7.2-inch, 6-inch, 5.5-inch, and 120-mm.

[b] Excludes chemical bombs procured empty by Ordnance Department to be filled by Chemical Warfare arsenals. The total exceeds 100,000,000 if the individual bombs in bomb clusters are counted separately. See Bomb—Research, Development, Production, and Performance by Maj. Berkeley R. Lewis, pp. 58–59.

Source: Whiting, Statistics, Procurement sec., 9 Apr 52, Table PR–8.

and sizes of shell to fit the weapons being used to achieve the specific objective of the moment. With literally hundreds of different sizes and types of shell in common use, this problem was enormously difficult from both the procurement and the distri-

bution angles. But at the end of the war the Ammunition Division was prepared to stand on its record of procurement and to maintain that, except for heavy artillery, lack of production was not the cause of shortages in overseas supply.[75] (*Table 14*) The Mead Committee of the U.S. Senate supported this stand in a report issued in July 1945.[76] Perhaps the most thorough analysis of the problem was made by the General Board, U.S. Forces, European Theater. It concluded that no one factor caused the shortage but that three elements entered the picture at different times: (a) insufficient discharge over the beaches or through the ports, June through October 1944; (b) inability to move ammunition from ports and beaches to the armies, August through October 1944; and (c) inability of the Zone of Interior to meet requirements, November 1944 through March 1945.[77]

[75] For a discussion of requirements, see Chapter III. The problems of overseas supply will be treated in the next volume of this series.

[76] Mead Comm. *Report* No. 110, pt. 2, 79th Cong., 1st sess., 6 Jul 45.

[77] Rpt of Gen Bd, U.S. Forces, European Theater, Arty Sec, Study No. 58, ch. 7, n.d.

CHAPTER VIII

Small Arms

In a war that saw the employment of huge artillery weapons on a grand scale and that featured first the "block buster" and then the awe-inspiring atomic bomb, the smallest of military weapons—rifles, carbines, pistols, and machine guns—nevertheless played an important role throughout. Among ground combat troops, small arms were regarded as valued personal possessions, usually winning a place on mythical lists of "the soldier's best friends." Their effectiveness, light weight, and simplicity of operation made them the most versatile and most widely used weapons of the whole war.

As with so many other terms in military language, "small arms" did not have a hard and fast meaning. General usage over the years defined it as including all weapons with bore diameter of .60-inch (.60-caliber) or less, whether pistols, revolvers, rifles, carbines, submachine guns, or machine guns. These standard hand or shoulder weapons of infantry troops were supplemented traditionally by mortars that stood somewhere between shoulder weapons and artillery. But in World War II the infantry soldier also fought with 2.36-inch rocket launchers and a few recoilless rifles which, in spite of their large calibers, were generally classed as small arms or, more meaningfully, as infantry weapons.[1] By this usage, the determining characteristic was not diameter of bore but portability—whether the weapon could be carried into combat by infantry troops and could be fired from the hand, shoulder, or light support. The dividing line between small arms and artillery was thus less distinct than that separating the two classes of ammunition. With ammunition the diameter of the projectile was the deciding factor: everything up to and including .60-caliber was small arms; everything over .60-caliber was artillery.

Though small arms were regarded as being primarily ground weapons, the combat infantryman had no monopoly on them. Virtually every soldier in an overseas theater, whether assigned to a combat arm or a supply service, at one time or another used a rifle, carbine, or pistol. Small arms also went to sea and were almost as familiar to the sailor as to the soldier; every warship carried its store of such weapons, ranging from pistols to antiaircraft machine guns. More important, machine guns were the principal armament of Allied warplanes. The long-range, rapid-firing .50-caliber machine gun played the leading role both in plane-to-plane combat and in strafing attacks on surface targets. Easily the most outstanding aircraft gun of the war, it was also the most versatile, the same basic mechanism

[1] See Chapter V, above, for discussion of mortars.

serving for infantry, aircraft, tank, or antiaircraft use.[2]

Unlike the manufacture of artillery weapons, small arms production did not require the use of huge dies, presses, forges, and cranes, for the smaller weapons consisted of fewer and less complicated parts and were not equipped with intricate fire control devices or elaborate recoil mechanisms. The M1 rifle, for example, consisted of about seventy parts while an artillery piece, together with its on-carriage fire control equipment, consisted of thousands. Nevertheless, mass production of small arms was an exacting process. Parts had to be cut and machined to rigid tolerances. Detailed specifications had to be met to assure finished weapons that could fire thousands of rounds with little deviation in accuracy and could withstand exposure to heat, cold, rain, snow, mud, and sand. Carrying on a tradition that began in the days of Eli Whitney, Ordnance insisted upon complete interchangeability of parts for like models.[3]

Production of most small arms got under way fairly quickly in 1940–42 because the basic designs had been worked out and standardized long before the outbreak of hostilities, and manufacturing techniques had been well developed. Some standard weapons of 1940–42 were, in fact, essentially World War I designs that had stood the test of time. Among the most widely used of the older weapons were the 1903 Springfield rifle, the 1918 Browning automatic rifle (BAR), and the .45-caliber automatic pistol adopted in 1911. Four basic infantry weapons were comparatively new—the M1 rifle, the carbine, the M3 submachine gun, and the Thompson submachine gun. The last, a modified version of a commercially produced weapon, had won acceptance by the Navy in 1928, been adopted by the Army four years later as a limited procurement item, and in 1938 been classed as a standard Army weapon. The more easily mass produced M3 submachine gun supplanted the Thompson as a production item in 1944. The semiautomatic M1 rifle had been adopted in 1936 and put into small-scale production at Springfield Armory the following year. A lightweight carbine, adopted in record time, went into production in 1941.[4]

Aid to Britain in 1940

Although Ordnance research and development had brought forth a number of improved models during the two peacetime decades, the meager funds available in those years had not permitted quantity production. Nor had there been any sense of urgency for small arms procurement.

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[2] (1) Record of Army Ordnance Research and Development, vol. 2, Jan 46, R&D Serv, OCO, OHF; (2) Lt. Col. George M. Chinn, *The Machine Gun,* vol. I (Washington, 1951), p. 334; (3) Lt. Col. William C. Farmer, ed., *Ordnance Field Guide,* vol. II (Harrisburg: Military Service Publishing Company, 1946), p. 110; (4) Green, Thomson, and Roots, *Planning Munitions for War,* p. 178; (5) PSP 36, U.S. Machine Guns, Calibers .30 and .50, 1940–45, 18 Feb 46, compiled by Lt Col Emanual Schugar, Maj Berkeley R. Lewis, and William H. Davis, pp. 10–14 (6); Catalog of Standard Ord Items—Small Arms, 1 Mar 44, pp. 402–04.

[3] Lecture, Maj James L. Hatcher, Ordnance Production Difficulties and Their Solution, 20 Feb 39, ICAF. This lecture is quoted extensively in "Armament Production," *Army Ordnance,* XXI, No. 123 (November–December), 221–24.

[4] For the research and development background on small arms, see Green, Thomson, and Roots, *Planning Munitions for War,* pp. 175–78, and Record of Army Ordnance Research and Development, vol. 2, bks. 1 and 3. For the carbine, see History of Small Arms Matériel U.S. Carbine, Cal. .30, prepared by Maj H. P. Smith and William H. Davis under the direction of Lt Col H. H. Mitchell (1945) OHF.

After World War I, some three million rifles plus large quantities of pistols and machine guns had been reconditioned and put in storage along with machinery for their manufacture. These reserve stocks were considered more than adequate to meet replacement needs of the small peacetime Army and to equip a larger force in time of emergency. Though reserves of aircraft machine guns were virtually nonexistent, this fact caused little concern because the air arm possessed few planes and both Springfield Armory and Colt's Patent Fire Arms Company were producing enough for peacetime needs.

This complacent view was rudely shaken in the summer of 1940 as the British Army suffered its Dunkerque and both Belgium and France fell to the Germans. To bolster the hard-pressed British forces, President Roosevelt decided to transfer to them all weapons and ammunition that might be considered surplus to the needs of United States forces.[5] As a result, during the summer of 1940 the British received about 615,000 Enfield rifles, 25,000 BAR's, 86,000 .30-caliber machine guns, and 20,000 revolvers. Transfer of this matériel took a big bite out of the U.S. Army's small arms stockpile, and at the same time the President's call for 50,000 airplanes boosted machine gun requirements. Complacency soon gave way to alarm, and immediate increase in the output of small arms of all kinds was demanded. But quantity production could not be achieved overnight. As with other types of munitions, increased production depended on expansion of facilities, installation of specialized machine tools, and recruitment and training of new workers, all of which took time. It was at this point that the public began to ask what Ordnance had done to prepare for such an emergency.

Production Preparedness

While the meager Ordnance budget in the 1920's and 1930's had barely sufficed to keep the arsenals open and had not permitted placing any substantial small arms orders with private industry, Ordnance had endeavored in other ways to prepare industry for its wartime task. During the late 1930's and in early 1940 contracts for production studies of small arms of various types were awarded to several concerns. Typical of such studies were those prepared by Remington Arms Company, Inc. on .30-caliber aircraft machine guns and the new M1 rifle; by Colt's Patent Fire Arms Manufacturing Company on .30- and .50-caliber aircraft machine guns; and by the Singer Manufacturing Company and the Nash-Kelvinator Company on .45-caliber pistols.[6] These studies did not call for actual manufacture but merely for analysis of ways and means by which the item could best be produced should the need arise.[7] Growing out of production studies were detailed descrip-

[5] See Green, Thomson, and Roots, *Planning Munitions for War*, ch. III, and Leighton and Coakley, *Global Logistics, 1940–1943*, pp. 33–34. For a summary of the stocks on hand, see Memo, Brig Gen Richard C. Moore, ACofS G-4, for CofS 5 Jun 40, sub: Surplus Ord Matériel . . ., G-4/26057-2.

[6] (1) PSP 76, Design, Development and Procurement of Small Arms, 1917–45, by William H. Davis, SA Div, Ind Serv, May 45, p. 6; (2) PP 76, Small Arms and Small Arms Ammunition, Design, Development and Procurement 1917–45, by Lt Col Calvin H. Goddard, Historical Sec, Exec Div, Jun 45, p. 52; (3) PSP 36, U.S. Machine Guns, Calibers .30 and .50, Development, Requirements and Production 1940–45, 18 Feb 46, pp. 70a–72; (4) Hist, Rochester Ord Dist, vol. I, 1923–42, pp. 46–47. For an explanation of the term "production study" in Ordnance prewar planning, see Chapter II.

[7] Ltr, CofOrd to Budget Officer of the WD, 8 Apr 40, OO 111.3/7485.



SAGINAW GUN PLANT, *Mich., where machinery and equipment installed for operations on 30-caliber machine gun barrels are shown.*

tions of manufacture prepared by the arsenals and private industry for all kinds of small arms. Springfield Armory kept data of this type for aircraft guns; Rock Island Arsenal kept a similar file on ground machine guns.[8]

Further to prepare industry for emergency production, Ordnance in 1939 and 1940 had placed four educational orders for small arms—one each for rifles and machine guns and two for pistols.[9] To the Winchester Repeating Arms Company had gone an order for five hundred M1 rifles and to Saginaw Steering Gear Division of General Motors Corporation an order for five hundred .30-caliber machine guns. Ordnance had placed an order for five hundred pistols with the Singer Manufacturing Company of Worcester, Mass., which had previously completed its production study on this weapon; a similar order had gone to the Harrington and Richardson Arms Company of Worcester, Mass.[10] After Pearl Harbor, Winchester and Saginaw continued to manufacture their educational order items, but the two educational orders for pistols, fortunately far less important weapons than machine guns or rifles, proved of less direct benefit

[8] Among the important "descriptions of manufacture" were those prepared at Springfield Armory covering the .30-caliber M2 aircraft machine gun, the .50-caliber M2 machine gun, and the M1 rifle; those prepared at Rock Island Arsenal covering the Browning .30-caliber M1917A1 and M1919A4 ground type machine guns and their mounts and the BAR, and one prepared by the Singer Manufacturing Company for the .45-caliber automatic pistol. PSP 76, p. 7.

[9] The educational orders program is discussed in Chapter II, above.

[10] (1) PP 76, pp. 18, 29, 53; (2) PSP 36, U.S. Machine Guns, Calibers .30 and .50, Development, Requirements and Production, 1940–1945.

to wartime production. Although Singer satisfactorily completed the five hundred pistols called for under its educational order, Ordnance did not call upon it to make pistols after 1941, for its facilities were by then heavily committed to manufacture of artillery directors, which had a higher priority. Upon completion of the educational order, Singer transferred all tools and other material relating to pistol manufacture to the Ithaca Gun Company, which turned out large quantities of excellent pistols.[11] The Harrington and Richardson contract turned out badly. After two extensions in delivery date owing to management difficulties and changes in operating personnel the contract was canceled in June 1942 before a single finished pistol had been produced.[12]

Despite Springfield Armory's production potential, Ordnance had decided to award an educational order for the Garand rifle because of the large requirement for rifles in the Protective Mobilization Plan. In the spring of 1939 the Infantry listed the new rifle as the top priority item in the rearmament program. The million-dollar contract went to Winchester, was successfully completed, and was soon followed by large production orders.[13]

Though not part of Ordnance plans for production preparedness, foreign orders in 1939–40 helped in a very practical way to prepare American industry for its wartime role. After the outbreak of war in Europe in September 1939, Britain, France, the Netherlands, China, and other countries offered contracts to U.S. firms that had experience in the manufacture of military weapons or sporting arms. As American manufacturers were not keenly interested in munitions production, most such negotiations proceeded slowly during the winter of 1939–40, and some other complicated arrangements had to be worked out with the few companies interested in foreign munitions contracts.[14]

In December 1939 and early 1940, for example, both Britain and France placed substantial orders for Thompson submachine guns with the Auto Ordnance Corporation. This concern owned manufacturing rights for the Thompson gun but had neither plant nor skilled labor force. Auto Ordnance therefore subcontracted the work to the Savage Arms Company of Utica, N.Y. The weapons thus produced were the first "Tommy guns" turned out in the United States since Colt had completed a small order for Auto Ordnance in 1921–22.[15] The Netherlands government meanwhile entered into a similar contract with Defense Supplies Corporation, a newly organized American firm with exclusive license to manufacture a new submachine gun known as the High Standard. Like Auto Ordnance, Defense Supplies had no manufacturing facilities and had to

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[11] (1) Hist, New York Ord Dist, vol. 100, pt. 3, Contractor Histories, Fire Contl Div MS, Rpt by Singer Manufacturing Co., 9 Jul 45, p. 3; (2) PSP 39, Pistol, Automatic, Cal. .45, M1911A1, 1917 through August 1945, compiled by Annie J. Gregg and reviewed by John P. Aitchison, 31 Jan 47, OHF, p. 10.

[12] (1) Hist, Boston Ord Dist, vol. I, 1922 Through 1942, pp. 10–11, 67, OHF; (2) PP 76, Small Arms and Small Arms Ammunition, Design, Development and Procurement 1917–45, p. 29; (3) PSP 39, pp. 9–11.

[13] Green, Thomson, and Roots, *Planning Munitions for War*, pp. 58–59. See below for further discussion of Winchester production.

[14] SA Div, Historical Review of Lend-Lease Activities—Small Arms and Small Arms Ammunition, 17 Jul 45, OHF.

[15] PSP 40, Submachine Guns, 1921–45, by William H. Davis and Capt Andrew J. Gleason, SA Div, Ind Serv, Dec 45, pp. 1–4. In 1944 the Auto Ordnance Corp. was renamed Maguire Industries, Inc. Hist, Springfield Ord Dist, vol. 100, pt. 23, Contractor Histories, Maguire Industries, Inc.

subcontract the work to the Marlin Firearms Company of New Haven, Conn.

More important than submachine gun orders was the foreign demand for Browning machine guns. In the fall of 1939, when the British government turned to American industry for manufacture of these weapons, it soon became apparent that the Colt Company, holder of patent rights on the Browning guns and their sole commercial producer, would not be able to supply all that were needed. The British government not only arranged to finance expansion of the Colt plant but also opened negotiations with three other firms to produce Browning guns under a Colt license. During the winter of the so-called "phony war" these negotiations moved slowly with each side holding out for more favorable terms. But the swift German victories of May and June 1940 changed the picture almost overnight. Agreement was soon reached on construction of three new aircraft machine gun plants by the Buffalo Arms Corporation, High Standard Manufacturing Company, and the Kelsey-Hayes Wheel Company.[16]

For rifles the British turned to the Savage Arms Corporation, signing a contract with it in March 1941 for manufacture of the standard British rifle, the .303-caliber Lee-Enfield (No. 4, Mark I) at its plant, known as the J. Stevens Arms Company Division, near Chicopee Falls, Mass. Although tooling was rushed and the company completed its first rifle in July, quantity production was just getting started when the Japanese attacked Pearl Harbor. Meanwhile, in October, the U.S. Government, under provisions of the Lend-Lease Act, had taken over administration of the British contract. Additional orders were placed after Pearl Harbor, and by June 1944, when the contract was terminated, Savage had produced 1,030,228 rifles, plus spare parts.[17]

Early in 1941 Britain asked the Remington Arms Company to produce half a million Lee-Enfields at its Ilion, N.Y., plant. At this point General Wesson raised an objection. He proposed that the reserve machinery for manufacturing Springfields be removed from storage at Rock Island and leased to Remington, and that Remington use it to make .30-caliber Springfields instead of .303-caliber Lee-Enfields for the British. As the labor situation at Rock Island was acute, Ordnance opposed opening the rifle plant there. Further, the Army had enough rifles on hand to equip a 2-million-man force, and output of the new semiautomatic rifle was expected to add even more to the reserve stocks.[18] Wesson pointed out that, starting from scratch, it would take Remington two and a half years to get into production on Lee-Enfield rifles for the British. Using the Rock Island machinery, production of Springfields could reach one thousand per day within one year, and after completion of the British contract this machinery would be in place for supply of

[16] PP 36, U.S. Machine Guns, Calibers .30 and .50, Development, Requirements and Production 1940–45, Jul 45, OHF. See also History of Small Arms Matériel, Buffalo Arms Corp., 9 Mar 45, OHF.

[17] (1) Hist, Springfield Ord Dist, Sub-Office Admin Div. I (1942) sec. on Savage Sub-Office; (2) Hist, Springfield Ord Dist, vol. 100, pt. 3.

[18] (1) Memo, Col Vincent Meyer, WDGS G-4 for ASW, 10 Oct 40, sub: Advisability of Opening up the Springfield Rifle Plant . . . ; (2) Memo, Lt Col Willis R. Slaughter, OASW for Col Spaulding, 16 Oct 40, same sub; (3) Memo, CofOrd for ASW, 19 Oct 40, sub: Prod of U.S. Rifle, Caliber .30, M1903; (4) Memo, SW for CofS, 23 Oct 40, sub: Advisability of Opening . . . Rifle Plant. . . . All in folder 474 Small Arms, ASF Prod Div files. See also G-4 files 32116.

the U.S. Army if needed. The British were not at all enthusiastic about this proposal, insisting that they wanted only rifles of .303-caliber. But they finally conceded the point after a delay of several months and accepted Wesson's plan. The rental agreement was signed early in 1941, just a few days before passage of the Lend-Lease Act under which the Army was later to take over all British rifle procurement in the United States. The machinery was quickly shipped to Ilion where manufacturing got under way in less than a year, and continued until 28 February 1944.[19]

Manufacturing capacity created to fill foreign orders was an important resource when the United States began to rearm in earnest during 1941. But of greater value were the two Ordnance arsenals, Springfield and Rock Island, experienced in the manufacture of small arms. Though badly in need of new machine tools, and staffed with only a nucleus of skilled workmen, these two arsenals stood ready not only to expand their own output as needed but also to share with civilian industry their technical knowledge and their war reserve machinery. Springfield Armory, the traditional center for military rifle production, had begun as early as 1937 to tool up for production of the new Garand rifle, and as public interest in rearmament grew in 1940 and early 1941 its progress was closely watched.

Getting the Garand into Production

Despite a rather long period of preparation, mass production of the Garand rifle proved to be far more difficult than anyone anticipated. In part, the difficulty sprang from the usual problems encountered in beginning quantity production of a new weapon. But in the case of the Garand, run-of-the-mill difficulties were compounded by a violent public controversy touched off when the competing Johnson rifle was submitted for Army test in 1938, two years after standardization of the Garand and while tooling up for its manufacture was under way at Springfield Armory. Throughout most of the defense period (1939–41) debate raged in the halls of Congress and in magazines and newspapers across the nation over the merits of these two weapons, and before the controversy subsided a third semiautomatic model had entered the picture. Some critics meanwhile contended that the old, mechanically reliable Springfield was superior to any of the semiautomatics; others expressed doubts that the Garand could ever be successfully mass-produced. Probably no other weapon in American history went into production amid such intense controversy.[20]

Officially designated "Rifle, semiautomatic, cal. .30, M1," the new weapon was universally known either as "the Garand" or "the M1." The product of a 35-year search, it was gas-operated, weighed about

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[19] (1) Statement by Wesson in Review of Production Plans of Small Arms Division, 20 Feb 42, T676A, pp. 38–39; (2) Hist, Rochester Ord Dist, vol. 100, pt. 9, Ilion Works; (3) *In Abundance and On Time, 1939–43,* published by Remington Arms Co., Bridgeport, Conn., 1944; (4) Lt. Col. H. H. Mitchell, Hist, Small Arms Matériel, U.S. Rifle Cal. .30 M1903 [1945], SA Br, Ind Div, OCO, p. 23; (5) PP 76.

[20] The most complete published account of the development of the Garand is made by Maj. Gen. Julian S. Hatcher, *The Book of the Garand* (Washington: Infantry Journal Press, 1948). See also Green, Thomson, and Roots, *Planning Munitions for War,* pp. 175–77; Maj. Guy H. Drewry, "Our New Service Rifle," *The American Rifleman,* vol. 86, No. 8 (Aug 1938), pp. 5–9, and manuscript History of Springfield Armory by Constance McLaughlin Green, vol. II, bk. I, pp. 43–48 and 74–76.

nine and a half pounds, and was loaded by an 8-round clip. It could fire more than twice as fast as the Springfield. With it a soldier could fire eight aimed shots without taking his eye off the target, for all he needed to do was squeeze the trigger for each shot.[21] Designed by John C. Garand, chief civilian engineer at Springfield, it was subjected to grueling service tests by both the Infantry and the Cavalry before being adopted in January 1936. Garand received no monetary reward for his invention beyond his modest Armory salary—though a bill to grant him $100,000 was introduced in Congress—but he was the recipient of numerous medals. In 1941 the Army Ordnance Association honored him with its first Brig. Gen. John H. Rice Gold Medal for Meritorious Service in Armament Engineering. Three years later Garand received an official government award, the Medal for Merit.[22]



JOHN C. GARAND *at work in his model shop, September 1940.*

Tooling at Springfield

As soon as the Garand was adopted, Springfield began preparations for producing it in quantity, but at that time the Armory was at low ebb, having lived on a hand-to-mouth basis since the end of World War I. A small cadre of skilled workers remained, engaged for the most part in turning out each year a few improved Springfield rifles and rifle parts. Most of the machine tools on hand had been in use for twenty or thirty years, and some even antedated the Civil War. Surveying these tools to determine which could be used in producing parts for the new rifle was in itself a major undertaking. Preparing manufacturing drawings, planning production line processes, and designing and making new tools, jigs, fixtures, and

[21] A semiautomatic weapon differs from a fully automatic weapon in that the former requires a separate squeeze of the trigger for each shot while the latter fires until the magazine is empty as long as the trigger is held down.

[22] (1) "Army Ordnance Medalists, 1941," *Army Ordnance,* XXII, No. 127 (July-August 1941), 30–31; (2) New York *Times,* March 29, 1944, p. 22; (3) PSP 37, U.S. Rifle, Cal. .30 M1, Design, Development, Procurement, and Production, by William H. Davis, Jul 46, OHF; (4) Green, Thomson, and Roots, *Planning Munitions for War,* pp. 175–77; (5) Philip B. Sharpe, *The Rifle in America* (New York: Funk and Wagnalls Company, 1953), pp. 513–31; (6) Hatcher, *The Book of the Garand;* (7) Melvin M. Johnson, Jr., *Rifles and Machine Guns* (New York: W. Morrow and Company, 1944), pp. 40–45; (8) Walter H. B. Smith, *Small Arms of the World* (Harrisburg, Pa.: Military Service Publishing Company, 1955), pp. 154–57; (9) "Garand's Gun," *Newsweek,* December 4, 1939, pp. 18–19; (10) Edwin Teale, "He Invented the World's Deadliest Rifle," *Popular Science,* December 1940, pp. 68–71; (11) Joseph W. Shields, Jr., *From Flintlock to M1* (New York: Coward-McCann,

gages were all equally time-consuming.[23]

In 1934 the Armory model shop had completed an order for eighty experimental Garands, but tooling up for quantity production was an entirely different matter. When work began in the fall of 1937 on an order for 1,500 rifles it soon became clear that many of the old machines that appeared to be in good condition had lost, through long use, the accuracy needed to meet close tolerances. It soon became clear also that an entirely new system of production would be required to achieve high-speed output. Determined that the new rifle should be manufactured by the most modern methods to attain a high rate of production with a saving of manpower, space, and operating cost, Ordnance launched a major retooling program at Springfield in the spring of 1938.[24] Tooling engineers from all over the country were invited to aid in design of modern production equipment and to submit bids for its manufacture. Coming at a time when the machine-tool industry was in financial doldrums, this invitation met with a ready response. After detailed study of each rifle part, and consultation with machine tool builders, machining operations were substantially reduced. Many of the machine tools and much of the accessory equipment on hand at Springfield could be used in the modernized production setup, but the quantity of new equipment needed was substantial.

When Congress in 1938 appropriated $1,800,000 for retooling, Ordnance anticipated the project would be completed by the end of the following year and would boost production from ten thousand to fifty thousand rifles per year.[25] This sum supplemented approximately one million dollars that had already been expended at Springfield for new equipment and gages, primarily for the M1 rifle, since 1935.[26] As the years from 1935 on had brought a gradual upswing in all activities at the Armory, Ordnance decided to modernize, to the extent of funds available, the whole Springfield manufacturing plant during the process of tooling up for output of the new rifle.[27] While no new buildings were erected at the Armory before 1940, many improvements such as better wiring, new floors, and strengthening of supports as well as the shifting of existing machinery were required to house the new rifle-producing equipment and reorganize the production line. Some of the buildings at the Armory were positively archaic.

The first production models of the M1 rifle came off the line in September 1937

1954), pp. 172–81; (12) *Who's Who in America*, 1956–57.

[23] (1) Lecture, Hatcher, 20 Feb 39; (2) "1,000 Garands a Day" in armament section of *American Machinist*, vol. 84, November 27, 1940.

[24] (1) Lecture, Hatcher, 20 Feb 39; (2) Campbell, *The Industry-Ordnance Team*, p. 192; (3) Lt. Col. H. H. Mitchell, Hist of Small Arms Matériel, U.S. Rifle Cal. .30 M1, 12 Dec 44, pp. 10–11; (4) PSP 37, U.S. Rifle Cal. .30 M1, History of Design, Development, Procurement, and Production, 1936–45, pp. 52–55; (5) Hist, Springfield Armory, vol. II, bk. 1, p. 64; (6) Col. Gilbert H. Stewart, "Springfield Armory Tools Up for New Semi-Automatic Rifles," *Machinery*, vol. 45, No. 5 (July 1939).

[25] (1) Statement by Craig, Hearings, *WDAB*, FY 1940, H.R., 76th Cong., 1st sess., 26 Jan 39, p. 6; (2) Statement by Wesson before House Subcomm. on same bill, 1 Feb 39, pp. 396–97 of the *Hearings;* (3) Ltr, Wesson to CO Springfield Armory, 16 Dec 38, sub: Spec Authority for Proc of Caliber .30 M1 Rifle Equipment, copy appended to Mitchell, Hist SA Matériel, U.S. Rifle Cal. .30 M1, 12 Dec 44; (4) Memo, Col W. L. Clay, OCO to Col Haislip, WD Budget and Legislative Plng Br, 28 Jan 39, OO 111.3/6954.

[26] PSP 37, U.S. Rifle Cal. .30 M1, Hist of Design, Development, Proc and Prod, 1936–45, p. 55.

[27] Ltr, Wesson, CofOrd, to Hon. Charles R. Clason, H.R., 7 May 40, OO 474.2/2960.

at a rate of about 10 per day. By the time the first order for 1,500 was completed the following March, daily output stood at 20, and work was started on a second slightly larger order. Boosted to 40 in September 1938, daily output gradually continued to rise as new tools and equipment were installed and new orders were received, reaching a rate of 100 per day one year later and 200 per day or 50,000 per year in January 1940.[28] But future requirements had also risen in the fall of 1939. Against a need for 150,000 new rifles during the next two years, Springfield could produce only about 100,000 if it continued on an 8-hour day. Under these circumstances General Wesson decided that the Armory should be kept on an 8-hour day and that additional rifles should be obtained from private industry. He reasoned that this plan would keep extra-shift reserve capacity at the Armory for an emergency and would enable industry to tool up for rifle production.

When Ordnance called for bids in the summer of 1939, two famous gunmaking concerns, Remington and Winchester, responded. Each submitted a bid based on the assumption that it would furnish all necessary tools and equipment. Winchester not only turned in the lower bid on this basis but also submitted an alternate bid —$1 million less—assuming use of tools and equipment being procured under its educational order. On the basis of this latter proposal, Winchester received a contract for 65,000 Garand rifles to be completed by June 1942. As the million dollar reduction in the second Winchester bid was approximately equal to the cost to the government of the educational order, there was no saving in money but there was a full year's reduction in the time required for tooling up.[29]

Production Troubles

In the fall of 1939, just as the contract with Winchester was being signed, the Garand rifle made its public debut and at once ran into a storm of criticism, much of it related to the troubles experienced with the first production models of the new rifle. While the first eighty toolroom models, made in 1934 under the designer's direct supervision, had performed superbly, the first production models were plagued by several new and unexpected minor troubles. The cam on the operating rod tended to stick, and the rear sights would not hold their adjustment. Another puzzling defect was that the seventh round in the clip often failed to feed, and frequently the 8-round clip jumped out of the gun after the seventh round had been fired. Eventually it was found that very

[28] For details on output during these years, see (1) Memo, Lt Col Guy H. Drewry to Chief of Ind Div, 25 Sep 39, sub: Status of M1 Rifle Prod, ex. 20, Mitchell, Hist of SA Matériel, U.S. Rifle Cal. .30 M1, Jul 46; (2) Memo, Capt William T. Moore to CofOrd through Chief of Ind Serv, 9 Mar 40, sub: Costs—Caliber .30 M1 Rifles, Spare Parts and Accessories, ex. 21 to above study; (3) William H. Davis, Springfield Armory, Pertinent Data Concerning Plant and Activities 1794—Feb 1946, SA Div, Ind Serv, OCO, 7 Mar 46, p. 2. For a popular version, see Donald Wilhelm, "What 'On Order' Means," *Reader's Digest*, October 1940, pp. 33-36.

[29] For details on the placing of this production order and the benefits gained from the educational order, see: (1) Memo, Lt Col Drewry to Chief Ind Serv, 24 Aug 39, sub: Bids on Cir Proposal 852-39-483, M1 Rifles, Extra Parts & Combination Tools, ex. 23, Mitchell, Hist SA Matériel, U.S. Rifle Cal. .30 M1, 12 Dec 44, SA Br, Ind Div; (2) Lecture, Wesson, Ordnance Department Procurement, 15 Jan 40, ICAF, p. 6; (3) Harold F. Williamson, Winchester—*The Gun That Won the West* (Washington: Combat Forces Press, 1952), pp. 385-88; (4) Statements by Col Rutherford and Wesson, *WDAB*, 1941, H.R., 76th Cong., 3d sess., 27 Feb 40 and 12 Mar 40.

few of these defects were inherent in the design of the rifle. Nearly all stemmed from the fact that during retooling for mass production slight changes had been introduced in the shape and dimensions of some of the parts. Perhaps, one Ordnance officer later suggested, many of these troubles might have been avoided if Garand, a topflight machine-tool designer as well as designer of the rifle, had been consulted more closely during the retooling program. But other Ordnance officers challenged this view; they asserted that no liberties were taken with the design and that every engineering change made at the Armory had Garand's approval.[30]

The Infantry, well aware of these troubles with the production models, was not alarmed, for it accepted the Ordnance Department's assurance that the defects could and would be corrected. But the general public was kept in the dark regarding the troubles experienced with the rifle and the progress made in remedying them. So was the staff of the National Rifle Association, an organization that numbered its members in the hundreds of thousands and for almost half a century had been recognized as a quasi-governmental institution devoted to the promotion of small arms shooting as a part of the national defense. Had the NRA been kept fully and frankly informed, it might have provided constructive criticism and powerful support of any decisions reached by the Army.

Details of the construction and operation of the Garand had first been given to the public in the fall of 1938 with no hint of unusual production or performance difficulties.[31] The first public demonstration came one year later when two hundred Garand rifles were sent to Camp Perry, Ohio, for use in the small arms firing school for civilians held in conjunction with the National Rifle Matches. The performance of these rifles immediately raised doubts. The expert rifle shots who had assembled for the annual marksmanship contest were accustomed to using the National Match Rifle, an improved Springfield made with extra care and painstakingly adjusted for the best results in long-range shooting. To these experts the Garand rifles did not appeal, for the Garands were battle rifles, not target models. Their sights gave good visibility under poor lighting conditions, but did not make for high scores at long ranges under match conditions. Even more disturbing to the sharpshooters was the fact that the Garand sights would not hold their adjustment.[32] Ordnance was well aware of this problem and had in production at Springfield an improved gas cylinder assembly to correct it, but the public was not informed. Although civilians at Camp Perry were invited to test fire the new rifles they had a vague suspicion that everything was not above board. "There was always an Army man at the shooter's elbow," wrote one observer, "ready to snatch the rifle away and perform some sleight of hand at the slightest sign of a malfunction. Moreover, the members of the NRA staff, to their surprise, found that

[30] (1) Hatcher, *Book of the Garand,* p. 120; (2) Comments on draft manuscript of this chapter by Maj Gen Elbert L. Ford (Ret.) and Maj Gen James Kirk (Ret.), 18 Apr 57, OHF; (3) Lecture, Hatcher, Ordnance Production Difficulties and Their Solution, 20 Feb 39, ICAF.

[31] (1) Drewry, "Our New Service Rifle," *The American Rifleman,* vol. 86, No. 8 (August 1938), pp. 5–9; (2) Capt. Frank J. Jervey, "The New Semiautomatic Rifle," *Army Ordnance,* XIX, No. 111 (November–December 1938), 144–47.

[32] See testimony by Maj Gen Milton A. Reckord, CG 29th Div, National Guard, before *WDAB,* H.R., 76th Cong., 3d sess., pp. 783–86, 14 Mar 40.

they were unwelcome whenever they approached a Garand or wanted to fire it."[33]

The Garand-Johnson Controversy

This official protective attitude toward the Garand was doubly suspicious in view of the fact that Capt. Melvin M. Johnson, Jr., USMC Reserve, had recently brought forth a rival semiautomatic. The Army had tested toolroom models of the Johnson rifle in the summer of 1938 and, following redesign, again in December 1939.[34] It operated on the short-recoil principle and was designed so that its barrel could be quickly replaced in the field. The mechanical performance of the Johnson rifle was satisfactory, but in February 1940 the Ordnance Committee recommended that it be given no further consideration because it was not superior to the Garand for which Springfield Armory was already tooled.[35] This action, coupled with the bad impression made by the Garand at the 1939 rifle matches, set off the fireworks. The Washington *Evening Star* ran a series of three articles in February 1940 under the heading "Battle Efficiency of Garand Rifle Provokes Controversy." The Associated Press reported in March that the House military appropriations subcommittee was giving the rifle controversy "exhaustive study behind closed doors."[36] After failing to get answers from the Army to its questions about the Garand, or rifles for test, the NRA published an editorial in the April 1940 issue of *The American Rifleman* expressing grave doubts about the new weapon and its slow rate of production.[37] The editorial also questioned the Army's decision to drop its 172-grain bullet in favor of the shorter range 152-grain bullet. The NRA urged the Army to lay all the facts on the table and clear up the whole rifle issue.

The flames of controversy were fanned higher in May 1940 when *The American Rifleman* published a long article by one of its staff members who had obtained a Garand for personal test. Though generally favorable to the Garand, the article pointed out shortcomings and cited the low production rate and the change in ammunition.[38] This article, together with testimony being presented to Congressional committees, inspired a series of newspaper and magazine articles on the subject. *Life* called it "one of the greatest military squabbles in U.S. history."[39]

During lengthy committee hearings Congressmen listened to conflicting testimony and found themselves as confused as the general public.[40] It seemed for a time in the spring of 1940 that appropriations for the Garand rifle might be stopped

[33] Hatcher, *Book of the Garand,* p. 129. General Hatcher was chief of the Small Arms Division, Manufacturing Service, OCO, during the early 1930's. His brother was Ordnance adviser at the national matches in 1939.

[34] (1) Ltr, ASW to Congressman Clyde L. Herring, 16 May 40, OO 474.2/2996; (2) Wesson's testimony on these tests in *Hearings,* H.R. *WDAB,* 1940, 76th Cong., 1st sess., 1 Feb 39. pp. 401–22. See also annual reports of Johnson Automatics, Inc., and other related material on Johnson rifles and light machine guns in folder Johnson Automatics, Incorporated, OHF.

[35] OCM 15650, 23 Feb 40.

[36] Associated Press dispatch, March 22, 1940.

[37] "The Courage to be Frank," *The American Rifleman,* vol. 88, No. 4 (April 1940), p. 4.

[38] F. C. Ness, "M-1 (Garand Semi-automatic) Rifle," *The American Rifleman,* vol. 88, No. 5 (May 1940), 43–45. An article by the same author on the Johnson rifle had appeared in the same magazine in November 1938.

[39] *Life,* November 18, 1940, pp. 55–56.

[40] *Hearings WDAB,* 1940 and 1941, H.R. and S., 76th Cong., 1st and 3d sess. See also *Hearings on S. 3983,* 76th Cong., 3d sess., 14 May 40. Excerpts from these sources are in OHF.

entirely and all the time and money spent in tooling up for its production might be wasted. The Army's claim that the Garand was an excellent weapon and the best semiautomatic available was hotly disputed before the Congressional committees by proponents of the Johnson rifle who insisted their weapon was more accurate, was less complicated in design, easier to maintain in the field, and much simpler to manufacture. They also charged that the tests had not been conducted fairly.[41] Ordnance replied that, as the Johnson rifle had never been produced in quantity, nor tested on a large scale, there was no real evidence that it would function better or could be produced more easily than the Garand. Long experience in weapons manufacture had taught Ordnance that unforeseen difficulties nearly always app ar between the test of toolroom models and large-scale production, and that estimates of the time required to produce new weapons in quantity were seldom fulfilled.[42] Meanwhile, a member of the U.S. Senate introduced a bill to force adoption of the Johnson as the standard rifle for the Army and Navy.[43]

In defending the decision to drop long-range ammunition and produce only shorter-range types for all .30-caliber machine guns and rifles, military spokesmen cited the Infantry Board's findings that the more powerful ammunition was not required for combat, and that it was dangerous to use in training because suitable target ranges could seldom be found that would protect neighboring communities. Adoption of the lower-powered ammunition for machine guns was defended on the ground that the 81-mm. mortar eliminated the need for long-range machine gun fire; that the new ammunition would permit longer life of barrels and parts and the searching of more area on the reverse sides of slopes; and that use of one type of .30-caliber ball ammunition would simplify manufacture.[44] The only real reason for the change, said the critics, was the heavy recoil when long-range ammunition was used in the Garand. Was it wise, they asked, to give up long-range ammunition to accommodate a weapon whose performance was doubtful in other respects?

In April and May 1940 the House and Senate committees approved funds for manufacture of twenty five thousand more Garands. Though the Congressmen were not altogether sure that the Garand was better than the Johnson, they agreed with the Army that, as Springfield was being tooled for the Garand, it would be unwise to launch production of a second weapon. Meanwhile the Marine Corps held off replacing its Springfields with either Johnsons or Garands, and the rifle controversy stayed very much alive all summer. Late in the year the Marines announced they

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[41] As examples, see statement of Melvin M. Johnson, Sr., 13 May 40, before *WDAB,* 1941, S., copy in OHF.

[42] For statement of Army views see Memo, ASW to SW, 30 Aug 40, OO 474.2/149, and Memo, Marshall for SW, 23 Apr 40, *Hearings,* S. Mil Affairs Comm., 76th Cong., 3d sess., 29 May 40, pp. 82–85. See also Johnson's dispassionate summary in *Rifles and Machine Guns,* pp. 40–45.

[43] *Hearings on S. 3983,* 76th Cong., 3d sess., 14 May 40.

[44] (1) "The Garand Rifle," *Army Ordnance,* XXI, No. 121 (July–August 1940), 52–57; (2) *Hearings, WDAB,* 1941, H.R. 76th Cong., 3d sess.; (3) Hatcher, *Book of the Garand,* pp. 125–27; (4) Ltr, McFarland to Congressman Walter G. Andrews, 10 May 40, OO 474.2/2982; (5) Memo, Gen Marshall for SW, 23 Apr 40, sub: Investigation of Gen Staff Concerning M1 Semiautomatic Rifle (Garand), copy in *Hearings,* S. Mil Affairs Comm., 76th Cong., 3d sess., On Johnson Semiautomatic Rifle, S.3983, 29 May 1940, pp. 82–85.

would conduct exhaustive tests of the Springfield, Garand, and Johnson, along with a third semiautomatic recently designed by Winchester. Held by an organization that had no bias in favor of the Garand such as had been imputed to Ordnance, these tests commanded widespread interest and respect. The final report placed the Garand first among the semiautomatics; though no more accurate than the Johnson, it had proved itself more rugged and more reliable in operation. The old reliable Springfield led the field in accuracy, ruggedness, and dependability, but it simply could not pour out lead as fast as the semiautomatics. The Winchester gun proved too susceptible to breakdown to be a serious contender in the competition. With release of this report and adoption of the Garand by the Marine Corps, public criticism of the new rifle subsided. Meanwhile Ordnance remedied the defects in the early production models, and output of Garands rose rapidly as the long slow process of tooling up neared completion. As the emergency deepened, Springfield and Winchester were soon working around the clock; by mid-1941 Winchester was turning out over one hundred rifles per day, the Armory one thousand.[45]

Improved techniques helped speed production and saved both time and scarce materials. For barrel manufacture, Springfield abandoned its practice of buying round bar stock of uniform diameter and substituted forged barrel blanks tapered toward one end. Time on the turning lathe machine for each barrel was cut in half. Cutting the rifling by broaches also saved time and yielded a better product.[46] The introduction of tumbling as early as 1940 to supplant burring and filing of several small components was another production short cut that grew in importance during the war. As they came from the machines, small parts were put in a mixture of light abrasive and oil or water in used beer kegs obtained from the local brewery. The kegs were then rotated gently until the parts were worn smooth and could be rinsed clean with hot water.[47] All these short cuts were important, for the Garand was not an easy gun to make. It consisted of some seventy parts and required nearly one thousand machining operations.[48]

As a result of all these efforts, U.S. troops entered World War II with semiautomatic rifles that gave them a decided advantage over their enemies. No other major power equipped its soldiers with a really good semiautomatic rifle. The Rus-

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[45] Report of Board to Conduct Competitive Test with Caliber .30 Rifles Held at Marine Corps Base, San Diego, Calif., 12 Nov 40–21 Dec 40, dtd 15 Jan 41, prepared by Hq Fleet Marine Force, Marine Corps Base, San Diego, Calif., OKD 474.1/27.1. The report of the Marine Corps board is also quoted in detail in Hatcher, *Book of the Garand,* pages 141–52. For further comments on the test, see (1) Mitchell, Hist of Small Arms Matériel, U.S. Rifle Cal. .30 M1, 12 Dec 44, p. 14; (2) Robert McCormick, "What Have We Got for Guns," *Collier's,* May 3, 1941, pp. 14–15; (3) "Report on the Garand," *Time,* March 12, 1941, pp. 20–21; (4) Smith, *Small Arms of the World,* p. 157; (5) Sharpe, *op. cit.,* pp. 503–12. On production, see Hist, Springfield Armory, vol. II, bk. II, pp. 95–96 and chart following p. 145; Davis, PSP 37, U.S. Rifle Cal. .30, Jul 45, p. 66, OHF.

[46] "Rifling Machine-Gun Barrels by Broaching," *Machinery,* vol. 49, No. 2 (October 1942), 157–59.

[47] Hist, Springfield Armory, vol. II, bk. II (1939–41), pp. 86–105. For a description of older manufacturing techniques, see Col. Gilbert H. Stewart, "Springfield Armory Tools up for New Semi-Automatic Rifles," *Machinery,* vol. 45, No. 5 (July 1939).

[48] Brig. Gen. James Kirk, "Machining the Garand Rifle," *Iron Age,* vol. 151, No. 19 (May 13, 1943), 66–71.

sians used the M1940 Tokarev rifle extensively but abandoned it because of its many inherent defects. During the war the Germans produced a few semiautomatics but they were never very effective and did not reach the battlefield in significant numbers. The standard German rifle at the end of the war was still a bolt-action piece. The only reasonably satisfactory Japanese semiautomatic in World War II was an imitation of the Garand.[49]

The Carbine Enters the Picture

One of the most popular items of ordnance used by American troops in World War II was the lightweight carbine. Designed to replace the automatic pistol for certain purposes, it was intended primarily as a defensive weapon for service troops; but it also appealed to combat infantrymen as a companion weapon for the more powerful Garand, and was affectionately nicknamed "baby Garand." Fully loaded with a 15-cartridge magazine and with sling attached, it weighed less than six pounds and was about three feet long. It was fairly accurate at ranges up to three hundred yards—at least four times the effective range of the pistol. A gas-operated, semiautomatic weapon, the carbine followed some of the design principles of the Garand, but with certain distinctive features.

Selecting the Best Design

By definition, a carbine is a light rifle with a short barrel, commonly used during the nineteenth century by mounted troops. Early in the twentieth century, carbines passed out of the picture in the United States as the Springfield rifle, adopted in 1903, proved satisfactory for both mounted and foot troops. But by the 1940's, aircraft, tanks, and new infantry weapons had brought about marked changes in military tactics. Cavalry was no longer as important as it had been, but new elements with even greater mobility had come on the scene with the result that flanks and rear areas, including airfields, were under constant threat of air or mechanized attack. At the same time, the addition to small infantry units of such weapons as machine guns, trench mortars, and antitank guns brought the need for an auxiliary offensive-defensive weapon for the soldiers who manned them or carried ammunition for them. The pistol was ideal for combat at point-blank range. It was issued to officers, to troops manning crew-served weapons, and to rear area service troops, but few soldiers could hit anything with it beyond twenty-five yards. As a full-size rifle was unnecessarily heavy for such troops, the carbine seemed to be the answer.[50]

The Infantry, as early as 1938, had asked that Ordnance develop a .30-caliber carbine weighing five pounds or less, and with an accuracy range of three hundred yards. Ordnance objected on the ground

[49] (1) DA Pamphlet 30–50–1, Handbook on The Soviet and Satellite Armies, pt. I—The Soviet Army, Mar 53, p. 96; (2) *Biennial Rpt of the Chief of Staff of the U.S. Army to SW, Jul 1, 43–Jun 30, 45*, pp. 97–98; (3) Shields, *From Flintlock to M1*, p. 172; (4) Smith, *Small Arms of the World*, pp. 153, 157–58; (5) PSP 83, Small Arms Development in World War II, Jul 47, by R&D Div, p. 4.

[50] History of Small Arms Matériel, U.S. Carbine, Cal. .30, prepared by Maj. H. P. Smith and William H. Davis under the direction of Mitchell [1945]. This manuscript study, prepared in the Small Arms Branch of the Industrial Service, is the best account of carbine development and production. See also Brig. Gen. James Kirk, "Manufacturing the Light Carbine," *Iron Age*, vol. 151, No. 14 (April 8, 1943), 47–52.

that such a weapon would require special ammunition. But the Infantry pressed its demand, and in the fall of 1940 a definite requirement was set up for a weapon of this type.[51] Thereafter events moved with bewildering speed. Ordnance requested Winchester, which had extensive experience with ammunition for semiautomatic weapons, to undertake design of a cartridge for the proposed carbine. Modeled on an existing Winchester .32-caliber cartridge, the new carbine ammunition was submitted in November 1940, found satisfactory, and approved for production in small experimental lots.[52]

Meanwhile Ordnance had sent a circular to gun manufacturers and designers throughout the country inviting submission of model weapons for preliminary engineering tests. Of the nine models presented for trial in the summer of 1941, three did not meet the general specifications and were withdrawn, leaving six models actually tested. Though all showed promise, none was entirely satisfactory. As a result of the tests, the Ordnance Committee dropped the requirement for full-automatic fire, deciding that the proposed carbine should be strictly semiautomatic. Two of the guns tested showed such promise that five toolroom models of each, embodying the improvements recommended after the tests, were ordered. One was the Bendix Aviation Corporation entry designed by George J. Hyde; the other was the Springfield Armory entry designed by John C. Garand. In August 1940, Hyde had become associated with the Inland Manufacturing Division of General Motors Corporation, and had constructed there the toolroom models of his design. At the same time, Inland signed a contract for preparation of production studies of both the Hyde and Garand models.[53]

Since none of the models tested in May and June proved satisfactory, Ordnance extended the deadline until 15 September 1941, the date set for the final service tests. It urged inventors to improve and resubmit their guns, and invited designers who had not yet entered the contest to do so. In July 1941 Ordnance, impressed by an improved version of Winchester's semiautomatic rifle, asked Winchester to build a sample carbine of similar design. Fully occupied with production of the M1 rifle and other development work, Winchester had not submitted a carbine for the earlier tests. But in just fourteen days after accepting Ordnance's invitation to construct a carbine, Winchester completed a handmade first model. Though not a finished product, it passed its preliminary tests at Aberdeen on 11 August 1941. There remained only thirty-four days for Winchester to perfect its design and complete an improved specimen for entry in the general service tests set for 15 September. After intensive day and night work

[51] (1) Record of Army Ordnance Research and Development, vol. 2, Small Arms and Small Arms Ammunition, bk. I, ch. 2, Jan 46, OHF; (2) Design, Development and Production of Carbine, Cal. .30, Jan 45, by OCO, p. 1, OHF; (3) Ltr, CofInf to CofOrd, 25 Mar 38, sub: Weapons and Ammo Carriers, OO 474/3991; (4) Ltr, CofInf to TAG thru CofOrd, 16 Sep 38, sub: Light Weapons for Ammo Carriers, OO 474/4246; (5) Ltr, CofInf to TAG, 15 Jun 40, sub: Carbine for Infantry Soldiers, with Indorsements 1 through 7, OO 474.5/120.

[52] (1) Hist of Small Arms Matériel, U.S. Carbine, Cal. .30, 1945; (2) Design, Development, and Prod of Carbine, Cal. .30, Jan 45; (3) Sharpe, *op. cit.*, pp. 532–44.

[53] (1) Hist of Small Arms Matériel, U.S. Carbine, Cal. .30, pp. 6–7; (2) Hist, Cincinnati Ord Dist, vol. I, pt. 2, 1922–42, pp. 23–26; (3) Hist, Cincinnati Ord Dist, vol. 100, pt. 2, Contractor Histories—Inland Div of General Motors Corp.

that set a new record for weapon development, Winchester met the deadline.[54]

All told, six models were entered in the September tests, including one each of the two designs that had earlier showed such promise that Ordnance had ordered toolroom models. The Winchester carbine outperformed them all. On 30 September 1941, exactly one year after Ordnance had first announced that a carbine was desired by the Army and only two months after Winchester had started work on its design, the Ordnance Committee recommended standardization of the Winchester model. This recommendation was formally approved on 22 October 1941, and the new weapon was given the designation carbine, caliber .30, M1.[55]

Production Contracts

Just as speed had keynoted development of the new weapon, speed became the goal for getting into production. The first requirement was set at 886,698, and funds were at once made available for procurement.[56] Since Winchester's facilities were inadequate to turn out this number, Ordnance selected as a second contractor GMC's Inland Division, which had gained some knowledge of carbine manufacture through its production studies of the Hyde, Springfield, and Winchester models. Without waiting until an agreement could be worked out with the government regarding manufacturing rights, Winchester quickly agreed to share its knowledge with Inland. In November 1941, Ordnance placed large contracts with both Winchester and Inland for each to produce at the rate of one thousand per day.[57] Soon thereafter Winchester assigned a license to the United States Government for production of M1 carbines in exchange for a fee of $886,000.[58]

Post-Pearl Harbor Requirements

Pearl Harbor found the United States with something over 1,600,000 rifles on hand, in depot stocks, and in the hands of troops, including state guards. They were mostly Springfields and Enfields, but included nearly 350,000 new Garands. The inventory also included about 480,000 pistols and revolvers, about 60,000 machine guns (mostly .30-caliber) and some 56,000 BAR's.[59] During the hectic weeks that followed the attack on Pearl Harbor, Anglo-American planners drew up ambitious programs for procuring millions of additional small arms. In his message to

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[54] The story of the carbine's development is briefly told by Edwin Pugsley, a Winchester executive, in his epilogue to Williamson, *Winchester —The Gun That Won The West,* pages 385–88. See also Edwin Pugsley, *Development of the .30 caliber M1 Carbine,* 12 Jul 44, a five-page historical summary filed in OO 474.5/8387, copy in OHF; Hist, SA Matériel, U.S. Carbine, Cal. .30, pp. 3–4; Sharpe, *op. cit.,* pp. 536–37; Johnson, *Rifles and Machine Guns,* pp. 46–48, 257–60; and Arcadi Gluckman, *United States Muskets, Rifles and Carbines* (Buffalo: O. Ulbrich Company, 1948), pp. 444–47.

[55] (1) OCM 17278, 30 Sep 41; (2) OCM 17360, 22 Oct 41.

[56] Design, Development and Prod of Carbine, Cal. .30, Jan 45, p. 6.

[57] (1) *Ibid.;* (2) Memo, CofOrd for Brig Gen Rutherford, OUSW, 4 Nov 41, sub: Proposed Site for Manufacture of Rifle, U.S. Carbine, Cal. .30, M1, at Inland Mfg. Div. . . , OO 675/21715 Misc.; (3) Ltr, CofOrd to OUSW, 31 Oct 41, sub: Negotiated Contract (re M1 Carbine at Winchester), OO 160/78532; (4) Hist of SA Matériel, U.S. Carbine, Cal. .30, pp. 16–17; (5) Hist, Cincinnati Ord Dist, vol. I, pt. 2, 1922–42, pp. 23–36 and vol. 100, pt. 2, Contractor Histories Inland Div, GMC.

[58] (1) Design, Development and Production of the Carbine, Cal. .30, p. 26, citing contract ORD-625, OO 160/131149; (2) Pugsley, Development of the .30 Caliber M1 Carbine; (3) Sharpe, *op. cit.,* pp. 538–39.

[59] These figures were compiled from a variety of documents in small arms document notebook, OHF.

Congress on 6 January 1942, President Roosevelt set the pace by listing requirements for one million machine guns of all kinds. In the Army's munitions program of February 1942, rifle requirements were set at four million for the year 1942; the staggering total of twelve million rifles became the goal for production by June 1944. In addition, more than four million carbines were to be turned out during the same 30-month period, plus three and a half million pistols and five million submachine guns. The grand total was twenty five million weapons.[60] Only about one-third of the rifles were for United States forces; the remaining two-thirds—over five million Springfields, nearly a million Garands, and over a million Enfields—were scheduled for lend-lease.

Even for some of the Army people these figures appeared high. The following exchange at the production conference on small arms in February 1942 illustrates the feeling of incredulity with which some planners viewed the post-Pearl Harbor requirements:

> Gen. Somervell: I would just like to ask a question. It may be terribly ignorant, but we set up for an American army of 10 million people, 528,000 of these machine guns. Now we are proposing to build 1,302,000 of them. In other words, it will be for an army of about 24 million people.
>
> Judge Patterson: What's this? Where do you get that figure?
>
> General Somervell: Take line three. . . . God, I just don't believe it.
>
> General Aurand: I can explain it . . . About from 75 to 80 percent of the tanks that are on this program are Defense Aid tanks. . . . If we are going to get the tanks . . . and other things that are in there, we are going to have these machine guns for them.
>
> General Moore: They are basing that on a lot of wastage, a lot of short life for tanks, and of course if a tank goes out, a machine gun goes with it. So it really isn't based on the number of men: it is based on the tanks.[61]

To supply U.S. ground forces with small arms, to provide machine guns for airplanes and tanks, and to meet the sometimes frantic demands of friendly nations —all this added up to an impossible production load. Ordnance drew up plans to boost output of rifles, machine guns, submachine guns, and pistols, but by June 1942 requirements were scaled down, chiefly through cuts in lend-lease. Garand rifles, for example, were eliminated altogether from foreign aid and were reserved exclusively for U.S. forces. By November 1942 requirements had been cut still further to bring them within the realm of possible achievement. Lend-lease requirements were set at about two and a half million rifles, mostly .303-caliber Lee-Enfields. For U.S. forces the November 1942 Army Supply Program called for more than three and a half million Garands and nearly five and a half million carbines by December 1944. Production schedules for these two weapons were closely coordinated because it was hoped that a shortage of one could be temporarily offset by increased production of the other.

Rifle Production

World War II rifle production in the United States included five main types: the Springfield, the Browning automatic

[60] (1) Overall Requirements for War Munitions Program, 11 Feb 42; (2) Memo, USW for G-4, 21 Feb 42, USW file 104 Rifles, copy in OHF.

[61] Review of Prod Plans of the SA Div, 20 Feb 42, pp. 29-30. See also Memo, USW for G-4, 21 Feb 42, wherein Patterson asked for a review of the huge requirements for small arms, and Memo, G-4 for USW, 23 Feb 42, wherein Somervell defended existing requirements. Both in USW file 104 Rifles, and copy in OHF.

rifle (BAR), the Brtitish Lee-Enfield, the Garand, and the carbine. (*See Table 15.*) The newest and smallest, the carbine, won the quantity production laurels, its more than six million nearly equaling the total for the other four. The Garand was the preferred weapon for front-line troops, but during 1942 and 1943 its production could not keep up with demand. Oldest of the lot was the Springfield, adopted while Theodore Roosevelt was in the White House but still able to hold its own when matched with newer designs, and useful as a substitute for the Garand. Most unusual from the production viewpoint was the BAR, manufactured chiefly by a group of firms known as the New England Small Arms Corporation.

Springfields

As noted above, manufacture of Springfield rifles for the British got under way in 1941 at Remington's Ilion plant with machinery shipped from Rock Island. But many problems arose. Some machine tools needed by Remington were not supplied by the arsenal, and many were badly worn from previous hard use. Remington had to obtain hundreds of new manufacturing drawings as well as a largc number of gages. Worst of all, the tools and techniques from Rock Island were outdated; newer and cheaper manufacturing processes developed since 1918 had not been adapted to manufacture of the Springfield rifle. In the early days, highly skilled craftsmen had literally hewn parts of the Springfield out of solid steel blocks and, by careful machining and hand finishing, had produced components that functioned so well when assembled that every gun fancier was proud to own a Springfield. But such methods were costly in terms of time, materials, and skilled manpower.

Just as the first pieces were coming off the line at Ilion, Pearl Harbor brought a desperate need for speedier production. Remington at once began work on design changes and improved techniques to simplify manufacture. It eliminated the polishing of outside surfaces; increased tolerances on outside surfaces to permit finishing of forgings by buffing instead of machining; redesigned twenty-three parts so they could be made of stampings instead of forgings; and eliminated several parts completely. As a result, each rifle required less steel, less labor, and less machine-tool time. More parts were subcontracted to firms with stamping facilities. The modified gun—no longer the collector's pride, but still an effective weapon—was approved for manufacture in May 1942 as M1903A3.[62] Another change to speed production came later when tests at Aberdeen proved that two rifling grooves gave just as good results as the traditional four, but the effect on production was not great because plants already tooled for 4-groove production continued without change.[63]

[62] (1) Hist. Rochester Ord Dist, vol. 100, pt. 9, Contractor Histories—Summary Report, Production of Rifle, U.S. Cal. .30 M1903 and M1903A3 at Ilion Works of the Remington Arms Co., Inc., 9 May 45, by Remington Arms Co., Inc.; (2) Mitchell, Hist, SA Matériel; U.S. Rifle Cal. .30 M1903, [1945], pp. 23–28; (3) Ltr, Rochester Ord Dist to OCO, 14 Jun 44, sub: Historical Data—SA Matériel, with attached rpt dtd 15 Jun 44, sub: Production of Rifles, U.S. Cal. .30 M1903 in Rochester Ord Dist, pt. I Remington Arms Co., OO 474/3053; (4) Ltr, Col Drewry, OCO to Rochester Ord Dist, 22 Apr 42, sub: Change in Contract DA-W-740-Ord-36 Remington Arms Co., OO 400.3295/55624 Misc. (x); (5) Ltr, Remington Arms Co., Inc., to Col Guy H. Drewry, 19 Feb 42, re modification of M1903 rifle, OO 474.1/1132.

[63] (1) Mitchell, Hist, SA Matériel, U.S. Rifle Cal. .30 M1903 [1945], p. 31; (2) OCM 19053,

Requirements for Springfields were so high in early 1942 that Ordnance brought in a second producer, the L. C. Smith-Corona Typewriter Corporation of Syracuse, N.Y. The first contract was for 100,000 rifles followed in July by a second order for 280,000 to be completed by December 1943. Smith-Corona subcontracted with twenty other firms for minor components. Production was hampered by the fact that Remington had not completed its redesign work before Smith-Corona started production. A continuous series of design changes marked the production period, with one change order in July 1943 affecting practically every component.[64]

By the fall of 1943 termination of contracts for Springfields was in sight, for Garands and carbines were by then being turned out in quantity and requirements had been lowered. Remington and Smith-Corona completed their final rifles in February, 1944. Remington continued with the manufacture of spare rifle parts while Smith-Corona, after completing 234,580 M1903 rifles, returned to making typewriters. Total output of the two contractors was 1,318,951 M1903 rifles of all types.[65]

Lag in Garand Production

In the fall of 1941 Springfield Armory's production of 1,000 Garands per day looked good, but after Pearl Harbor it fell far short of meeting requirements. It had to be raised to 2,000 per day, and then boosted to 3,000 while Winchester raised its output from 100 per day to 750. In August 1942, total production amounted to 68,660 for the month while requirements to the end of the program in June 1944 stood at about four million, or 200,000 per month. It was a huge gap that was not closed until the war was nearly over.

All during 1942, 1943, and early 1944 production of the Garand lagged behind requirements, lending support to the argument of critics that it was a hard-to-manufacture weapon. Springfield was plagued by one problem after another.[66] Slow deliveries of new equipment hampered it at the outset, and then lack of materials slowed production. Late in 1942 the War Production Board, apparently acting without full knowledge of the facts, canceled the Armory's order for receiver steel with the result that forging operations on receivers stopped for four weeks. New broaching techniques were adopted to save time and material, but for a long period the Armory's broaching capacity was insufficient to meet the rifle schedule of 90,000 per month. Labor turnover, including the drafting of several experienced machine operators, also held back production. At Winchester, slow delivery of new heat-treating furnaces delayed production. The requirement of complete interchange-

15 Oct 42; 19129, 4 Nov 42; (3) Ltr, Maj Sam Marshall, OCO, to CO, Springfield Armory, 23 Oct 42, sub: Two Groove Rifling for Rifle Barrels, OO 474.4/802; (4) Julian S. Hatcher, *Hatcher's Notebook* (Harrisburg, Pa.: The Military Service Publishing Company, 1947), pp. 7, 17.

[64] Hist, Rochester Ord Dist, vol. 100, pt. 9, Contractor Histories—Rifle Production at the Syracuse Plant of L. C. Smith & Corona Typewriters, Inc. during World War II, 14 May 45, by Harold McD. Brown.

[65] (1) Whiting, Statistics, Proc sec., 9 Apr 52, p. 47; (2) PP 76, Small Arms and Small Arms Ammunition, Design, Development and Procurement 1917–45, Jun 45, pp. 6–10.

[66] As an example, see Ltr, Col G. A. Woody, Springfield Armory, to CofOrd, 25 Feb 41, sub: Expansion of M1 Rifle Prod, OO 400.12/4138, copy in OHF.

TABLE 15—RIFLE PRODUCTION, 1940–1945

Type of Weapon	Quantity
Garand (including 6,896 sniper models)	4,014,731
Springfield (including 28,365 sniper models)	1,318,951
Browning automatic (BAR)	188,380
Lee-Enfield, .303-caliber (British)	1,030,228
Carbines, .30-caliber	6,117,827

Source: Whiting, Statistics, Table PR-8.

ability of all parts caused Winchester the most trouble, for in commercial practice such interchangeability was not required.[67] Considering the long period of preparation at Springfield Armory, Winchester's educational order in 1939, and the urgency of Garand production, output during the 1940–42 period was a major disappointment in the Ordnance record. The weapon's high quality was not matched by a sufficiently high rate of production until the end of 1943.[68] (*Table 15*)

Carbines

The ink had barely dried on the first two carbine contracts with Winchester and Inland in 1941 when the United States found itself at war. Before Pearl Harbor, requirements for carbines had stood at 886,698, but the War Munitions Program drawn up in February 1942 listed over one million needed by the end of 1942 and over three million by the end of 1943. As Winchester and Inland were being set up to produce only one thousand each per day and could not start producing at all before June, achievement of the one million goal for 1942 was clearly impossible for them. Part of the 1942 shortage could be offset by speeding production of Springfields and by issuing old Enfields in place of carbines, but for the future additional producers had to be lined up. As no single plant could meet the whole deficit, five smaller plants were placed under contract, each to turn out thirty thousand carbines per month. Known as the second wave of carbine plants, these were the Rock-Ola Company and Quality Hardware and Machine Company, both of Chicago; Irwin-Pederson Arms Company of Grand Rapids; Underwood-Elliott-Fisher Company of Hartford, Conn.; and the Rochester Defense Corporation of Rochester, N.Y.[69] Most were inexperienced in munitions making, having turned from making hardware, juke boxes, and

[67] See General Report on Small Arms Production, 18 Mar 43, by War Projects Unit, Bur of the Budget, pt. VII, copy in OHF.

[68] Manufacturing and inspection techniques are discussed below in Chapter XIV; in Hist, Springfield Armory, vol. II, bk. II, 1939–41, pp. 100–104; and in PSP 76. For conservation of materials, see Green, Thomson, and Roots, *Planning Munitions for War*, ch. XVIII.

[69] Rochester Defense Corp. was taken over by the National Postal Meter Co. in the summer of 1942, and National Postal Meter became Commercial Controls Corp. in 1944; (1) Design, Development and Production of Carbine Cal. .30, Jan 45, by OCO, pp. 7–9; (2) Hist, SA Matériel, U.S. Carbine Cal. .30 [1945], pp. 18–21; (3) Correspondence between OCO and OUSW in Mar and Apr 42, filed in OO 160; (4) History, Procurement of Carbine Cal. .30 M1 in Chicago Ord Dist, 28 Jun 46, by Samuel O. Rice, Historian Chicago Ord Dist, filed in Hist, Chicago Ord Dist, vol. 100, pt. 3—Contractor Histories.

typewriters; yet all but one proved successful.

No sooner had these five new producers been added than further expansion became necessary. By June 1942 carbine requirements had jumped to over four million needed by the end of 1943. In what was known as the third wave of expansion a contract was awarded in August 1942 to Standard Products Company of Port Clinton, Ohio, for manufacture of carbines at the rate of forty five thousand per month.[70] Meanwhile Inland had started producing in June, only six months after signing its contract, and by the end of the year reached a rate of one thousand per day. Winchester started producing in September, followed by Underwood-Elliott-Fisher and Rock-Ola in November. Although the November 1942 Army Supply Program made deep cuts in most items, the drop in carbine requirements was slight and the need for additional producers again became apparent. In January and February 1943 contracts were placed with International Business Machines Corporation and Saginaw Steering Gear Division of General Motors Corporation, both of whom were nearing completion of orders for other types of small arms. This so-called fourth wave brought the total of carbine prime contractors to ten. Of this group, Inland, the first plant to start producing, became the leader, making available to other firms the details of its manufacturing techniques along with drawings and specifications for tools, jigs, and fixtures. Because of its close contacts with gage manufacturers, Inland was awarded a contract for procurement of gages for the entire carbine program.[71] Of all the carbine contractors, the only one that failed to produce was Irwin-Pederson. After this concern experienced many production problems Ordnance canceled the contract, purchased the company's plant at Grand Rapids, and arranged for Saginaw Steering to operate it.[72]

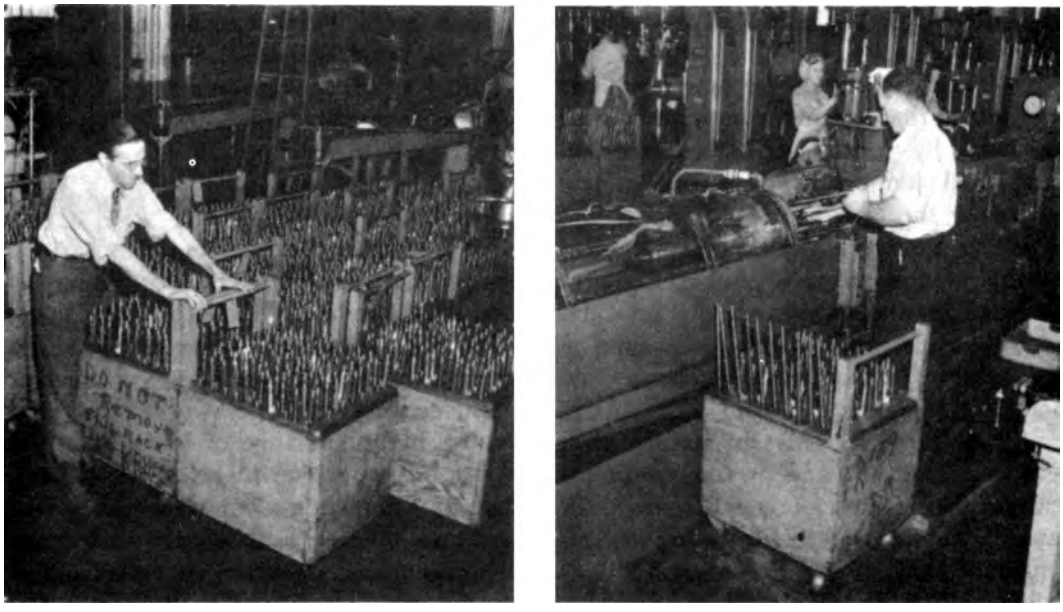
Integration Committees

With so many contractors in the carbine picture the need for over-all co-ordination soon arose. In late March 1942 Ordnance called together representatives of the seven prime contractors, discussed production problems, and gradually worked out procedures for interchange of ideas, raw materials, and machine tools. At first called Carbine Production Committee, this group later took the name of industry integration committee in common with other similar committees formed by the Ordnance Department. The carbine committee appears to have been the first such committee formed by the Ordnance Department, with the mechanical time fuze committee a close second. The carbine committee was headed in the beginning by Lt. Col. Ed-

[70] For a graphic description of this company's work, see Thomas E. Lloyd, "Mass Production of the Caliber 0.30 M-1 Carbine," *Iron Age,* vol. 152, No. 9 (August 26, 1943), 42-47.

[71] Rpt, Production History of Carbine Cal. .30 M1 and M1A1, filed as Incl 1 to 1st Indorsement, Cincinnati Ord Dist to CofOrd, 22 Apr 44, sub: Historical Data, Carbine Cal. .30 M1, Inland Manufacturing Co., OO 474.5/7279.

[72] (1) Ltr, Brig Gen James Kirk, OCO, to Detroit Ord Dist, 20 Mar 43, sub: Contract W-374-Ord-1548 with Irwin-Pedersen Arms Co., with attached Ltr, Maj Gen Thomas J. Hayes, OCO, to Director of Purchases Div SOS, 10 Mar 43, sub: Termination of Order for 146,735 Carbines, M1, with Irwin-Pedersen. . . , OO 160/94129—Irwin-Pedersen Arms Co.; (2) *Out of the Valley to Victory,* published by Saginaw Steering Gear Div of GMC in 1943; (3) Rpt, Historical Data on Carbine Cal. .30—Irwin-Pedersen Co. and Saginaw Steering Gear Div of GMC, 1 Jul 44, filed in folder marked Hist of Carbine Cal. .30, OHF.



PRODUCING CARBINE BARRELS. *Finished barrels ready for the assembly department (left); broaching the rifling grooves in the carbine barrels (right).*

ward C. Franklin as chairman and Mr. D. M. Fincke of the Underwood-Elliott-Fisher Company as assistant chairman. It became a central clearing house for all sorts of problems encountered by the prime contractors.

In the early stages, the committee held meetings every month or six weeks to discuss engineering changes that would improve the functioning of the carbine or speed its manufacture. It forwarded recommendations to the Office Chief of Ordnance and Springfield Armory for review and approval.[73] Meetings to discuss inspection procedures were held at regular intervals and included representatives of district offices and resident inspectors from each carbine plant. At frequent intervals the committee conducted interchangeability tests as checks on the standardization of inspection procedures at the various plants. Carbines from each plant were brought together, disassembled, their parts systematically scrambled, and then reassembled and tested.[74]

A special problem for carbine producers was the supply of alloy steel. Though the amounts required by the individual carbine contractors were small, the contractors were compelled to buy in large quantities at the insistence of the steel mills, which would deliver only minimum mill heats. This left some carbine producers with a year's supply of steel on hand while

[73] See Flow Chart of Carbine Industry Integration Committee Engineering Changes in History of Carbine Industry Integration Committee and Prior Carbine Committee, pt. IV, OHF.

[74] Hist, Carbine Industry Integration Comm. and Prior Carbine Comms., 15 Apr 44, OHF. This history reproduces many of the basic documents and describes the activities of the committee in detail.



COMPLETED CARBINES, *.30-caliber M1, are checked by company inspectors at end of assembly line.*

other producers were unable to get enough to assure continuous production. To deal with this situation a Raw Materials Facility, or central steel warehouse, was established and operated under contract by Brace-Mueller-Huntley, Inc. The carbine contractors, together with machine gun and other small arms contractors, placed their special steel orders with this central warehouse; it in turn pooled them into large orders placed with the steel mills. The Raw Materials Facility contract was canceled in the spring of 1943, shortly after the Controlled Materials Plan became effective.[75]

The Production Record

Only 115,000 carbines were delivered in 1942 against a requirement for more than one million, and Springfields and Enfields had to be substituted for carbines. But in 1943, with ten plants in production, output reached nearly three million, against a requirement for four million. As requirements for 1944 were only half those for 1943, the deficit was carried over to make 1944 requirements approximately three million. The end of 1943, with production at the rate of 500,000 per month, found Ordnance planning drastic cuts in carbine capacity. Action followed promptly, and of nine firms in production in January only two, Inland and Winchester, were still

[75] (1) Hist, Ind Serv, SA Div, vol. I, 1939–43, pp. 10–11 and vol. VII, Hist of Small Arms Raw Matériels Facility at Rochester, N.Y.; (2) Ltr, Brig Gen Levin H. Campbell, Jr., to OUSW, 6 Feb 42, sub: Proposed Establishment of a Central Warehouse for Supply of Steel for SA Mfg, OO 160/117290; (3) Planning Sheets, Equipment Sec of ASP, by SA Div, Ind Serv, 15 Jun 42, p. 4 and 15 Sep 42, p. 11.

producing in June. Both the latter firms were low-cost producers and both were in noncritical labor areas. Between them they were easily able to meet carbine requirements for the rest of the war. Total production of carbines during three and a half years was a little over six million, probably the greatest quantity of small arms of any kind ever produced in such a short time.

In the spring of 1944 the Army achieved its original goal—a carbine that could be set for full automatic as well as semiautomatic fire. The M2 carbine, as it was called, went into production at Inland in April 1944 and at Winchester the following month. By April 1945, with the collapse of all German resistance in sight, Inland had reached a production rate of more than 100,000 per month. Meanwhile M1 carbines not yet issued to troops were modified for selective automatic fire.[76]

The BAR

The Browning automatic rifle—part rifle, part machine gun—was familiarly known to U.S. infantrymen of both World Wars as the BAR. Only slight change occurred in the 1918 model during the 1920's and 1930's, and substantial quantities left over from World War I were held in storage. But, after transfer of some twenty-five thousand to the British in 1940–41, followed by rapid expansion of the U.S. Army, the post-Pearl Harbor requirement for 150,000 BAR's demanded immediate new production as well as modernization at Springfield Armory of the M1918's in stock. During the winter of 1941–42, six New England firms,[77] with encouragement from Ordnance, formed the New England Small Arms Corporation for manufacture of BAR's and other munitions, using some government-owned equipment left over from World War I. After award of the first contract early in 1942 this corporation continued throughout the war as the main source of BAR's. Manufacture of components was carried out by the six member companies in their own plants or by subcontractors. The corporation encountered its share of manufacturing problems, including scarcity of machine tools, slow delivery of materials, lack of skilled workers, and mistakes in Ordnance drawings.[78] But production began early in 1943 and eventually rose to a total of over 168,000 rifles plus spare parts.

Ordnance had meanwhile placed a contract with a second producer, International Business Machines, to assure an adequate supply. This firm quickly reached the production stage and by May 1943 was turning out five thousand BAR's per month. A few weeks later requirements dropped and Ordnance terminated the contract after only about twenty thousand rifles had been produced. To make use of the equipment IBM had installed, Ordnance placed with IBM a substantial order for carbines, which were then on the critical list.[79]

Machine Guns

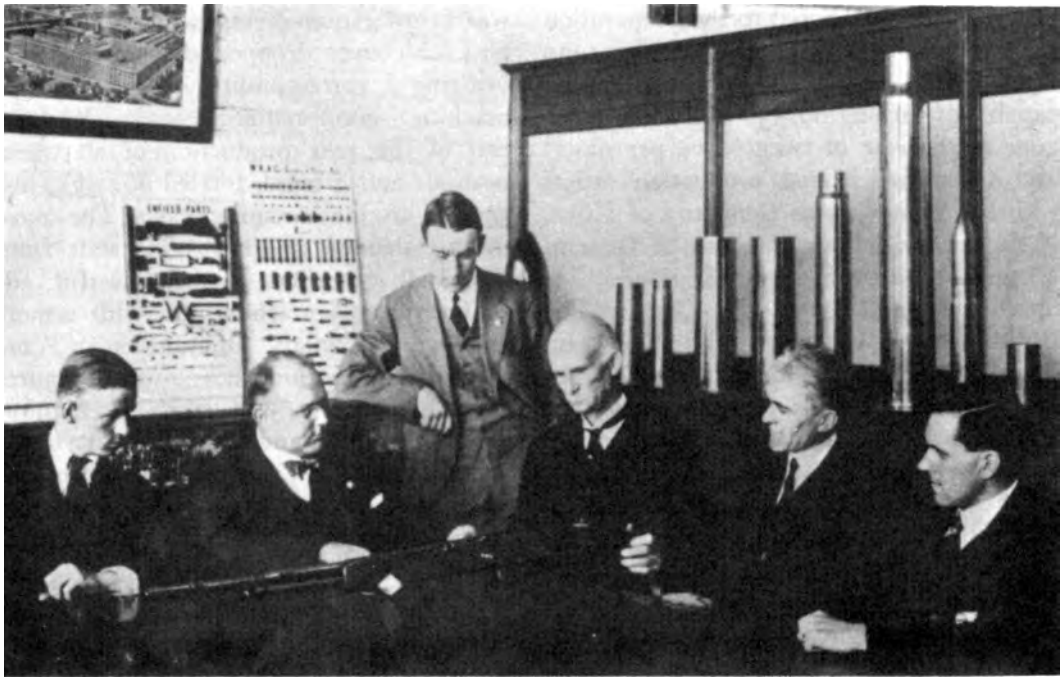
With about 140,000 machine guns left over from World War I, the Army felt no

[76] Supplement I to History of Carbines, Cal. .30, Jul 44 to Jun 45, by C. A. S. Howlett, 19 Jul 45, OHF.

[77] International Silver Co., Blake Mfg Corp., Elliott Addressing Machine Co., National Blank Book Co., A. G. Spalding and Brothers, and the Boston Wire Stitcher Co. See Hist, Boston Ord Dist, I, 65–66. See PSP 41, Browning Automatic Rifle, Development, Procurement and Production 1917 to 1945 by Capt. Charles H. Schroder; Hist, Boston Ord Dist, Jan–Jun 44, pp. 40–48.

[78] Hist, Boston Ord Dist, Jun 44, pp. 40–49, and vol. 100, pt. 6.

[79] Hist, New York Ord Dist, II, pt. 1, 372–77.



JOHN M. BROWNING, GUN INVENTOR, *attending a World War I conference with officials of the Winchester Repeating Arms Company. From left: Val A. Browning, Edwin Pugsley, Fred Werme, Mr. Browning, Frank F. Burton, and William C. Roemer.*

urgent need for new production during the 1920's and early 1930's. As time went on, the various wartime types—Lewis, Vickers, Marlin, and others—were one by one declared obsolete, though prudently kept in storage for an emergency, until only the Browning models remained as standard. At Springfield and Rock Island the M1917 Brownings were modified and given new designations, M1917A1 (water-cooled) and M1919A4 (air-cooled). The one outstanding machine gun development of these years was the redesign of the .50-caliber Browning machine gun so that it could be quickly converted to serve as tank, aircraft, or antiaircraft weapon. The heavy barrel of the tank gun, the water-jacket barrel of the AA gun, or the lighter parts of the aircraft gun could be attached in a matter of minutes without modification of the basic receiver. This simplified design, adopted in 1933, eased manufacture, maintenance, and troop training throughout the war.[80]

Of the commercial gunmaking firms in the United States, only Colt retained active interest in machine guns during the interwar years. Under contract with Ordnance, it made production studies on

[80] (1) Chinn, *The Machine Gun*, vol. I, pt. IV; (2) Green, Thomson, and Roots, *Planning Munitions for War*, p. 178; (3) PP 36, U.S. Machine Guns, Calibers .30 and .50, Development, Requirements and Production 1940–45, Jul 45, pp. 37–38; (4) PSP 36. The latter, a 268-page typed study, is the best single source for machine gun production data.

Browning guns, both .30-caliber and .50-caliber, and contributed to the preparation of descriptions of manufacture. In 1939 Rock Island installed a production line capable of turning out .30-caliber machine guns at the rate of twenty five per day,[81] and Ordnance placed production orders with the Savage Arms Company of Utica, N.Y., and with four divisions of General Motors—Saginaw Steering, Frigidaire, AC Spark Plug, and Brown-Lipe-Chapin. The British placed contracts with Colt and three other firms to make machine guns for planes and tanks being built in the United States for the British Army, and to all these firms Ordnance released its latest designs. Thus, total machine gun production capacity created during the defense period for the U.S. Army and its allies was considerable. By Pearl Harbor, Ordnance had contracted for annual production of some 430,000 .30-caliber and 300,000 .50-caliber guns, and ten plants, including Rock Island, were in production. supported by scores of subcontractors.

When President Roosevelt announced his "must" program in January 1942, he called for the production of 500,000 machine guns each year for the next two years. The War Munitions Program of February 1942 put total requirements at 1,302,000 for 1942–43 and the first half of 1944. To meet the demand for aircraft guns Ordnance found itself well prepared; it was able to report in February 1942 that output of caliber .50's was running well ahead of plane production, so far ahead, in fact, that caliber .50's were being mounted on 37-mm. AA carriages as additional weapons. General Wesson had told his staff earlier: "Forget everything else, but be sure you have a gun on every plane that comes out of this country; I don't care where it goes, I want a gun for it." [82] For ground machine guns, capacity was below requirements early in 1942 but tank objectives dropped during the year, bringing a corresponding drop in ground machine gun requirements.[83] By the end of the year production of all types, both air and ground, totaled 662,331, just enough to meet requirements. The most sharply defined trend was the shift from the small .30-caliber to the powerful .50-caliber aircraft machine gun with armor-piercing, incendiary ammunition. (*Table 16*) Hidden within these over-all figures were many stops and starts as requirements were cut and factories shut down at one point only to be followed by an emergency demand for new production a few months later.

The .50-caliber aircraft gun program reached its peak during early 1944 when production capacity rose to 45,000 per month, just enough to meet the Army Supply Program requirement of 540,000 for the year.[84] With 1945 requirements set at 747,000 guns, Ordnance planned to build two additional plants, but dropped the matter during the second half of the year when requirements were cut and surplus machine guns piled up in Field Service warehouses. The contract with the Buffalo Arms Corporation, a high-cost

[81] Hist, Rock Island Arsenal, I (1918–39), 59–60.

[82] Review of Prod Plans for SA Div, 20 Feb 42, p. 20

[83] (1) Memo, USW for Glancy, 4 May 42; (2) Memo, ASF Prod Br for USW, 9 May 42, sub: Caliber .50 AA Machine Guns and Mounts; (3) Memo. Maj Gen Campbell for Glancy, 9 May 42, sub: Caliber .50 AA Guns and Mounts. All in ASF Prod Div 472.93 AA Guns, Job 19B, G1867; (4) PSP 36, pp. 93–97.

[84] Memo, CofOrd for ASF Prod Div, 10 Jan 44, sub: Capacity for Prod . . . , ASF Prod Div, 472.91 Aircraft Guns.

TABLE 16—MACHINE GUN PRODUCTION, 1940–1945

Size	[a]1940	1941	1942	1943	1944	[b]1945
.50-cal. (all types)	5,155	49,479	347,492	641,638	677,011	239,821
.30-cal. (all types)	3,633	27,672	314,839	188,331	121,771	62,977

[a] Covers only period from 1 July through 31 December 1940.
[b] Covers only period from 1 January through 31 August 1945.

Source: Whiting, Statistics, Table PR-8.

producer in a tight labor area, was terminated early in 1945, and Kelsey-Hayes was put in a standby status.

Production engineers worked miracles in simplifying processes, saving material, and speeding production of machine guns. Rifling broaches more than cut in half the time required for rifling barrels. Pearlitic malleable iron castings, known as Arma steel, not only saved scarce steel alloys but proved superior to the steel or bronze originally used for certain machine gun parts. Substitution of castings, stampings, or a combination of stamped and riveted parts for completely machined parts saved countless man-hours and machine-tool-hours, and resulted in lower costs. There were problems, too, that had to be ironed out through the Machine Gun Industry Integration Committee. Some problems stemmed from the fact that commercial machine gun production had been on a small scale during the preceding two decades, and had been limited to one manufacturer. Colt's small peacetime orders had not warranted extensive application of mass-production techniques. Tolerances, specifications, and inspection rules had not been worked out in sufficient detail to guide numerous producers unfamiliar with gunmaking, nor were the rules always applied in the same way. The General Motors plants, for example, complained that inspectors were rejecting parts for exceeding tolerances on the drawings although the parts were identical with those taken from sample guns made by Colt. Tripods were the chief bottleneck in 1941 and could be turned out in adequate quantities only by adopting less complicated designs.[85] An Army inspecting officer reported in April 1943 that, although production to date had been "extremely satisfactory," some of the older plants clung to outmoded methods, resisted change, and were generally less efficient than the newcomers.[86] But, all things considered, machine gun production was one of the most successful features of the whole Ordnance program.

Submachine Guns

In June 1942 Ordnance placed an order for a new type of Thompson submachine gun, the M2, with the Marlin Firearms Company of New Haven, Conn.; but, before production started, the M3 supplanted

[85] These matters appear frequently in Gen. Wesson's conference in 1941 and PSP 36, pp. 158ff. See also (1) Armament section of *American Machinist*, vol. 85, (July 23, 1941); (2) Memo, Maj Gen Campbell for Glancy, 9 May 42, sub: Cal. .50 AA Gun and Mounts, ASF Prod Div 472.93 AA Guns, Job 19B, G1867.

[86] Ltr, Lt Col Jack G. Allen to TIG, 12 Apr 43, sub: Study of . . . Machine Gun Proc, ASF Prod Div 472—Guns.

the M2.[87] Built along the lines of the British Sten and the German Schmeisser, the new gun had been designed by the Inland Division of General Motors. As all Inland's capacity was committed to production of the carbine, a contract for the M3 went to another General Motors division, Guide Lamp, with Buffalo Arms Corporation making the bolt.

The M3, nicknamed the "grease gun" for its resemblance to the tool used for lubricating automobiles, weighed less than a Garand, yet it could fire .45-caliber pistol ammunition at a rate of four hundred shots per minute and could be produced for as little as $20. It was of the type known in Europe as "machine pistols." With its folding stock and barrel removed for packing it was small enough to fit into a briefcase. In contrast to the precision-made Thompson the M3 was designed for cheap mass production with unskilled labor, making full use of stamped metal parts and other short cuts. But it did not escape manufacturing problems. There were so many manufacturing problems, in fact, that, for lack of M3's, manufacture of M1's had to be continued into February 1944 instead of stopping as planned in the fall of 1943. All told, some 621,000 M3's were produced as compared to roughly twice that number of Thompsons and M1's combined.[88]

In making M3's, Guide Lamp adopted an entirely new process for rifling the barrel, using neither the traditional hooked cutter that required an experienced operator nor the more or less automatic broaching machine. Instead, it inserted in each barrel a mandrel that had the rifling lands and grooves cut on its outside surface in reverse. A powerful hydraulic press then forced the barrel through a ring die, squeezing it forcibly against the hard steel mandrel and thus imprinting the rifling on the inside of the barrel. The barrel's tight grip on the mandrel was then loosened by an ingenious centerless rolling machine that stretched the metal slightly. The whole sequence of press work, rolling, and mandrel removal could be performed by three girls, and each mandrel, made of special nondeforming steel, lasted for thousands of barrels.[89]

The Bazooka Rocket Launcher

Most impressive small arms development of the year was the 'bazooka'—a rocket-launching device operated by two men. Armed with this weapon, the individual foot soldier possessed, for the first time, the means whereby he could, single-handedly, do battle with a tank.

So wrote the Chief of Ordnance in his annual report for the fiscal year 1943. After a century of neglect the rocket had again come into its own as a weapon of war, and the United States, though slower than other countries to take it up, made rapid strides after Pearl Harbor.[90]

In its original form the bazooka was one of the simplest pieces of equipment ever produced by Ordnance. It consisted essentially of a 54-inch steel tube of 2.36-inch inside diameter, open at both ends, equipped with two hand grips, a trigger, and simple sights. When Ordnance first

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[87] The M3 was standardized by OCM 19401, 23 December 1942. For research and development, see Rcd of Army Ord Research and Development, vol. 2, bk. 1.

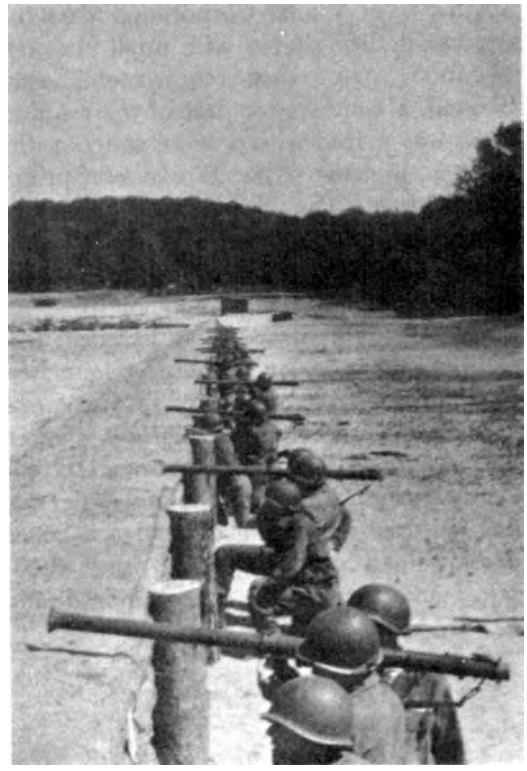
[88] (1) PSP 40; (2) Whiting, Statistics, PR–8.

[89] "Novel Methods Speed Manufacture of M3 Submachine Gun," *American Machinist*, vol. 88, Armament Section (May 11, 1944).

[90] Green, Thomson, and Roots, *Planning Munitions for War*, pp. 328–30. See also PP 79, The Bazooka, OHF. Production of rockets is treated in Chapter VI, above.

asked General Electric to manufacture bazookas it allowed the company only thirty days for delivery of 5,000. GE had to spend nearly half the allowed time in making working models for test by Ordnance; not until the fourteenth model was tested did Ordnance give its approval. Then GE threw all its resources into assembling materials and setting up a makeshift production line. Skilled workmen were borrowed from many departments; office workers with technical skills went to work on production lines; executives and foremen lugged materials and lent a hand whenever needed. According to the company's historical report, the 30-day deadline was met with eighty-nine minutes to spare.[91]

The bazooka was such an immediate success that Ordnance asked General Electric to produce some sixty thousand more in 1942, nearly one hundred thousand in 1943, and two hundred thousand in 1944. Battlefield reports dictated a number of design changes, starting with deflectors to protect the gunner against backblast of slow-burning rockets in cold weather. This was followed by wrapping the rear section of the barrel with piano wire to reinforce it against detonation of rocket motors within the launcher, substituting a generator for batteries in the firing mechanism, eliminating the forward hand grip, and, in the fall of 1943, the most radical change of all, the take-apart launcher M9. Each design change posed its own problems, but, as the bazooka enjoyed a high priority, nothing was allowed to stand in its way for very long. In fact, production schedules were met more consistently on the bazooka than on any other item of small arms manufacture. Perhaps the worst failure was that of the Magnavox Company to produce the complicated firing device on schedule.[92]



OFFICER CANDIDATES AT FONTAINEBLEAU, *France, learning to fire the 2.36-inch bazooka.*

General Electric's Bridgeport works, though making use of more than one hundred subcontractors, carried the production load almost single-handedly for the first two years, despite objections by the

[91] "Development and Production of Rocket Launchers" by the General Electric Co., a contractor's report in Hist, Springfield Ord Dist, vol. 100, pt. 1, pp. 13–14. Project Paper No. 79, The Bazooka, OHF, concludes its coverage of this incident by stating that GE met the deadline with 79 minutes to spare! See also John Anderson Miller, *Men and Volts at War* (New York: McGraw-Hill Book Company, 1947), pp. 105–09.

[92] Hist, Springfield Ord Dist, vol. 100, pt. 1, p. 4.

Smaller War Plants Corporation that the work should be shared with small business. In June 1944, when requirements were boosted, a contract for part of the requirement was placed with a small concern, the Cheney Bigelow Wire Works of Springfield, Mass. The Springfield Ordnance District was at first skeptical of the company's ability to meet production schedules, but during the winter of 1944–45 Cheney Bigelow turned in an excellent record of production on the M9A1 launcher. Further orders were canceled in May 1945 at both GE and Cheney Bigelow, though GE continued until the Japanese surrender to work on an experimental order for five hundred aluminum launchers. Cheney Bigelow had produced some forty thousand, and GE nearly four hundred and fifty thousand.[93]

Recoilless Rifles

Though the basic idea of the recoilless rifle, which ranks with the bazooka as one of the most impressive ordnance developments of World War II, was perhaps a century old, its practical application came only in the 1940's under the forced draft of war research. The 57-mm. recoilless rifle put artillery fire power in the hands of the individual foot soldier, for it required no ponderous carriage or recoil mechanism. It was, in fact, an altogether new type of weapon for the infantry's arsenal. Developed by the Small Arms Division of the Ordnance Research and Development Service, and light enough to be fired from the shoulder, it was usually classed as a small arms weapon, though it fired artillery-type explosive shells. The larger 75-mm. rifle was more nearly an artillery piece. Whatever their classification, they were outstanding new weapons; only their late arrival in the last months of the war robbed them of honors they might otherwise have won.[94]

After demonstration of 57-mm. and 75-mm. recoilless rifles at Aberdeen in September 1944 for the Secretary of War and high-ranking officers of both War and Navy Departments, orders for one thousand of each were placed with industry. The guns were tentatively named "Kromuskits" in honor of the two Frankford Arsenal inventors, William J. Kroeger and C. Walton Musser, but the name did not stick. Final design work was completed in conferences attended by representatives of both the small arms designers and artillery production engineers. As the Ordnance districts reported that no U.S. facilities to manufacture the 57-mm. weapon were available, a contract went through the Detroit district to the Dominion Engineering Works in Canada. An order for the 75's went to the Miller Printing Machinery Company of Pittsburgh, Pa., and by March, 1945, production was under way without serious difficulties. Approximately one hundred recoilless rifles reached the European theater in mid-March 1945, about six weeks before Germany surrendered, and proved effective. Others went into action on Okinawa in May and June with spectacularly successful results. Before production stopped at the end of the sum-

[93] *Ibid.* This reference includes an account by the Springfield District, another by GE, and a third by Cheney Bigelow.

[94] (1) Green, Thomson, and Roots, *Planning Munitions for War*, pp. 330–31; (2) OCM 22989, 24 Feb 44, copy in PSP 78, 57-mm. Rifles T15E . . . , OHF; (3) Rcd of Army Ord Research and Development, vol. 2, bk. 3, Special Weapons, OHF; (4) Elizabeth C. O'Neill, Frankford Arsenal Doctrine, Recoilless Rifle—Development, Nov 55, OHF.



LOADING A 57-MM. RECOILLESS RIFLE *on Okinawa, June 1945.*

mer, 1,238 75's and 951 57's had been accepted.[95]

Miscellaneous Items

Under the small arms heading fell a number of miscellaneous items such as pistols, revolvers, bayonets, trench knives, helmets, and body armor. None was of great importance in the over-all procurement picture but, taken together, they rounded out the essential equipment of combat troops. Prominent among these minor items were .45-caliber pistols and .38-caliber revolvers. Pistols were made at first only by Colt but in 1942 three other producers were added—Remington-Rand, Union Switch and Signal, and the Ithaca Gun Company. As Springfield Armory and the High Standard Manufacturing Company had the needed capacity for making pistol barrels, they supplied the pistol contractors, as did the Flannery Bolt Company for a time. Pistols were not a high-priority item and were in short supply during the whole war, their production suffering from run-of-the-mill obstacles such as low priorities and fluctuating requirements.

The experience of Remington-Rand illustrates the problem. The company took over a vacant plant and bent every effort during 1942 and 1943 to train new workers, acquire needed tools, and build up production. Just as its production line was shifting into high gear at the end of 1943 the company's order was slashed. After workers had been laid off and production virtually halted, the company received an urgent request from Ordnance in the

[95] Prod rcds in OCO Ind Div. See also PSP 78; Rcd of Army Ord Research and Development, vol. 2, bk. 3, Spec Weapons, OHF; and Col. René R. Studler, "They Give Field-Artillery Firepower to the Infantry," *Army Ordnance,* XXIX, No. 152 (September–October 1945), 232–33.

spring of 1944 to restore and even increase its former rate of production. Ordnance was keenly aware of the fact that such starting and stopping of production was most uneconomical, but was forced into it by fluctuating requirements. Adoption of the carbine brought some reduction in over-all pistol requirements, but the demand for pistols nevertheless remained strong throughout 1944. Almost two million pistols were produced during the war, plus 889,000 .38-caliber revolvers, most of the latter by Smith and Wesson, Inc.[96]

Among small arms items, not including ammunition, steel helmets chalked up a record for quantity production, with more than twenty two million delivered before V–J Day. In 1940 the first contract with the McCord Radiator and Manufacturing Company of Detroit called for production of the famous World War I tin hat whose shallow pan-shaped design made it a comparatively simple item to produce. But soon a deeper model that gave more protection to the sides and rear of the head was adopted in 1941 after some 900,000 of the 1917 models had been produced. The switch to a new design held up production at a critical time and brought upon Ordnance a fair share of criticism, but McCord eventually solved the problem of mass-producing M1 helmets of tough Hadfield manganese steel. After turning out only 324,000 in 1940–41, McCord delivered five million in 1942. Meantime special flyer's helmets were standardized and nearly 400,000 were produced during the 1943–45 period. Protective vests, aprons, and groin armor for flyers also went into quantity production during the last two years of the war as experience showed that air crews needed protection against low velocity shell fragments and, unlike ground troops, could afford to sacrifice freedom of body movement for protection.[97]

Before the termination telegrams went out in August 1945, Ordnance had accepted some 21,000,000 rifles, machine guns, and other small arms to equip the U.S. and Allied armies, navies, and air forces. Although dwarfed by expenditures for artillery and artillery ammunition, the $2 billion small arms program nevertheless loomed large in comparison with the procurement activities of other technical services. From January 1942 to the end of 1945, the dollar value of small arms deliveries exceeded the dollar value of all procurement by either the Transportation Corps or Chemical Warfare Service, and was more than double that of the Medical Department. It amounted to about half the dollar value of all Signal Corps procurement; and a little less than half the value of all Corps of Engineer procurement.

Far more important than quantity, in the eyes of Ordnance small arms specialists, was the quality of the weapons supplied to fighting troops. Ordnance drew considerable satisfaction from battle re-

[96] There were two studies of this subject in OHF, both labeled PSP 39. One is entitled PSP Relating to Pistol, Automatic, Caliber .45, M1911A1, 1917 through August 1945, compiled by Annie J. Gregg and reviewed by John P. Aitchison (31 January 1947). The other is entitled Hand Weapons Development, Production and Procurement of Miscellaneous Pistols and Revolvers in World War II (August 1945), written by Walter W. Sanborn and reviewed by Maj. H. P. Smith. See also Hist, Rochester Ord Dist, vol. 100, pt. 11.

[97] (1) Whiting, Statistics; (2) Daniel L. Wells, The Story of the New American Helmet (undated brochure in Hist, Detroit Ord Dist, vol. 105); (3) Maj Berkeley R. Lewis, Small Arms and Small Arms Ammunition, pp. 76–77. See also Green, Thomson, and Roots, *Planning Munitions for War*, pp. 379–80.

ports testifying that the U.S. Army's small arms were among the best in the world. The Garand rifle was generally regarded as the best infantry rifle of World War II, suffering only from complaints of slow production, not poor quality. The carbine was enthusiastically received and met criticism only when it was expected to reach long range or otherwise do what it was not designed to do. Browning machine guns earned world-wide fame. The .50-caliber aircraft gun was outstanding in aerial combat where its unfailing performance under extremes of heat and cold contributed notably to Allied victories in the air. Of wholly new developments the bazooka carried off the honors, followed later by the light recoilless rifle, and fortunately neither posed serious manufacturing problems.

But the picture was not all roseate, either from the design or the production viewpoint. There were no miracles associated with small arms procurement, in spite of the exuberant claims of public relations experts. Production of small arms was an exacting task that demanded essentially the same qualities as any other form of precision metal work—good machine tools, trained workers, efficient management, a steady flow of materials, and constant inspection to keep quality both high and uniform. As indicated in the preceding pages, wartime production of small arms, and all other types of ordnance, was frequently held up by lack of one or another of these elements. In dealing with such problems the nation was fortunate in having some production potential at the outbreak of war with a thriving civilian small arms industry and two government installations, Springfield and Rock Island. Though far less modern than they might have been, Springfield and Rock Island served both as producing plants and as centers of technical ordnance knowledge. It seems only fair to say that without them the conversion of industry from peace to war production would have been more difficult than it was and the eventual production of some two and a half million machine guns, six million carbines, and over six and a half million rifles would have taken much more time.

CHAPTER IX

Small Arms Ammunition

Rounds of small arms ammunition were produced during World War II in greater numbers than any other item of Army supply. Whereas most Ordnance matériel was counted in the thousands or millions, small arms ammunition was numbered in the billions of rounds, total production for the 1940–45 period amounting to more than forty-one billion. Some measure of the magnitude of small arms ammunition production may be gained by comparing it with total wartime production of artillery ammunition (excluding bombs, grenades, and mines) of one billion rounds, or with procurement of high-volume Quartermaster items such as men's socks, about half a billion pairs, or shoes, about 145,000,000 pairs. If fired at the rate of twenty rounds per minute, night and day, year after year, the small arms ammunition procured by Ordnance in World War II would have lasted for almost forty centuries. (*Table 17*)

The huge quantities of ammunition required for World War II dramatically reflected the impact on warfare of rapid-firing weapons. In the days of the American Revolution the firing of muskets was a slow process, each shot requiring the hand loading of both powder and ball.[1] A century later, after breech loaders had replaced muzzle loaders, the rate of fire increased somewhat, but it was not until late in the nineteenth century that the mechanical marvel known as the machine gun boosted the rate of fire a hundredfold.[2] Soon developed to the point where it could fire hundreds of shots in one minute, the new gun's appetite for ammunition was virtually insatiable. During World War II the trend toward faster-firing weapons continued, including all types and sizes but advancing most among the smaller calibers. Armed with the semiautomatic .30-caliber rifle M1, a U.S. infantryman could easily fire an 8-round clip in half a minute. With the semiautomatic carbine a 15-round clip could be fired with similar speed while the fully automatic carbine—adopted in 1944 and equipped with a 30-round magazine—could be fired even more rapidly. Standard machine guns using .30-caliber and .50-caliber ammunition, and submachine guns of .45-caliber, could fire at rates ranging from 400 to 1,200 rounds per minute. Armed with such weapons a single infantry platoon or individual bombing plane in World War II possessed as much

[1] Using the "Brown Bess" flintlock, an expert could load and fire five shots a minute under ideal conditions, but the average for combat was much less. James R. Jacobs, *The Beginning of the U.S. Army 1783–1812* (Princeton, N.J.: Princeton University Press, 1947), p. 7.

[2] Mechanically powered guns of the Gatling type had appeared as early as the Civil War, but the truly automatic machine gun did not appear until the 1880's.

TABLE 17—SMALL ARMS AMMUNITION PRODUCTION, 1940-1945

[IN ROUNDS]

Size	Quantity
Total	41,788,593,000
Caliber .60	6,100,000
Caliber .50	10,042,259,000
Caliber .45	4,072,000,000
Caliber .38	187,000,000
Caliber 9-mm.	548,600,000
Caliber 7.92-mm.	798,800,000
Caliber .303	1,068,000,000
Caliber .30	25,065,834,000

Source: Whiting, Statistics, p. 51.

small arms firepower as an entire infantry division of the Civil War era.

The huge volume of small arms ammunition procurement must not be interpreted as meaning that it exceeded artillery ammunition procurement in either size or complexity. There were only twelve government-owned, contractor-operated small arms ammunition plants as compared to more than sixty artillery ammunition plants and works. The dollar value of small arms ammunition was about one-fourth that of artillery ammunition. The difference in tonnage is suggested by the fact that a round of .30-caliber ball ammunition weighed only a few ounces while a 105-mm. howitzer round weighed about forty pounds. Compared to the twenty different calibers of artillery ammunition there were only three important sizes of small arms ammunition—.30-caliber, .45-caliber, and .50-caliber—and there were only five main small arms types—ball, armor-piercing (AP), armor-piercing-incendiary (AP-I), incendiary, and tracer.[3] The manufacture of the smaller ammunition was not only simpler but easier, for it did not involve the production of fuzes or the manufacture and loading of high explosives. (*See Table 17.*)

The mass production of high quality small arms ammunition was nevertheless an exacting process. Each round had to meet rigid specifications, particularly if it was to be used in aircraft machine guns. A defective round could usually be cleared from a ground machine gun without great difficulty, but fixed aircraft guns mounted in the wings could not be serviced while the plane was in the air. A slight imperfection in one cartridge might put the gun out of action at a critical moment and cause loss of both crew and plane. The Ordnance objective was to produce ammunition that could be fired round after round for billions of rounds, whether in tropic heat or arctic cold, in desert sand

[3] There were many other sizes, including .22-caliber, 60-caliber, and 7.92-mm. (for China), and many other types such as armor-piercing-incendiary-tracer, blanks, guard, dummy, and the so-called headlight tracer, but they were not produced in great quantities. All the main types are listed in Table 17.

or steaming jungle, without malfunctions and without significant deviations in performance.

Dwindling Reserves

Of the large reserve of ammunition held by the United States in 1919, a small portion was used in training each year during the 1920's and 1930's, and the remaining rounds gradually deteriorated in storage. There was some new production by Frankford Arsenal, but the quantities were small, and by the spring of 1940 the national stockpile was only about half what it had been twenty years before. Reserves of .30-caliber, which far exceeded all other calibers in volume, dropped from about one billion rounds in 1919 to a little over half a billion early in 1940.[4] This long, slow process of attrition was one cause of the shortage of small arms ammunition that developed with the approach of war in 1940–41. Reserves were further depleted in the summer of 1940 by shipment of rifle ammunition to the hard-pressed British forces.

The transfer of 138,000,000 rounds of .30-caliber ammunition to the British after Dunkerque took a big slice—nearly 25 percent—from the existing United States stock. A later shipment brought the total for British aid up to 188,000,000 rounds before passage of the Lend-Lease Act in March 1941. The first shipment was paid for through the U.S. Steel Export Company on a "cash-and-carry" basis; for the second shipment the British agreed to release fifty million rounds of new ammunition from their Remington contract to replace the old ammunition received from the United States.[5] But, regardless of the method of reimbursement, transfer of this matériel seriously weakened the Ordnance position. Just at the moment that demand for ammunition was rising—for troop training and equipping defense forces—Ordnance saw its reserves suddenly cut by from 25 to 30 percent. Pressure for increased production became intense during 1941, and Ordnance was subjected to frequent criticism for not having more ammunition on hand and for not producing new ammunition fast enough. Even without aid to Britain there would have been a shortage of rifle ammunition in the winter of 1940–41, but it was most disheartening for Ordnance officers to find in the fall of 1940 that, after two decades devoted to husbanding their reserves and planning for an emergency, they were short of the very types of ammunition most needed, and some of them tended to place more than the proper share of blame on aid to Britain.[6]

More important than apportionment of blame for the crisis was the action taken to meet it. Frankford Arsenal quickly stepped up its production but could not hope to keep pace with the mounting needs of the armed forces. Ground was therefore broken in the fall of 1940 for three large new government-owned ammunition plants with capacities running

[4] The exact figure as of 31 December 1939 was 588,411,466 rounds, valued at $16,951,466. Rpt on Ammo Stocks prepared by FS, Incl to Memo of F. W. F. Gleason for Olejar, 14 Jan 44, sub: Requested Report on Ammunition Stocks, OO 381.4/1889, copy in OHF.

[5] The details of this operation may be found in the monograph, How the Ordnance Department Aided Britain After Dunkirk, by Capt. Paul D. Olejar, 1 Jun 44, OHF.

[6] The whole subject of foreign aid during 1940–41 is discussed in Green, Thomson, and Roots, *Planning Munitions for War,* Chapter III. For discussion of this topic from a higher level of authority, see Watson, *Chief of Staff,* Pages 312–14, and Leighton and Coakley, *Global Logistics and Strategy,* Chapter I.

into the millions of rounds per day. But bringing new plants into production was a time-consuming operation. No amount of emergency action could banish the ammunition shortage overnight, and the lack of small arms ammunition hung like a cloud over the Ordnance program for the next year and a half.

Prewar Plans and Operations

During the 1930's Frankford was the only plant in the United States producing military small arms ammunition. Several commercial firms made sporting ammunition—Remington, Western, and Winchester were the best known—but the difference between sporting and military ammunition was great, comparable to the difference "between a taxicab and a tank," in the words of one observer.[7] Incendiary, tracer, and armor-piercing ammunition, to name three outstanding examples, presented production problems that had no counterpart in peacetime manufacture of cartridges to be used by hunters, farmers, or policemen. Private companies received no contracts during the 1930's for military ammunition because they could not underbid Frankford, and the Army was forbidden by law to purchase from industry unless the price was less than the cost of arsenal-produced ammunition. But by 1936 two facts had become apparent to Army planners: (1) a major war would require, in addition to Frankford's production, large-scale manufacture by commercial arms makers in existing plants, and (2) this production would have to be supplemented by a new government-owned ammunition plant in the midwest operated for the government by a leading industrial firm. In 1936 and 1937 Ordnance representatives conferred frequently with officials of the Remington Arms Company with a view to having Remington expand its capacity in time of emergency and also take over operation of a proposed new government plant. Following these discussions a formal statement of the plan drawn up by Frankford Arsenal was concurred in by Mr. C. K. Davis, president of Remington, in 1938.[8]

At the same time, after nearly twenty years of starvation rations, Frankford received $5 million for the purchase of new machinery and equipment of all sorts, part of an Ordnance-wide move to modernize all the arsenals. Navy orders and federal work relief projects helped supplement the regular appropriations. In 1939 Frankford obtained additional funds to expand its facilities for powder storage and .30- and .45-caliber production, and to build a complete new .50-caliber manufacturing section. The arsenal also purchased $800,000 worth of specialized production machinery known as War Reserve Equipment, and stored it for emergency use by the Remington Arms Company and Western Cartridge Company.[9] Arsenal personnel drew up plans for speeding production in the event of war, including model plant layouts, descriptions of manufacture, esti-

[7] *In Abundance and On Time,* p. 11. This little booklet, published by Remington Arms Company, Inc., records that company's contribution to the wartime production of small arms ammunition. See also History, Frankford Arsenal, Volume I, Part 1, Pages 34–35, and remarks by Brig. Gen. Kirk on the 1945 small arms ammunition program, 10 January 1945, OHF.

[8] The planners envisaged a manufacturing unit capable of producing in 24 hours the following quantities: 1,000,000 .30-caliber ball, 200,000–500,000 .30-caliber tracer and AP, and 300,000 .50-caliber (80 percent ball and AP and 20 percent tracer). SAA, I, p. 69.

[9] SAA, I, p. 49 and pp. 70–71. See also comments on draft of this chapter by Maj Gen James Kirk (Ret.), 6 Apr 57, OHF.

mates of personnel needs, lists of tools and machinery requirements, and data on commercial sources of raw materials. To prepare industry for its role in an emergency, Frankford placed twelve orders for small arms ammunition under the Educational Orders Act in fiscal years 1940 and 1941. Ten of these went to the Remington Arms Company for .30-caliber tracer, .30-caliber AP, .45-caliber ball, .50-caliber tracer, and .50-caliber AP. The remaining two orders went to the Western Cartridge Company for .30-caliber ball and .45-caliber ball. Frankford made exhaustive tests on all ammunition these companies produced to determine its conformity to drawings and specifications. The quantities in the early orders were small, seven contracts totaling only twenty-five million rounds, but in 1941 the three largest orders totaled nearly three hundred million rounds. The primary purpose of educational orders, of course, was not production but education for industry; nevertheless, after the transfer to Britain of over one-fourth the U.S. stockpile of small arms ammunition in the summer of 1940, production became more and more important.[10]

Allied with educational orders for complete rounds of ammunition were procurement orders placed with machine-tool builders in 1939 and 1940. Orders for machinery that had been developed and tested at Frankford were placed not only with the old line companies such as Waterbury-Farrel and E. W. Bliss but with many others who thus gained experience in building small arms ammunition machinery.[11] A most significant result of these steps was the eventual standardization of all American ammunition makers on Frankford Arsenal machinery, and the adoption of this machinery by Great Britain in 1940. This standardization made possible the pooling of machines and the transfer of equipment and spare parts from one plant to another to meet any emergency.[12]

Although not for educational purposes, the orders placed by other countries with U.S. firms played an important part in preparing American industry for war production. Beginning in 1939, small purchases of military cartridges were made of the Remington Arms Company by China, followed at the end of the year by Britain and France, and by Finland in 1940. The British orders, constituting the bulk of all foreign purchases after the fall of France, called for both American and British calibers—including .30- and .50-caliber cartridges for aircraft machine guns, .303-caliber rounds for rifles and machine guns, .45-caliber ball ammunition for Thompson submachine guns, and 9-mm. parabellum cartridges for British Sten submachine guns. As U.S. plants did not have capacity for such production, the British government had to supply machinery and capital for expansion to the Winchester plant in New Haven, Connecticut, and the Remington plant in Bridgeport, Connecticut. In addition, Britain financed the building of three new facilities for making small arms powder and one for making armor-piercing cores. These measures, in the opinion of Ordnance small arms ammunition specialists, were ultimately of value

[10] SAA, I, pp. 62–63. See also Hist, Frankford Arsenal, I, pt. I, pp. 1–5.

[11] The Waterbury-Farrel Foundry and Machine Company was located in Waterbury, Conn., and the E. W. Bliss Company in Brooklyn, N.Y. SAA, I, pp. 215–16 lists all the production machinery venders who supplied Ordnance in World War II.

[12] For details on machinery procurement, see SAA, I, pp. 200ff, and Hist, Frankford Arsenal, I, pt. I, pp. 35–36.

TABLE 18—ESTIMATED YEARLY CAPACITY OF FRANKFORD ARSENAL

Year [a]	Rounds of .30-cal.	Rounds of .45-Cal.	Rounds of .50-Cal.
1938	330,000,000	34,000,000	41,000,000
1939	360,000,000	44,000,000	41,000,000
1940	420,000,000	51,000,000	47,000,000
1941	486,000,000	81,000,000	76,000,000

[a] All figures as of 30 June of the year specified. They represent estimated capacity, not actual production.

Source: SAA, I, p. 48. See also Hist, Frankford Arsenal, SA Div, I, pt. 1, p. 23.

to the U.S. war effort because they enabled American producers to expand facilities, buy new machinery, train workers, and make arrangements for subcontracting.[13]

Meanwhile Frankford steadily increased its rate of production by buying new machinery, allotting more floor space to small arms ammunition, and recruiting employees to man extra shifts.[14] Because of the urgent need for immediate production to supply U.S. troops in 1940–41, Frankford was permitted to take for its own use the war reserve machinery earmarked for Remington and Western. In August 1940 the arsenal's small arms division went on a 6-day week, and added a second 8-hour shift later in the year, but a full third shift was not organized and put into production until mid-1941. As a result of these efforts, Frankford Arsenal's estimated yearly capacity, based on 'round-the-clock operation seven days a week, increased. (*Table 18*)

Building New Plants, 1940–42

At the start of the defense period there was considerable uncertainty as to how much ammunition would be needed and what arrangements should be made for its production. Ordnance leaders tended to be conservative in their estimates and reluctant to embark upon an overly ambitious program. They frequently questioned the estimates of future needs prepared by G–4 and the Assistant Secretary. In July and August 1940, when productive capacity to meet the Munitions Program of 30 June was under study, the ammunition requirements figures reached such high levels that about half the program was postponed to allow time for reconsideration of the whole subject. Ordnance started planning for only two new plants. Then in late September Brig. Gen. Richard C. Moore, Deputy Chief of Staff, informed Ordnance that the original requirements were sound and declared it was "imperative" that production of all small arms ammunition, particularly .30-caliber, be greatly increased at once.[15]

[13] SAA, I, pp. 84–86. To supply China with 7.92-mm. ammunition the plant of the Western Cartridge Co. at East Alton, Ill., was expanded in 1942.

[14] For an account of this process by the officer in charge, see "Small-Arms Ammunition," by Col. James Kirk, *Army Ordnance,* XXII, No. 129 (November–December 1941), 369. The manufacturing methods are described and illustrated with photographs.

[15] Memo, Deputy CofS (Gen Richard C. Moore) for CofOrd, 23 Sep 40, sub: Prod of SA Ammo, G–4/31773. See also disposition slip, Deputy CofS to TAG and CofOrd, 6 Aug 40, sub: Ammo Expenditure and Prod Program, in same file.

In reply, General Wesson reviewed the steps already taken to increase the capacity of Frankford Arsenal and commercial plants. The only way to gain more new production at once, he pointed out, was to take over the British contracts with commercial firms in the United States. To meet the future needs of the 2-million-man force, General Wesson said he would have to build three new plants (including the two under way) at a cost of $20 million each, but warned that they probably would not come into production for fifteen months. The proposal to take over British contracts was not acceptable, for it ran counter to the policy of aiding Britain, but G–4 and the Assistant Secretary promptly approved General Wesson's proposal to build three new plants. They thus launched the so-called First Wave of expansion in the Ordnance small arms ammunition program.[16]

The First Wave

While these discussions were in progress Ordnance drew up detailed plans for three government - owned, contractor - operated (GOCO) plants. After much intensive study, followed by approval of various agencies, the sites were selected—Lake City, Mo., Denver, Colo., and St. Louis, Mo.[17] The first two were to be operated by Remington and the third by the U.S. Cartridge Company (a subsidiary of Western Cartridge Company of East Alton, Ill.) with the McQuay-Norris Company operating the core-making part of the St. Louis plant.[18] A letter of intent covering the Lake City project was sent to Remington and Western as early as mid-September enabling them to proceed with engineering work and placement of orders for production equipment. Ground was broken by Senator Harry S. Truman the day after Christmas 1940, and the first loaded cartridges were produced in September 1941 —three months ahead of General Wesson's estimate. The site for the St. Louis plant, largest of the small arms ammunition facilities, was selected in January 1941, and production of .30-caliber and .50-caliber got under way within the year. Patterned after Lake City, the .30-caliber Denver plant went up faster, taking only seven months from the start of construction in March to first production in October 1941. With a daily population of some 20,000, the Denver plant was Colorado's fourth largest community. It covered a 2,000-acre reservation, had more than 200 buildings, a police force larger than that of Denver, a hospital, a railroad station, 11 miles of railroad track, 17 miles of roads, and 15 miles of fencing.[19]

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[16] (1) Memo, CofOrd for DCofS, 30 Sep 40, sub: Prod of SA Ammo, OO 471/200; (2) Memo, Lt Col Henry S. Aurand for Brig. Gen. Eugene Reybold, sub: Prod of SA Ammo, G–4/31773; (3) Memo, Acting ACofS (Col Reybold) for ASW, 3 Oct 40, sub: Prod of SA Ammo, G–4/31773; (4) Intervs with Burns and Maj. Gen. Charles T. Harris, fall of 1953.

[17] Memo, Chief of SA Div for Chief of Ind Serv, 16 Oct 40, sub: Funds for Manufacture of SA Ammo. . . , OHF. When this memo was written the Denver site had not yet been selected. Photostat copies of letters of approval signed by President Franklin D. Roosevelt are in OHF. The cost of all three plants was originally estimated to be $65,000,000.

[18] For description of the early planning on the production of armor-piercing cores, see History of the Core Program, by SA Div, Ind Serv, (1945), p. 205. A single government-owned source of supply was considered better than purchasing from many small commercial concerns because of the great need for screw machines and heat-treating equipment and the necessity for carefully controlling quality. Efficiency, speed, and economy dictated the decision to put all core production under one roof. The subject is also treated in SAA, I, pp. 270–84.

[19] For details on construction and early production, see the plant histories in OHF. Including later additions, the cost of building and equip-

These First Wave plants were all in production by December 1941. Combined, they had a capacity of over 300,000,000 rounds per month—more than six times the capacity of Frankford.[20] But all during 1941, while they were being built and equipped, Frankford was virtually the sole source of new small arms ammunition. Commercial firms under contract to the British were not disturbed. Frankford thus served as an element of the "Regular Army of production" holding the fort alone until new plants could come to the rescue. It also served as a school where contractor personnel were trained in methods of producing various types of ammunition.[21]

All during the 1940–41 defense period, small arms ammunition was in extremely short supply. It was the most critical class of items in Ordnance procurement. Both G–4 and the Assistant Secretary of War repeatedly urged Ordnance to open new plants as fast as possible. Secretary Patterson time after time stressed the need for more production. In February 1941, for example, he wrote to General Wesson as follows:

> As you know, the situation in regard to Caliber .30 and Caliber .50 small arms ammunition is most critical. The existing stocks together with deliveries scheduled for 1941 are, in general, not adequate to meet the needs of the Army and Navy for target practice . . . and to provide necessary combat reserves. . . . It will be necessary to limit training to a very small part of requirements.[22]

A few months later he told General Wesson and General Somervell that the shortage of small arms ammunition was being presented to him from day to day and that officers in the field considered it "the major deterrent to proper training of the troops."[23] Because of the urgency of the situation, construction and equipment of all the small arms plants was given an A–1–a priority in May 1941, the only such priority rating granted to Ordnance, and their operation after completion was given the same rating.[24]

The Second Wave

Under these pressures Ordnance drew up plans for the Second Wave of three plants. Approved by the War Department in the spring of 1941, construction of the Utah, Twin Cities, and Des Moines plants began during late July and August. In addition to its already heavy burden as operator of Lake City and Denver, Remington undertook to operate the Utah plant at Salt Lake City. To staff this facility, which covered five thousand acres, the company recruited and trained more than ten thousand employees in a non-

ping these three plants was a little more than $250,000,000. SAA, I, table opposite p. 114.

[20] The total daily capacity of the new plants included 8,000,000 .30-caliber, 2,000,000 .30-caliber carbine (added in December 1941) and 1,200,000 .50-caliber. Frankford's daily capacity in June 1941 was about 2,000,000, including .30-caliber, .45-caliber, and .50-caliber, SAA, I, p. 153.

[21] It should be noted that small arms ammunition was only one part of Frankford's responsibility. The arsenal was also a center for development and production of artillery ammunition and fire control apparatus.

[22] Memo, ASW for CofOrd, 10 Feb 41, sub: Expediting Prod of SA Ammo, OO 471.4/504. For G–4 opinion, see Memo, G–4 for CofOrd, 23 Sep 40, sub: Prod of SA Ammo. G–4 file 31773.

[23] Memo, Patterson for Wesson, 2 Jul 41, OO 471.4/1337.

[24] (1) Memo, ANMB for Brig Gen Charles T. Harris, 9 May 41, sub: Priority Rating for SA Ammo, OO 471.4/988; (2) Memo, Lt Col Drewry for Chief of Ind Serv, 13 May 41, sub: Priority Rating for SA Ammo, OO 471.41/1002.

industrial area where workers with factory experience were almost unknown. The Federal Cartridge Company of Anoka, Minn., contracted to operate the Twin Cities Ordnance Plant a few miles north of Minneapolis and St. Paul.[25] The plant at Des Moines, Iowa, went to a concern with no experience in ammunition production—the U.S. Rubber Company of Akron, Ohio. Because the rubber shortage had forced curtailment of its normal operations, this concern was able to place part of its managerial resources at the disposal of the Ordnance Department.[26] All these plants were of a less permanent type than those of the First Wave and came into production during February and March 1942, averaging only seven months from the date ground was broken. When completed, they brought total monthly production capacity up to 480,000,000 for .30-caliber and 140,000,000 for .50-caliber.[27] Steel cores for AP ammunition were supplied all the Second Wave plants by the Toledo Core Plant operated by the Willys-Overland Company.

In 1940 Ordnance saw that the old line brass and copper companies would not be able to produce all the brass strip needed by the ammunition program. As ammunition requirements rose time after time during 1941 the need for new brass strip capacity became more clearly apparent. Ordnance therefore made arrangements for building four new brass mills to be financed by the Defense Plant Corporation and operated under cost-plus-fixed-fee contracts by four leading brass companies —American, Bridgeport, Chase, and Revere. Expansion of existing privately owned plants—particularly Western Cartridge, supplier for the St. Louis plant—was also undertaken, but in 1942 the shortage of brass strip capacity became acute.[28]

Building and equipping all these new plants during 1941 in competition with hundreds of other high priority projects for scarce machine tools and building materials was not easy. For the First Wave, machine-tool deliveries took almost a year after the orders were placed, and there was nearly as long a delay in equipping the Second Wave plants. Heavy machinery needed for mass production of ammunition was of special design and could not have been built quickly even if machine-tool builders had not been flooded with other orders. At the request of the government, Remington and Western co-operated closely in standardizing equipment and placing orders for machinery, opening a joint office at Frankford for the purpose in November 1940. Intensive efforts were also made to provide an adequate supply of perishable tools at all the plants.[29]

Shortage of experienced management was another major bottleneck. It was estimated that in 1940 there were in the United States less than one hundred men

[25] On selection of these sites, see memo for record by E. M. Martin, 9 Sep 41, pp. 138–39, SAA, II, Ref 40. The Ordnance historical files contain histories of each plant.

[26] Memo, Maj Edward C. Franklin for Fisc Div, 1 Oct 41, pp. 140–41, in SAA, II, Ref 41. This memo explains the reasons for selecting each contractor for the Second Wave plants.

[27] Each plant was originally designed to produce 2,000,000 rounds of .30-caliber and 600,000 rounds of .50-caliber per day, but the quantities were changed frequently. See Incl to Memo, CofOrd for USW, 18 Apr 41, OO 400.12/2764.

[28] (1) SAA, I, pp. 254–58; (2) Memo, Campbell to Brig Gen Charles T. Harris, 23 Nov 40, Ref 107 in SAA, II.

[29] For details on procurement of machinery, see SAA, I, pp. 200ff. The contract with Remington to schedule and expedite procurement of all production machinery is described in History, Utah Ordnance Plant, Volume 101. The tool problem is discussed in History, St. Louis Ordnance Plant, Volumes VIII–IX.

with comprehensive knowledge of military ammunition production. To staff the First Wave plants, the small arms industry had spread its executive and supervisory personnel so thin that there was some question as to its ability to take over management of the Second Wave. Ordnance officers were deeply concerned about this matter, for they recalled the failure of many firms to produce in 1917–18. "During the last war," wrote General Wesson, "a large number of concerns, inexperienced in the production of small arms ammunition, attempted its production and the records show that not one of them ever delivered a satisfactory round." [30]

All these factors combined led General Wesson to conclude in the spring of 1941 that, beyond the three First Wave plants under contract and the three Second Wave plants just approved, no further expansion of small arms ammunition facilities should be undertaken. He felt that taxing the managerial ability of the ammunition industry beyond its capacity would jeopardize the entire program.[31]

The Third Wave

No additional plants were authorized by the War Department during the summer of 1941, but in September, Col. Thomas J. Hayes of the Under Secretary's office made a comparison of requirements with production capacity and concluded that capacity fell far short of meeting the needs of the Army, Navy, and Air Corps—without even considering defense aid.[32] After his requirements figures were confirmed by G–4, Colonel Hayes recommended that Ordnance create additional capacity at once, including facilities for rolling sheet brass. He recognized that copper would be difficult to obtain but did not believe it should be accepted as "the determining factor in this question" in view of the possible savings from converting to steel artillery cases, salvaging used brass cases, and curtailing civilian use of copper.[33] General Harris, then acting Chief of Ordnance, was reluctant to undertake this expansion (estimated to cost $225 million if new plants were built) without more definite assurance that copper and machine tools would be available. He cited figures to show that requirements for the new plants, when added to those of existing plants, would total fifty-three million pounds of copper per month, or nearly 18 percent of all copper expected to be available to the United States during 1942. He quoted the Office of Production Management to the effect that this amount of copper could not be allocated to small arms ammunition without seriously curtailing production of other items. But on 1 November the Under Secretary's Office overruled General Harris and directed Ordnance to go ahead with the new construction. General Hayes meanwhile reiterated his opinion that curtailment of civilian consumption would ease the copper

[30] Memo, CofOrd for USW, 18 Apr 41, sub: Prod Capacity for Cal. .30 and Cal. .50 Ammo, OO 400.12/2764, copy in SAA, II, Ref 16b. For a list of the concerns that did produce ammunition in World War I, see Memo, Col René R. Studler for CofOrd, 12 Aug 41, sub: SA Ammo Prod during the World War. Gen Minton's file, Reports Requested. For an excellent brief account of World War I experiences, see Crowell, *America's Munitions 1917–18*, Chapter 12, Book 1.

[31] *Ibid.*

[32] Memo, Col Thomas J. Hayes, OUSW, for WD Facilities Bd, 15 Sep 41, sub: Prod Capacity for . . . Ammo, SAA, II, Ref 48.

[33] Memo, Hayes, OUSW, for WD Facilities Bd, 3 Oct 41, sub: Prod Capacity for . . . Ammo, SAA, II, Ref 50. See also Memo, G–4 for WD Facilities Bd, 26 Sep 41, same sub, in G–4/28664–104, OO 471.4/2169, and copy in SAA, II, Ref 62.

shortage and pointed out again that existing plants, even operating twenty-four hours per day seven days a week, could not meet stated requirements.[34]

Still doubting the wisdom of this decision, Generals Wesson and Harris in mid-November called for a reconsideration of the whole subject of ammunition requirements. They pointed out that facilities sufficient to maintain an army of four million men in the field were under construction and would start producing early in 1942. "By reason of shipping difficulties alone," they wrote, "it does not appear probable that an American army of 4,000-000 men will engage in combat within the next twelve months either in this hemisphere or in any other theater. This twelve month period will permit filling up the lines of supply and producing a reserve . . . sufficient . . . for an additional year." They argued that no new plants were needed, except possibly for special new items, and challenged the validity of the astronomical figures being used for 1942 ammunition requirements. In addition to their contention that four million men would not see combat overseas in 1942, the generals asserted that the established Day of Supply for computing ammunition requirements was far too high and could possibly be reduced by as much as 75 percent.[35]

While awaiting an answer, Ordnance went ahead with plans to carry out the 1 November directive. To provide the additional capacity as quickly and economically as possible, Colonel Drewry, Chief of the Small Arms Branch, decided to expand existing plants rather than build new ones —and also take into account the fact that the plants were producing from 30 to 40 percent more than expected.[36] Space originally provided at each plant for storage of incoming and outgoing materials was taken over for manufacturing. One new building was erected at Lake City and three at Twin Cities. AP cores were produced by the Edison G. E. Appliance Company of Chicago, operator of the Chicago Core Plant, and by Cuneo Press, Inc., and other commercial firms.[37] This expansion, generally referred to as the Third Wave, was estimated to cost just under $100 million and to add about 50 percent to the capacity established by the first two waves.[38] While these steps were being taken war broke out with the attack on Pearl Harbor, and Secretary Patterson redoubled his demands for more ammunition. "The combat forces need .50-caliber ammunition more than anything else," he wrote late in December. "The need is urgent and pressing. . . . There is no time to lose." [39]

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[34] (1) Memo, CofOrd for USW, 8 Oct 41, sub: Additional Prod Capacity for . . . Ammo, and 1st Indorsement, 1 Nov 41, OO 471.4/2172; (2) Memo, Brig Gen Hayes for WD Facilities Bd, 24 Oct 41, OO 471.4/2172.

[35] Memo, CofOrd, for USW, 17 Nov 41, sub: Plng Rules for the Victory Program, OO 381/48577 and ExecO files. See also Ltr, Brig Gen Guy H. Drewry (Ret.) to Thomson, 26 Jan 54, OHF, stating, "I thought the small arms ammunition requirements were unrealistic and excessive from the beginning."

[36] The capacity of each plant had been conservatively estimated in advance without operating experience to show what might be accomplished by adapting conveyorized production to previous Remington and Frankford procedures.

[37] (1) Hist, Core Program, pp. 15–17; (2) SAA, II, p. 281.

[38] (1) SAA, I, p. 164. See also the original statement of this plan by Col Drewry in Memo for Brig Gen Charles Harris, 13 Nov 41, sub: Plan for Increased Prod Capacity of SA Ammo, OHF. For Secretary Patterson's approval and detailed statement of costs, see Memorandum of Approval-No. 9, 20 Dec 41, copy in SAA, II, p. 199.

[39] Memo, USW for CofOrd, 27 Dec 41, sub: .50-Cal. Ammo, OO 471.4/2977. See also strongly worded Memo of Somervell (G-4) to USW, 26

Post Pearl Harbor Requirements

The Ordnance memo of mid-November was answered by the tide of events more than by careful study of production problems. In the hectic weeks following Pearl Harbor the planners reviewed the Day of Supply, the planned rate of mobilization, probable losses through ship sinkings, the maximum production to be expected from existing plants, the time required to build new facilities, the availability of machine tools, the supply of copper, and aid to allies. The British Prime Minister and his staff came to Washington in December 1941 for a series of conferences at which the need for increasing American production goals was forcefully presented. The huge lend-lease requirements then formulated greatly strengthened the case for new ammunition plants, but Ordnance considered them "unrealistic and excessive." General Harris argued in vain to have the estimates for foreign aid reduced. "But in those days," he remarked later, "it was practically treason to question anything the British asked for." [40]

During January and February 1942 the prevailing attitude among the high-level planning agencies in Washington was that the sky was the limit. There was no time for tediously accurate computations but only for quick and generous estimates. Following the Churchill-Roosevelt conversations in December and the signing of the Declaration of the United Nations on New Year's Day 1942, President Roosevelt revealed the new production goals in a dramatic message to Congress. The armed services were to procure during 1942 some forty-five thousand airplanes, forty-five thousand tanks, five hundred thousand machine guns, and "ammunition commensurate to this program on the assumption that these munitions of war are to be used in combat." [41]

Under this statement of policy by the Commander in Chief, requirements for small arms ammunition reached dizzy heights, one proposal calling for the production of 122 billion rounds by the end of 1944. General Harris, who as chief of the Industrial Service was responsible for procuring these vast quantities of ammunition, felt that the Presidential advisers, and their British counterparts, were suffering from an attack of the jitters and were asking Ordnance and American industry to do things that were neither necessary nor possible. Conceding that there was an ammunition shortage at the moment, he urged patience and assured his listeners that when the new plants came into production the nation would find that, for the first time since the emergency began, it had "too much, too soon." "Give us a little time," he pleaded, "and you will have ammunition running out of your ears." He and General Wesson warned

Dec 41, sub: Priority of Munitions, referring to the "acute shortage" of .50-caliber ammunition and the "urgent necessity for increased production," USW file 104 Ammo.

[40] Interv with Maj Gen Charles T. Harris, Jr., Dec 53. In telephone conversation with the author on 7 January 1954, Maj Gen Hayes declared that the lend-lease requirements formulated in December 1941 were "staggering" and were first presented to Ordnance during a long night conference on 30 December 1941. See also memo referring to this conference, Hayes for USW, 1 Jan 42, USW files 104, Ammo. General Drewry's opinion that the requirements were too high is expressed in letter to the author, 26 January 1954, OHF.

[41] See also Ltr, President Franklin D. Roosevelt to Stimson, 3 Jan 42, ex. 19 in PSP 55, vol. I, by Maj Paul D. Olejar and others, Jul 45, OHF, and Incl to Memo, Patterson for Knudsen, 2 Jan 42, OUSW Madigan file (Ord Gen), 50–240.

that additional plants were unnecessary, would be a waste of money and materials, and would not be able to operate for lack of copper. But these pleas were out of tune with the prevailing Washington mood, and in mid-February, when G–4 commented on the Ordnance memo of 17 November, the existing Day of Supply and the over-all ammunition requirements were upheld. "The quantities contained in current programs," wrote General Somervell, "are not excessive." [42] The War Production Board gave assurance that sufficient copper would be available, and Ordnance was directed to build eighty more production lines—the equivalent of three new plants—before the end of the year.[43] These new lines, known as the Fourth Wave, could produce during 1943 about 5,500,000,000 rounds of .30-caliber or 3,240,000,000 rounds of .50-caliber. G–4 was to determine the proportion of each caliber and type. One hundred more lines were tentatively proposed for the first half of 1943, but it was planned to review the situation again before these lines were finally authorized.[44]

The Fourth Wave

The 80-line expansion was mostly for .30-caliber ammunition, 51 of the lines being devoted to that caliber. It was designed to increase existing capacity by about 40 percent and bring total yearly production up to 22,500,000,000 rounds.[45] Ordnance decided to achieve it by expanding four existing plants—Lake City, Denver, Des Moines, and Evansville—, by converting the Kings Mills plant from .45-caliber to .30-caliber carbine, and by converting five commercial plants that had formerly made candy, textiles, rubber tires, and automobiles. Remington undertook to operate the Lowell Plant in Massachusetts, Kelly-Springfield Tire Company the Allegany Plant in Maryland, U.S. Rubber Company the Eau Claire (Wis.) and Milwaukee plants, and Simmons Bed Company the Kenosha plant in Wisconsin. A new cup plant in Detroit, to be operated by the Parker-Wolverine Company, was added in the fall. Contrary to expectations, most of these plants got into production before the end of the year, Milwaukee and Eau Claire starting up in August, Allegany and Lowell in November. At the year's end there were twelve small arms ammunition plants in operation, and the peak of the wartime expansion had been reached. (*See Illustration*) The designed capacity of these plants was about twenty billion rounds per year, but their

[42] (1) Intervs with Maj Gen Charles T. Harris, Jr., Dec; (2) Memo, G–4 for USW, 12 Feb 42, sub: Day of Supply. . . , G–4/20052–67 and Ord ExecO files; (3) Memo, CofOrd for OUSW, 10 Jan 42, sub: SA Prod Capacity, OHF; (4) Memo, CofOrd for OUSW, 31 Jan 42, sub: Request for Approval of Facilities Project (Evansville), OO 160/116196 Chrysler; (5) Excerpts from testimony of Col Drewry at conf, 30–31 Dec 41, 21 Jan 42, SAA, II, pp. 216–18; (6) Memo, CofOrd for CG, SOS, 25 Apr 42, sub: Additional Capacity for SA Matériel, Ref 109 in SAA, II.

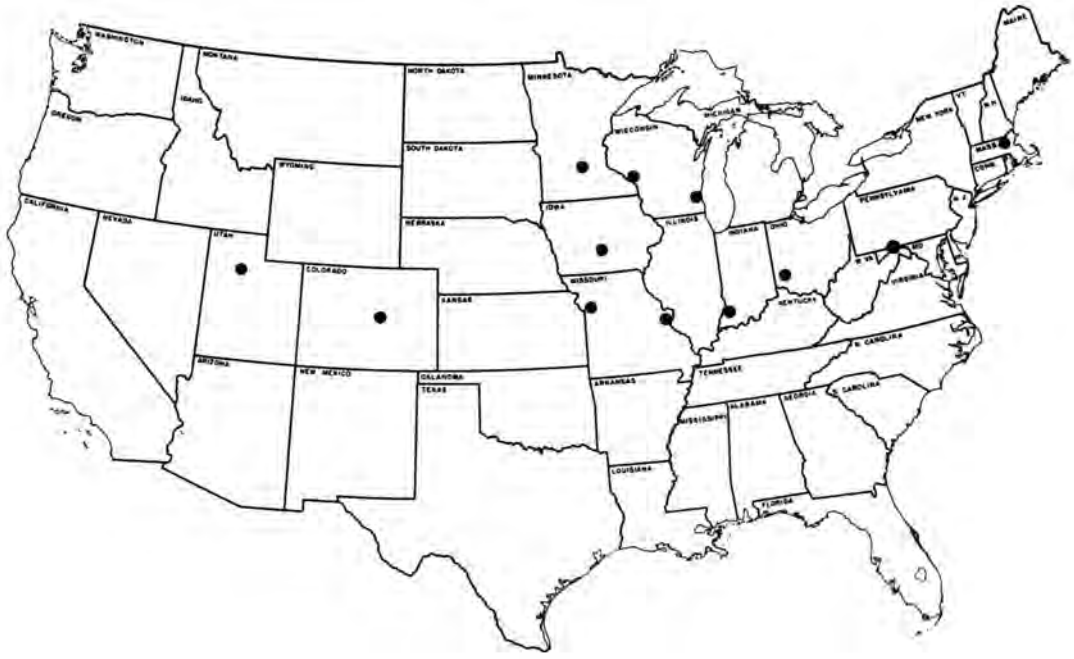
[43] A "line" was a manufacturing area capable of producing 250,000 rounds of .30-caliber or 150,000 rounds of .50-caliber per 24-hour day. As plants could produce 30 percent or 40 percent over designed capacity, figures for line capacity went up considerably in 1942.

[44] (1) Memo, Col Drewry for CofOrd, 23 Feb 42, sub: Confirmation of Decisions Made During Conf, Friday, Feb 20, 1942. SAA, II, pp. 221–24. For detailed reports of the discussions of this problem, see the series of stenographic reports of conferences in the first half of 1942 entitled Review of Production Plans of Small Arms Division. Excerpts from these reports are in SAA, II.

[45] Memo, SA Div for Ind Serv Prod Div, 6 Mar 42, sub: Request for A–1–a Rating. . . , SAA, II, p. 354.

ORDNANCE DEPARTMENT

SMALL ARMS AMMUNITION INDUSTRY



SMALL ARMS AMMUNITION PLANTS

	Plant	Location	Contractor
1.	Allegany Ordnance Plant	Cumberland, Md.	Kelly-Springfield Eng. Co. (Goodyear)
2.	Denver Ordnance Plant	Denver, Colo.	Remington Arms Co.
3.	Des Moines Ordnance Plant	Des Moines, Iowa	United States Rubber Co.
4.	Eau Claire Ordnance Plant	Eau Claire, Wis.	United States Rubber Co.
5.	Evansville Ordnance Plant	Evansville, Ind.	Chrysler Corporation
6.	Kings Mills Ordnance Plant	Kings Mills, Ohio	Remington Arms Co.
7.	Lake City Ordnance Plant	Independence, Mo.	Remington Arms Co.
8.	Lowell Ordnance Plant	Lowell, Mass.	Remington Arms Co.
9.	Milwaukee Ordnance Plant	Milwaukee, Wis.	United States Rubber Co.
10.	St. Louis Ordnance Plant	St. Louis, Mo.	United States Cartridge Co.
11.	Twin Cities Ordnance Plant	New Brighton, Minn.	Federal Cartridge Co.
12.	Utah Ordnance Plant	Salt Lake City, Utah	Remington Arms Co.

maximum actual capacity was close to thirty billion.[46]

Coming just before the 80-line Fourth Wave, but generally considered part of it, was the Evansville plant in Indiana operated by the Chrysler Corporation to manufacture .45-caliber ammunition. Requirements for this caliber had been low during 1940 and most of 1941, but in August 1941 new British and Chinese requirements necessitated doubling existing capacity. A contract was soon placed with Remington to convert its Kings Mills plant at Cincinnati, Ohio, to .45-caliber production, and in late January 1942 the Chrysler Corporation agreed to convert its idle body plant at Evansville, Indiana, to .45-caliber production. In the summer of 1942 the Kings Mills Plant was converted to .30-caliber carbine cartridges. Between June 1942, when it started producing, and the spring of 1944, when it closed, Evansville turned out over 90 percent of all .45-caliber ammunition produced in the United States. The Sunbeam Electric Company operated a division of the Evansville Plant making cartridge cases.[47]

The Fourth Wave was the high point for small arms ammunition, so high, in fact, that it was never reached. Plans for one of the plants were canceled before the contract was signed, and during the summer of 1942, as Ordnance had predicted, the shortage of copper and a revision of requirements led to curtailment at all other plants. Because of the lack of copper, Twin Cities, Des Moines, and Utah were specifically directed in June to freeze their production at the level attained in mid-May. In spite of efforts to use steel in place of brass, the copper shortage caused a loss of over one hundred eighty-five thousand rounds in the single month of June 1942.[48] Magnesium was so scarce that Ordnance reported its plants were "living from hand to mouth—eating off the stove."[49] Before the Fourth Wave plants were more than half built, substantial cuts were made in requirements. With .30-caliber, for example, requirements for 1942 production were cut back from 8.6 billion in March 1942 to 4.8 billion in September. There were some increases in .50-caliber and .30-caliber carbine requirements for 1943 but they were small in comparison with the cuts in .30-caliber and .45-caliber.[50] Total output required for 1942 dropped from fifty-nine billion in February to twenty-three billion in November.[51]

The Fifth Wave

As early as July 1942 Ordnance submitted recommendations for curtailing 1943 production and making minor

[46] Interim Rpt on SA Ammo, 26 Dec 44, by War Projects Unit, Bur of the Budget, OO 471.4/2333(c). For a brief period in 1943 the Scioto Ordnance Plant at Marion, Ohio, produced small arms ammunition and brought the total up to 13.

[47] Bullets by the Billion, issued by Evansville Ord Plant. Evansville was not a government-owned plant as were the first six plants, but a privately owned plant converted to war production. The same was true of Lowell, Allegany, and Eau Claire.

[48] Memo, CofOrd for CG SOS 1 Jul 42, sub: Curtailment of Prod at SA Ammo Plants Due to Shortage of Copper, Ref III, SAA, II. The figure of 209,000,000 rounds is given in Review of Production Plans, Small Arms Branch, 20 July 1942. See also discussion of copper as "the limiting factor in ammunition production" by Kirk in Review of the Production Plans of the Small Arms Division, 19 Jun 42.

[49] Review of Prod Plans, SA Br, 16 Dec 42, ExecO file.

[50] (1) Memo, Col Drewry for Chief, Ind Serv, 3 Jun 42, sub: Prod and Rqmts of SA Matériel, and attached buck slip, both in OHF; (2) SAA, I, p. 178.

[51] Review of Prod Plans, SA Br, 16 Dec 42, T676A.

changes in plants already in operation or under construction. The recommendations were promptly approved by the Services of Supply and the Under Secretary and, though calling for reduction rather than expansion, came to be known as the Fifth Wave. Kenosha was canceled entirely; Kings Mills shifted from .45-caliber to .30-caliber carbine; Evansville closed down twenty lines; Allegany and Lowell switched from .30-caliber ball to .50-caliber AP; and additional capacity for .50-caliber was created at Lake City, Des Moines, and Twin Cities. Including other minor changes, forty-three lines were canceled and four added—two for .50-caliber incendiary and two for .50-caliber AP. Planned production for 1943 was reduced by 2,500,000,000 rounds. The period of facilities expansion, which had cost about $500 million for buildings and equipment, was over, and the period of readjustment and retrenchment was beginning.[52]

The Philadelphia Suboffice

General Campbell decentralized the office force for administration of the small arms ammunition plants in the summer of 1942 by creating the Small Arms Ammunition Suboffice in Philadelphia. It was headed by Lt. Col. Boone Gross and was administratively attached to Frankford Arsenal. Under control of the Small Arms Division in Washington, it co-ordinated small arms ammunition production in much the same way that FDAP in St. Louis co-ordinated production of artillery ammunition. Inspection problems and requests for engineering changes were handled by the Philadelphia office in collaboration with Frankford Arsenal. Manufacturing costs at the GOCO plants were studied and compared, and efforts were made to reduce contract prices where the evidence warranted such action.[53] In July 1943 the Philadelphia suboffice adopted an incentive plan for determining fees paid to plant operators. This plan provided that the contractor's fee would be raised or lowered, within specified limits, according to the success he achieved in producing high quality ammunition, lowering costs, and using manpower effectively.[54]

All the plants were further tied together by industry integration committees. The foundation for this co-operative effort was laid in 1940 when Remington and Western, with Ordnance approval and encouragement, agreed to use identical machinery in the new plants they were to operate. This was long before industry integration committees were formally established in 1942. Remington and Western were soon joined by other contractor-operators, Federal Cartridge, U.S. Rubber, Chrysler, and Kelly-Springfield, and by many concerns making bullet cores, clad metal jackets, tools and metallic belt links, and ammunition containers. These committees held countless meetings to iron out technical difficulties, exchange information,

[52] (1) Memo for record by Col James Kirk, 8 Jul 42, sub: Prod Capacity for SA Ammo, and incls, OHF; (2) SAA, I, pp. 178ff; (3) Hist, Lake City Ord Plant, II, Jan-Mar 43, app. A; (4) Review of Prod Plans, SA Br, 16 Dec 42, T676A. For details on costs, see SAA, I, pp. 114–30.

[53] (1) Lt Col Boone Gross, Cost Analysis of Six GOCO Small Arms Ammunition Plants, 4 Jan 43; (2) Campbell, *The Industry-Ordnance Team*, pp. 62–63; (3) SAA, I, pp. 108–10 and 131–40; (4) Maj A. R. Coleman, "Economy in Weapon Production," *Army Ordnance*, XXVII, No. 145 (July–August 1944), 83–87.

[54] For a description of the plan and its application to one plant, see 2d Indorsement, Philadelphia Suboffice to OCO, 29 Dec 44, on Report of Special Inspection of CPFF Contracts at St. Louis Ord Plant, 30 Nov 44, OOP 333.1/182 St. Louis OP (Incl file). See also SAA, I, pp. 132–40.

and agree upon standard engineering practices. "It is impossible to over evaluate the work of the various participating industries," states the official history of the Small Arms Branch. "It has been brilliant and distinguished." [55]

Production Processes and Problems

The number of GOCO plants making small arms ammunition was only one-fifth the number of artillery ammunition plants and works, for it included no smokeless powder or TNT plants, no chemical works like Baytown, nor any loading plants comparable to Kingsbury or Cornhusker. As smokeless powder for rifle and machine gun cartridges was required in comparatively small quantities it was obtained from the powder plants built for artillery ammunition. High explosives such as TNT and RDX were not used at all in small arms ammunition. Nor did manufacture of small caliber cartridges require separate plants for making cases, shells, fuzes, or other components, or for loading and assembling complete rounds. Each small arms plant was a self-contained unit wherein thousands of workers—including as many women as men—completed the whole process of manufacture amid rows of huge automatic machines, conveyor belts, and annealing furnaces. Raw material in the form of brass strips or cups, lead billets, steel wire, and smokeless powder came in at one end of the plant; millions of bright and shining cartridges came out the other end.

Description of Manufacture

Operations within the St. Louis Ordnance Plant, largest of the small arms ammunition facilities, may be cited as fairly representative of the production process. Covering an area of three hundred acres and employing more than forty thousand workers, this $130 million plant, operated by the United States Cartridge Company, was the largest employer of labor in the St. Louis area. Its first lot of ammunition was accepted by Ordnance on the day after Pearl Harbor, and during the next four years it turned out over seven billion rounds, including ball, armor-piercing, and incendiary types.[56]

Each cartridge made at St. Louis, as at other plants, consisted of three metal parts —case, primer, and bullet. The case was normally made of brass and, except for size, was similar to an artillery case. The primer, inserted in a pocket in the head of the case, was a small cup containing a sensitive explosive. When struck by the firing pin it burst into flame and ignited the propellent powder in the case. The bullet was an elongated lead slug covered with a thin jacket of gilding metal (a soft copper alloy) or copper-clad steel and was held firmly in the mouth of the case. Each of these parts had to meet rigid specifications governing its weight, shape, lineal measurements, and exterior finish—specifications that had been worked out during

[55] (1) SAA, I, pp. 342–484; (2) History of all Small-Arms Industry Integration Committees. Both volumes contain many letters from small arms ammunition contractors describing the work of the committees and praising their usefulness. See also, for specific data on each committee, McMullen, Industry Integration Committees.

[56] (1) History, St. Louis Ordnance Plant, OHF; (2) Bullets by the Billion, a pamphlet for employees and visitors issued by the St. Louis plant in 1943, copy in vol. VI of plant history. For related data on ammunition see TM 9-1900, 18 Jun 45, and Bullets by the Billion issued by the Evansville plant. Reports of inspecting officers also contain a wealth of specific information. See OOP 333.1 St. Louis Ord Plant.

many years of experiment and been tested by firing millions of rounds at Ordnance proof ranges.[57]

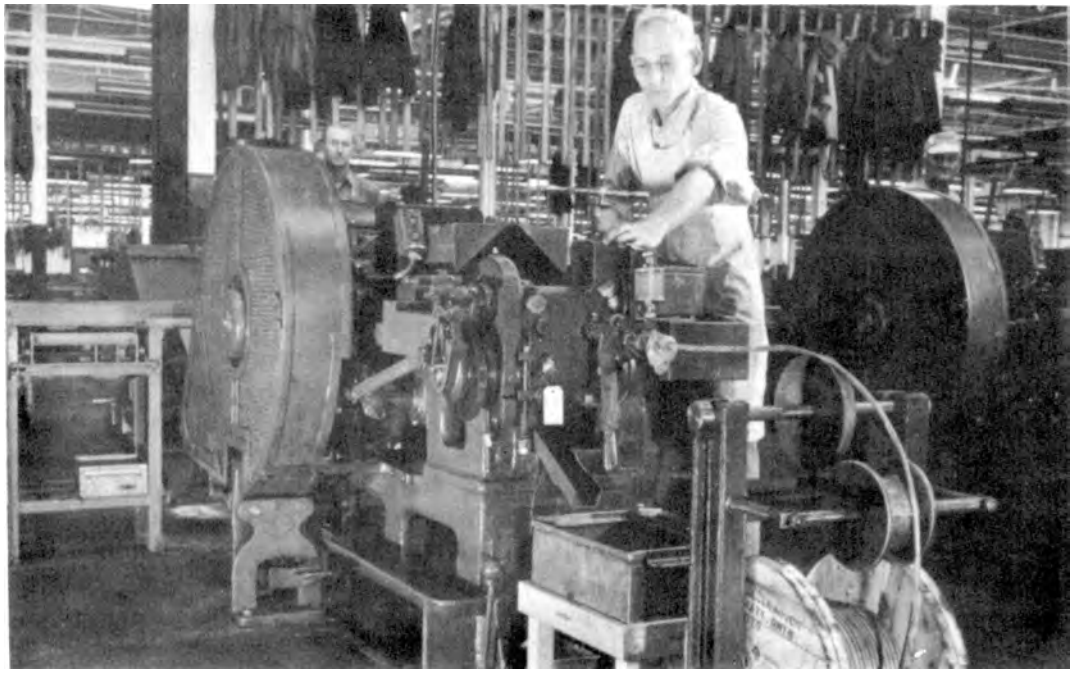
Cartridge brass came to the St. Louis plant from Western Cartridge Company's nearby brass mill at East Alton, Ill., in the form of long strips coiled like huge rolls of cellophane tape. The first step in cartridge case manufacture at St. Louis was to feed these brass strips into a blank-and-cup machine that simultaneously stamped out round disks and formed them into cups. These cups were then washed, dried, and placed in furnaces to relieve stresses and strains developed during the cupping process. If not relieved, these metallurgical pressures might cause the case to crack during later manufacturing operations or during storage. Ordnance later transferred this phase of cartridge manufacture to the brass mills as the shipment to ammunition plants of strips containing a good deal of scrap was less economical than shipment of cups.

As they emerged from the furnaces the cups had to be "pickled" in an acid bath to remove the oxide film that formed during annealing. To wash off every trace of surface impurity they were rinsed in cold water, bathed in hot soapy water, rinsed again, and dried. Only then were they ready for the "first draw" during which a long, powerful punch was forced into each cup, making it deeper and thinner-walled—more like a drinking glass than a cup. Four such draws were needed before the case reached its proper length, and after each draw the cases had again to be annealed, pickled, washed, dried, and trimmed. Company inspectors visually examined the cups after each operation to detect crooked heads, scratches, or other defects; they also gaged them for length, inside and outside diameter, and wall thickness. Next came the punching of a small pocket in the head of the case to hold the primer cup, followed by the heading operation that flattened the end of the case, stamped on it the plant initials and year of manufacture, and cut the extractor groove.

The tapering and necking process was far more difficult than it appeared to be. It demanded careful annealing and precision working of the case to give it a narrow neck, sloping shoulders, and a slightly tapered body. Only the body was annealed—not the head, for it had to remain hard—so the cases were slipped into holes in a revolving dial that exposed the bodies to a row of gas burners while the heads were submerged in cold water. The next step was insertion of the primer. The machine used for this purpose first punched a "flash hole" in the primer pocket, then seated the primer to the proper depth and crimped it into place. After shellac and varnish were applied to make the cases moisture-proof, they were dried and inspected. If they passed muster they were ready to be filled with powder and topped with bullets.

The bullets used at St. Louis were innocent-looking metal slugs that appeared to present no difficult manufacturing problems. But in fact their fabrication involved a number of rather intricate steps. The simplest type of ammunition was ball, with tracer, armor-piercing, and incendiary rounds each introducing its own complications. Ball bullets belied their name. They were not ball-shaped but pointed at the nose. AP bullets not only had a pointed nose but also a slight taper or boattail at the base. The only small arms bullet that

[57] For contemporary description data, see TM 9-1900, Small-Arms Ammunition, 23 May 42.



LEAD SLUGS FOR .45-CALIBER BULLETS *being cut from reel of lead wire.*

even approached ball shape was the .45-caliber.[58] The essential material in .30-caliber and .45-caliber ball bullets was lead, but the lead had to be covered with a bullet jacket, normally made of gilding metal. Cutting the lead slugs from lengths of slender wire was a comparatively simple operation, but forming the bullet jacket was something akin to making cartridge cases. Starting with strips of gilding metal, disks were stamped out and formed into cups which then went through a whole series of annealing, pickling, cleaning, and drawing operations before they were ready to be slipped over the lead slugs. As it did with cartridge brass, Ordnance transferred the process from its ammunition plants to commercial suppliers. For armor-piercing ammunition special AP cores of hardened steel took the place of lead slugs, and only enough lead was used to insure a snug fit. AP cores used by the St. Louis plant were manufactured by the McQuay-Norris Company in its core-making facility within the plant. A tracer bullet consisted of a jacket containing a small lead slug and illuminant powder that burned while the bullet was in flight. An incendiary bullet contained a chemical mixture that ignited on impact with the target.

Assembling the parts of the cartridge was usually referred to as "loading," although this term did not include insertion of the

[58] The use of the term "ball" was apparently a carryover from earlier days when spherical bullets were standard. It was used in World War II to describe bullets of plain lead, or soft steel and lead combined, and to distinguish them from bullets of a specialized nature such as AP, incendiary, or tracer.

primer into the case. At the loading machine the case was filled with smokeless powder, the bullet was inserted in its mouth, and the case was crimped to hold the bullet securely, i.e., the edge of the case mouth was rolled so that it bit into the groove or cannelure in the bullet. The nose of the bullet was then dipped into lacquer of the proper color to identify it as to type—red for tracer, black for AP, blue for incendiary, and so on. Powder was brought to the plant as needed from the Tyson Valley Powder Storage Area, a 2500-acre plot thirty-two miles southwest of the plant site.

All along the line of manufacture and assembly, company inspectors watched for imperfections that might cause trouble when a cartridge was fired. With the aid of mirrors and magnifying glasses some looked for surface defects while others with hand gages checked various dimensions. For inspection purposes the St. Louis plant used over sixteen thousand precision gages and micrometers costing more than half a million dollars. When completely loaded, the ammunition went through a machine that automatically checked each cartridge for weight, length, and profile. At this point government inspectors entered the picture to take samples from each lot for thorough inspection before acceptance of the entire lot. Ordnance considered this sampling technique, known as "quality control," adequate because employees of the company had already made countless inspections during the manufacturing process.[59] In the St. Louis "proof house" more than a million rounds were fired every month to check their performance; some were taken apart to see whether they had sufficient powder; others were soaked in water to test their ability to "keep their powder dry." Muzzle velocity tests and accuracy tests were also part of the program to maintain quality at a high level. All told, inspections on a typical round numbered more than fifty.

The St. Louis Episode

In January 1943 sensational charges of faulty inspection procedures at the St. Louis plant appeared in a local newspaper, the St. Louis *Star-Times*. "Unfit Shells Pass Plant Inspection at Factory Here, Inspectors Charge" was the front-page headline on 4 January 1943. "Five company employees have given statements to the St. Louis *Star-Times*," the article read, "charging manufacture of defective ammunition. All are engaged in some form of inspection and testing in the manufacture of .50-caliber machine gun cartridges. They say they have direct knowledge of defects in some of the component parts of cartridges produced under their eyes." Cases with cracked heads sometimes passed inspection, the employees charged in affidavits, and cases with ragged flash holes were passed "if any kind of hole was visible." Under pressure to speed production, powder was loaded into cases that still retained water after being washed and dried, or that contained grease or oil from production machines. One laboratory worker declared that defective brass had been used for the past month in cartridge cases despite reports of tests showing the defects. Another charge was that the company's production department approved cartridges with loose-fitting bullets. As Ordnance inspectors at the plant checked only small samples—less than 1 percent

[59] For discussion of over-all Ordnance policies on inspection, see Chapter XIV, below.

—from each lot of ammunition before accepting it for the government, the employees asserted there was a "strong chance" that defective cartridges were slipping through unnoticed in the 99 percent of each lot that was not government inspected.[60] Though not made public, a report of an inspecting officer dated 31 December 1942 cited complaints by employees that foremen had told minor inspectors to violate established practice by forcing gages to provide a greater amount of aircraft ammunition.[61]

The United States Cartridge Company promptly denied the charges and declared that "bad or imperfect ammunition has not been sent from this plant." It branded the charges "false and ridiculous" and called for a complete investigation by the government.[62] The other newspapers in St. Louis played down the story and suggested it was based on "tavern talk." On 6 January a spokesman for the Army declared that "no report had been received by the Ordnance Department about defective material from the St. Louis Small Arms Plant during the current situation." [63] The Federal Bureau of Investigation had been looking into the charges for several weeks before 4 January 1943 when the *Star-Times* broke the story, but after that date St. Louis was deluged with investigators. Maj. Gen. Thomas J. Hayes, chief of the Industrial Service, announced appointment of a board of experts, headed by Col. Merle H. Davis, chief of the St. Louis Ordnance district, to review the inspection methods at the plant.[64] The commanding officer, Lt. Col. Charles S. Paullin, meanwhile declared that the charges had unsettled operations and held up production.

The Davis Board spent several days studying inspection practices at the plant with a view toward making them as nearly foolproof as possible. It concluded that inspection at the St. Louis plant was neither better nor worse than at other plants and that, if any poor ammunition got through, it was inconsequential in amount. But it recommended more than a dozen changes in procedure to tighten up the inspection process.[65] When the report reached Washington it was not made public, but on 16 January Under Secretary Patterson told reporters, "The method of ordnance acceptance sampling and inspection of the finished product at the St. Louis Ordnance Plant is entirely satisfactory." [66] This categorical statement did not satisfy the critics who wanted to know

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[60] St. Louis *Star-Times*, January 4, 1943. The story was written by two of the paper's staff writers, Julius M. Klein and Ralph O'Leary. Additional data appeared in issues of the next few days. The newspaper and the two writers received the National Headliners' Club 1943 award for outstanding public service in publishing the articles.

[61] Ltr, Lt Col Arthur E. Allen to TIG, 31 Dec 42, sub: Spec Inspection of . . . St. Louis Ord Plant, OOP.333.1 St. Louis OP. Colonel Allen concluded that "the supervision, control and administration of the Government employees in the Inspection Department was lacking in efficiency and thoroughness . . ." and that morale in the Inspection Department was at "an unsatisfactory low ebb."

[62] The company placed a statement of its position in all St. Louis papers. Photostats of articles may be found in History, St. Louis Ordnance Plant, Volume 100, OHF.

[63] St. Louis *Post-Dispatch*, January 6, 1943.

[64] The other members of the board were Capt. James H. Dunbar, Jr., chief of engineering and inspection at the Small Arms Ammunition Suboffice, and Capt. Frank D. Grossman, Henry H. Hover, and Arthur W. Darby, all of Frankford Arsenal.

[65] (1) Interv with Brig Gen Merle H. Davis, 11 Dec 53; (2) St. Louis *Star-Times*, January 12, 1943.

[66] St. Louis *Post-Dispatch* and St. Louis *Star-Times*, January 16, 1943, and St. Louis *Globe-Democrat*, January 17, 1943.

why, if everything at the plant was satisfactory, the Davis Board had recommended numerous changes in existing inspection procedures. The next day Drew Pearson in a radio broadcast termed the Patterson statement a "whitewash" and predicted that, in spite of Army opposition, the Justice Department would proceed with its investigations.[67] In St. Louis General Campbell promptly branded the Pearson charges untrue. "Do you think a man [i.e., Colonel Davis] who has spent his entire life in the Army is going to whitewash any contractor?" the general asked a group of newsmen. "If you do, you don't know the United States Army. If the experts who investigated the plant here had found the charges borne out by the facts, you would have found us moving in there strongly. We could cancel our contract at any time." He went on to say that so little defective ammunition had gone to troops that combat commanders had requested shipments of defective cartridges to show their men how to deal with them.[68]

Not much was heard of the charges during the next ten months while further evidence was collected and presented to a federal grand jury. Then in December 1943 came the grand jury's report indicting ten persons on charges of sabotage and of conspiracy to defraud the government while employed at the St. Louis Ordnance Plant. With the indictments the grand jury submitted direct criticism of both the company and the Ordnance Department. After studying the voluminous documentary evidence, the jury concluded:

1. That the then authorized system of inspection and delivery to the United States Ordnance Department by the United States Cartridge Company was inefficient and highly conducive to the commission of the infractions for which true bills have been voted.



MAJ. GEN. THOMAS J. HAYES, *Chief of the Industrial Service, 1 July 1942 to 30 December 1944.*

2. That the system for acceptance of such ammunition on the part of the United States Ordnance Department was inefficient in a like manner as compared to the contractor and not equal to the task assigned.

The jury went on to say that the circumstances at the time "may or may not have extenuated the situation" and further observed that evidence submitted later showed that extensive improvements had been made in inspection procedure and supervision.[69]

[67] St. Louis *Star-Times*, January 18, 1943. Pearson's exact statement is quoted in memorandum of Julius H. Amberg to USW, 18 January 1943, sub: St. Louis Ord Plant USW, Geographic.

[68] General Campbell's remarks were reported by all the St. Louis papers on 18 January 1943.

[69] The grand jury indictment was printed in all the St. Louis papers on 22 December 1943. Photostat copies are in History, St. Louis Ordnance Plant, Volume 100. An eleventh individual was indicted later.

Trial, Acquittal, and Reform

Trial of five of the indicted employees resulted in their acquittal in April 1944. During the trial three of the defendants admitted that they had passed cartridges without adequate inspection but contended that it was done on orders of their superiors. After acquittal of the first group, charges against the others were not pressed by the government. A civil suit filed against the U.S. Cartridge Company, under the False Claims Act, in December 1943 dragged on for nearly ten years before it was finally settled. The company won its case in both the District Court and the Court of Appeals, and in 1953 the Supreme Court refused to issue a writ of certiorari to bring the case before it. The government introduced voluminous evidence to show that the company had not maintained a satisfactory system of inspection and that defective ammunition from the St. Louis plant had caused aircraft guns to jam in combat. In the opinion of the courts, the company had made every reasonable effort to maintain a satisfactory inspection system and could not be held liable for occasional unauthorized acts of a few employees.[70]

The facts of this case point to the conclusion that inspection practices at the St. Louis plant in late 1942 were neither wholly satisfactory nor as bad as the sensational newspaper charges suggested. Ordnance officers felt the plant was no better and no worse than other ammunition plants, except, perhaps, in the field of employee relations. There was apparently considerable employee dissatisfaction, and Ordnance officers close to the scene felt that at least some of the inspection complaints came from disgruntled former employees or from employees who did not fully understand the elaborate inspection system. Because inspection of ammunition was not a simple, cut-and-dried process but a long series of checks and rechecks employing many ingenious measuring and weighing devices, it was sometimes misunderstood or misinterpreted. Further, as the grand jury pointed out, there were extenuating circumstances. This huge plant was built and put into operation with great haste during a national emergency. The intense pressure to speed production in 1942 may have led some contractor employees on occasion to take shortcuts and push ammunition through without complying with every detail of the inspection rules. It also appears that, no matter how faithfully inspection procedures were observed, they were not foolproof. They were inevitably subject to improvement in the light of experience gained during the first year of mass production. Combat experience in North Africa and Italy in 1942–43 revealed instances of jammed aircraft guns, including some cases when planes returned with all their guns jammed. But whether this resulted from faulty inspection at the plant or from rough handling that broke the watertight liners of packing boxes and caused corrosion was never positively determined.[71]

[70] Memorandum opinion, United States of America *vs.* The U.S. Cartridge Company, No. 2486, District Court of U.S., Eastern District of Missouri, Eastern Division, 95 F. Supp. 384. See also U.S. Court of Appeals for Eighth Circuit, No. 14,389, United States of America *vs.* The U.S. Cartridge Company 198 F.2d 456, files of OCO Legal Office.

[71] (1) SAA, I, pp. 339–41; (2) 95 F. Supp. 391, *op. cit;* (3) Intervs during December 1953 and January 1954 with many persons familiar with the case, including Maj Gen Thomas J. Hayes, Brig Gen Merle H. Davis, and Brig Gen David L. Van Syckle.

Numerous changes were made in inspection methods at the St. Louis plant immediately after the newspaper charges appeared, along with a similar tightening up at other plants. When, for example, controlled studies during 1943 showed that the existing sampling method allowed poor lots to pass inspection in too many cases, it was replaced by the double sampling procedure.[72] The need for improvement and standardization was officially recognized by the chief of the Small Arms Branch in May 1943 when he issued a new directive establishing revised procedures to "insure that the methods in use appear to be sound even to the uninitiated observer, the worker in the plant, or the qualified investigator examining the plant." [73] An intensive study of inspection methods at all plants was made during 1943, prompted in part by the St. Louis episode; it resulted in a clarification of standards and publication of numerous manuals to guide inspectors.[74]

Maintenance of an adequate force of trained inspectors was always a problem. Salaries were low, and the work offered little room for advancement. Selective service took its share of the inspection staffs while pressure to economize on manpower led to widespread reduction of inspection forces. At one point, late in 1943, General Drewry declared flatly that, in trying to turn out "quality stuff," he was having some trouble. "I feel that this business of cutting too far is wrong and I don't propose to reduce our inspectors to the point where we can't guarantee a quality product. I just can't do it." [75]

Labor Problems

The St. Louis plant encountered a good deal of difficulty in dealing with labor unions, and in training and employing both white and colored workers. Some Ordnance officers felt that criticisms of employment and inspection practices that arose during the war were motivated in large part by labor elements hostile to the U.S. Cartridge Company. The location of the plant in a border state and in a city with a large Negro population provided a natural setting for problems in race relations.

In 1941 both U.S. Cartridge and McQuay-Norris had not only to recruit thousands of workers but also to train them in the specialized jobs required in ammunition manufacture. Both companies started with a nucleus of their own trained workers and supervisors, recruited new employees, established training schools, and quickly built up large work forces. Frankford Arsenal trained many employees for this and other plants. By July 1943 the entire St. Louis plant employed a total of forty-three thousand workers—thirty-five thousand by U.S. Cartridge and eight thousand by McQuay-Norris. The tight labor market of the early war years forced both companies to hire some workers who did not measure up even to the minimum

[72] (1) Hist, Denver Ord Plant, 1st supp, pp. 17–18; (2) Hist, Lake City Ord Plant, V, pp. 83–88.

[73] Memo, Chief of SA Br, 4 May 43, cited in SAA, I, pp. 339–40.

[74] SAA, I, pp. 339–41. Comments on the value of the manual on visual inspection issued in March 1944 appear in History, Lake City Ordnance Plant, VI, p. 117. A broad picture of the effort to improve inspection of all types of matériel during 1943 is presented in G. Rupert Gause, "Quality Through Inspection," *Army Ordnance*, XXV, No. 139 (March–April 1943), 117, and 1st Lt. Robert J. Saunders, "Standardized Inspection," *Army Ordnance*, XXIV, No. 137 (March–April 1943), 290.

[75] Rpt of Conf Ord Dist Chiefs, Philadelphia, 8 Oct 43, p. 23.

standards of peacetime employment. Nearly half the employees were women, many of whom had no previous industrial experience. To use such unskilled employees effectively, work was simplified as much as possible and new employees were given brief but intensive courses of instruction in the specific jobs assigned to them.[76]

In recruiting Negro workers the U.S. Cartridge Company, in common with other war plants in the area, adopted a policy of following the St. Louis population ratio of 90 percent white and 10 percent Negro. During most of the war years the number of Negro workers at the plant averaged between 10 and 12 percent—between three thousand and four thousand—but there was no intermingling of the two races. All colored workers were assigned to one production unit, under a white superintendent. The other seven units were staffed entirely by white workers. In the colored unit every major craft was represented and Negroes held all positions up to and including general foremen.[77]

These practices led to a number of racial disputes during 1943 but did not come under strong attack until late 1943 and early 1944 when cutbacks in production schedules forced the company to lay off many of its workers. Charges were then made that, in selecting employees to be laid off, the company discriminated against Negroes. The President's Committee on Fair Employment Practices (FEPC) held hearings on these charges (and others brought against other St. Louis plants) during the first week in August. It dismissed some of the complaints as groundless but upheld others and on 29 December 1944 ordered both the U.S. Cartridge Company and McQuay-Norris to abandon their quota systems and stop racial discrimination in hiring and firing workers. Referring to the cutbacks in the spring of 1944 when the use of different seniority systems for white and colored workers sometimes had worked to the advantage of one race and sometimes to another, the FEPC declared:

> A racial quota system is equally as mischievous when used to select employees for layoffs as when applied with regard to their hire. Executive Order 9346 does not provide that Negroes or other minority groups shall be hired or retained in employment in accordance with population ratios . . . . It is no defense to argue, as the respondent has done, that its quota system on certain occasions operated to the advantage of Negro employees and to the prejudice of white workers. The executive order forbids discrimination against white as well as against colored employees.[78]

By the time this decision was made the St. Louis plant had only about six months more of wartime operation ahead of it. Its notice to terminate came in June 1945. During this brief period the companies took steps to carry out the FEPC policy. They abandoned the quota system of hiring and attempted to recruit members of both races to work together on a nonsegregated basis, but they encountered considerable difficulty in carrying out the program. Operation of the plant on an integrated or nonsegregated basis, and hir-

[76] (1) Hist, St. Louis Ord Plant, vols. I–IX, OHF; (2) Ltr, Lt Col Carleton G. Chapman to TIG, 30 Nov 44, sub: Rpt of Spec inspection . . . of St. Louis Ord Plant, OO 333.1/1883 Misc (c); (3) SAA, I, p. 147.

[77] For comparison of operating efficiency, showing the colored unit to be much less efficient, see Ltr, Maj R. R. Porter to TIG, 14 Jul 45, sub: Spec Inspection of . . . St. Louis Ord Plant, OO 333.1/2323.

[78] St. Louis *Post-Dispatch,* December 29, 1944. Clippings from St. Louis newspapers of the period are in History, St. Louis Ordnance Plant, Volumes VIII–IX, OHF. The records of these cases and others are in the National Archives.

ing without regard to race, had to wait until the plant reopened in the early 1950's.[79]

Conversion from Copper to Steel

During 1941, as the copper shortage took definite shape on the horizon, Ordnance launched a far-reaching program to conserve copper in all types of matériel, including small arms ammunition. There were two main lines of endeavor as far as small arms cartridges were concerned—substitution of clad steel for gilding metal in bullet jackets, and substitution of steel for brass in cartridge cases. The development of clad steel jackets progressed so rapidly that by the fall of 1942 production of the new type jackets was in full swing. But conversion to steel cartridge cases proved to be a much more difficult problem.

Frankford Arsenal succeeded during 1941 and early 1942 in converting the .45-caliber case to steel, and by the summer of 1942 the steel case went into production at the Evansville plant. After thorough testing, it was accepted as standard in January 1943, the only small arms cartridge fully converted to steel in World War II.[80] Meanwhile, research on the .30- and .50-caliber cases encountered a host of technical problems, stemming in large part from the fact that steel is less elastic than brass. But the shortage of copper during 1942 forced continued efforts to develop acceptable steel cases. As soon as the new plants, built to make cases from brass, came into production they ran short of brass and had to begin the difficult task of converting their equipment and processing methods to the use of steel. To save time, development work was done on the production lines rather than in the laboratory. Then, just as success appeared to be within reach, the copper shortage eased, requirements dropped, and the whole steel conversion effort was discontinued except for experimental production lines at Frankford.[81] The progress made in producing steel cases was, in the words of General Hayes, "a miracle, but not a big enough miracle." [82]

Ammunition Belts

As efficient operation of machine guns was impossible without belts or other devices to feed ammunition, a small but essential phase of Ordnance ammunition procurement dealt with production of ammunition belts, both fabric and metallic. Of these two types, metallic belt links were used chiefly in aircraft guns and fabric belts in ground weapons until the closing months of the war when metallic belt links were issued to ground troops. Though they appeared to be simple to manufacture, both types posed troublesome manufacturing problems.

The principal producer of .30-caliber fabric belts for the U.S. Army in World War I was the Russell Manufacturing Company, which held a 1916 patent on a

[79] (1) Interv with Ray Bryan, Ord representative at St. Louis plant, and F. A. Lutz, Chief Ammo Sec, SA Br, OCO, 12 Jan 54; (2) Ltr, Porter to TIG, 14 Jul 45, sub: Spec Inspection of . . . St. Louis Ord Plant, OO 333.1/2323 St. Louis Ord Plant. The file of FEPC records contains one brief letter from each company reporting on its efforts to comply with the ruling.

[80] OCM 19493, 14 Jan 43. A detailed statement of the Ordnance plans for meeting the copper shortage in the fall of 1942 appears in Memo, CofOrd for CG SOS, 10 Sep 42, sub: Copper for Ammo Manufacture, ExecO file.

[81] For a more detailed account of this whole subject, see Green, Thomson, and Roots, *Planning Munitions for War,* Chapter XVIII.

[82] Rpt of Conf Ord Dist Chiefs, Springfield, Mass., 28 Jul 43, p. 7.



.50-CALIBER MACHINE GUN AMMUNITION IN FABRIC BELTS, *being arranged for crating by women in an ordnance arsenal.*

fabric belt. After the war this concern continued development work in co-operation with Springfield Armory and in 1936 was granted another patent on an improved belt design. Russell was the only source of fabric belts for the Army during the defense period, but in the fall of 1941, with requirements rising fast, Ordnance adopted a modified design to enable other producers to come into the picture without infringing the Russell patent. The need for this alternate design was eliminated after Pearl Harbor when Russell granted the government a royalty-free license for the duration of the emergency. By June 1942 six facilities other than Russell were producing the 250-round infantry-type belt, but of the twenty-eight million belts manufactured through May, 1944, when all production stopped for about eight months, Russell made slightly more than half. Meanwhile the temporary shortage of steel and of strip mill and furnace capacity in late 1942 prompted the adoption of .50-caliber fabric belts for aircraft guns. As Russell had previously made small quantities of such belts for foreign sale it was in a position to start production promptly. Several other concerns also made fabric .50-caliber belts before the project was terminated in September 1943 because of the easing of the metals shortage and reduction of ammunition requirements. Production of fabric belts for ground machine guns was resumed for a short time after the German breakthrough of December 1944, but in 1945 fabric belts gradually gave way to steel links for infantry use.[88]

[88] PSP 36, Machine Guns, Development and Production of Metallic Belt Links and Fabric Ammunition Belt, by SA Div, Ind Serv, OCO, Oct 45.

To manufacturers, metallic belt links were deceptively simple in appearance. Each steel link consisted of three small loops, two on one side and one on the other. A belt of ammunition was formed by placing the single loops of one link between the two loops of the other and inserting the cartridge through the three loops in much the same manner as one slides a bolt through the hinge of a screen door. Any number of links could be assembled in this manner to make a long belt of cartridges that had great flexibility and could be rolled and twisted to fit confined spaces in airplanes.[84] In addition, the belt links automatically fell apart as the cartridges that held them together were fired and ejected from the gun. Thus the origin of the term "disintegrating metallic belt links." Though simple in design these metallic links demanded exceptional accuracy in piercing, cutting, forming, and heat-treating to guarantee faultless performance when used in aerial combat. If links were too hard they were likely to break under pressure, and if too soft they might stretch and cause stoppage of the weapon. If either too loose or too tight they would not function properly. As rust or corrosion on links would render them unfit for use, they had to be given a carefully controlled rustproofing treatment before being sent to the field. Rigid inspection was essential to guard against acceptance of a single link that might cause trouble, for it was literally true that an ammunition belt was only as strong as its weakest link.

During the years of peace Rock Island Arsenal was the sole producer of links in the United States. As there was but a trickle of new ammunition produced each year the need for links was correspondingly small, but during 1940 Rock Island turned out about 50,000,000 .30-caliber links and about 15,000,000 .50-caliber. With requirements for aircraft ammunition on the rise, and with a shift toward the larger caliber taking place, Rock Island placed contracts with industry for .50-caliber links, beginning in June 1940 with the Fort Pitt Bedding Co. and three other concerns in 1941. Approximately 150,000,000 were produced in 1941, three times the 1940 output. In the summer of 1941 production of .30-caliber links began at Jackes Evans Manufacturing Company and General Aviation Equipment Company. After Pearl Harbor, requirements for both sizes combined rose to eighteen billion for the 2-year period 1942–43. To meet these astronomical requirements a speedier production process was introduced, using a progressive multi-station die developed at Rock Island in the 1930's, and contracts for link production were placed with many different firms. To speed production and break bottlenecks a Metallic Belt Link Industry Integration Committee was formed in the summer of 1942, and by September 1943 the monthly rate of production had reached more than half a billion. Thereafter requirements were reduced with some contracts being terminated outright and others continued at greatly reduced rates. Early in 1945, after the Battle of the Bulge, there was a brief period of rising requirements followed by contract cancellation as the end of the war appeared in view. Total production of metallic links during the 1940–45 period reached close to thirteen billion.[85]

[84] Green, Thomson, and Roots, *Planning Munitions for War*, p. 426.

[85] (1) PSP 36, Machine Guns, Development and Prod of Metallic Belt Links and Fabric Ammo Belt; (2) Whiting, Statistics, p. 47; (3) Historical Data, Link, Metallic Belt, Cal. .50, M2,

Packing Boxes and Cans

Packing small arms ammunition for overseas shipment was a troublesome problem for Ordnance during World War II. The boxes used at the start of the war were essentially the same as those used in World War I—nailed wooden boxes lined with terneplate (tin-coated sheet steel). When soldered shut, the liners of the M1917 boxes provided a tight seal against dirt, water, or air unless broken by rough handling. They had served well in the 1920's and 1930's but proved less suitable for the combat conditions encountered in World War II. Weighing one hundred pounds or more, they were too heavy for troops or native bearers to carry, and, when subjected to rough handling, the boxes or liners sometimes broke, resulting in dirty or corroded ammunition.[86]

Another difficulty with the M1917 pack was that it used scarce materials, particularly tin. Solder with a lower tin content was therefore prescribed for sealing the terneplate liners, and less tin was used in the liners themselves. Steel was substituted for brass in the nuts and bolts of the boxes, and zinc plating was used instead of cadmium to plate the handles and other box hardware. At the same time, Ordnance engineers studied the possible replacement of terneplate liners with nonmetallic materials such as wax paper, asphalt paper, and plastic film. The most promising substitute, waxed fiber board, was adopted in the summer of 1942, but it did not prove satisfactory and was abandoned a year later.

In peacetime, most ammunition had been shipped in bulk pack, with troops in the field responsible for assembling cartridges into clips or machine gun belts. This procedure was soon changed as the using arms demanded that cartridges be put in so-called functional assemblies or ready-to-use packs. Another major change in packing procedure occurred in the summer of 1942 when responsibility for packing ammunition was transferred from Field Service depots to the manufacturing plants. The earlier practice had been for the plants to pack ammunition in cartons and ship it to depots where it was unpacked, assembled into clips, belts, or links, and then repacked.

All during the first half of 1943 Ordnance received frequent reports that the packing of cartridges in M1917 boxes was unsatisfactory, whether in waxed paper cartons or terneplate liners. The chief complaints were of corroded or broken links and dirty ammunition caused by broken boxes or ruptured liners, but the boxes were also criticized as too heavy and hard to handle in the field. Minor changes and improvements were made, but it was not until the closing months of the year that steps were taken to introduce a completely new type of container. Under contract with Ordnance, the Chrysler Corporation and the American Can Company developed a hermetically sealed can that could be opened with a key in the same manner as a coffee can. The new pack, including an improved wooden box holding two cans totaling about fifty pounds,

as manufactured by S.W. Farber, Inc., in Hist, New York Ord Dist, vol. 100, pt. 1.

[86] Rcd of Army Ord Research and Development, vol. 2, bk. 2—Small Arms Ammunition, ch. 18; (2) PSP 58, Packaging, Development of, in the Ordnance Department, by Prod Serv Div, Ind Serv, OCO, Jul 45; (3) Small Arms Ammunition, Highlights of History, 1 Jul 44–1 Apr 45, supp. III, by Ammo Br, SA Div, OHF; (4) History of Ordnance Section, Hq Sixth Army, 27 Jan 43–15 Dec 45, pp. 40–41.

was standardized for .45-caliber and .30-caliber carbine ammunition early in 1944. It was extended to other calibers later in the year—too late to have any effect on the crucial Allied drive across France in the summer of 1944.[87]

The best ready-to-use packs were the .30-caliber M1 box containing belted cartridges and the .50-caliber M2 box holding linked ammunition. These boxes were not only packing containers for storage and shipment but were also ammunition feed boxes and were cheap enough to be expendable. Functional assemblies had such advantages that they were standardized, whenever possible, for future packing of ground ammunition. There was no need for packing aircraft ammunition in such assemblies, for it was removed from shipping containers and stowed aboard airplanes in special trays and feed boxes.[88]

Packing ammunition in the M2 boxes brought its share of problems. As the plants were not designed for this work it had to be squeezed into odd corners. One result was that in September 1943 nearly half the eight hundred thousand boxes packed developed leaks. As Colonel Boone Gross summed up the matter, "we had to go out and run a service program and buy new gaskets and then open up the boxes and test them 100%." [89]

Surpluses, Cutbacks, and Terminations

As 1942 was a year of shortages, 1943 was a year of surpluses. Production during the first half of 1943 was so great that, as General Harris had predicted early in 1942, the Army had ammunition "running out of its ears." The pipelines were filled and the monthly production of two billion cartridges was creating a storage problem for Field Service. At both ends of the line—in the plants and on the battlefield—earlier estimates had proven wholly inaccurate. The plants were producing at a rate far higher than had been expected, and the mobile tank warfare in North Africa called for much smaller expenditure of rifle and machine gun ammunition than had been anticipated.[90] In August 1943 the Procurement Review Board reported that the on-hand stock of small arms ammunition in the United States amounted to 2.5 billion rounds, with an additional 1.4 billion rounds—nearly equal to the entire AEF expenditure in World War I—in reserve in North Africa. It observed that the Day of Supply figures were "excessively large," that ammunition plants were operating far below their capacity, and that reserves of ammunition were "tremendous" and would soon be "astronomical." The Board bluntly concluded that "the War Department must take steps to bring production of ammunition and stocks of ammunition into the realm of reality." [91]

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[87] (1) SA Ammo, Highlights of Hist; (2) Hist, Frankford Arsenal, SA Ammo Div, I, pt. 3, p. 154; (3) Rcd of Army Ord Research and Development, vol. 2, bk. 2, ch. 18.

[88] SAA, I, pp. 335–38. For a detailed history of development of small arms ammunition packs, see Record of Army Ordnance Research and Development, Volume 2, Book 2.

[89] Rpt of Conf Ord Dist Chiefs, Philadelphia, 8 Oct 43, p. 22.

[90] On reduction of the Day of Supply for small arms ammunition, see correspondence during Sep–Oct 43 in Rqmts Docs. folder, OHF.

[91] Rpt of WD Proc Review Bd, 31 Aug 43. Members of the Board were Maj. Gen. Frank R. McCoy, Maj. Gen. Clarence C. Williams (former Chief of Ordnance), Brig. Gen. William E. Gillmore, and Mr. J. Madigan. See also comments on the report by General Somervell in the same file, and remarks by Brig Gen James Kirk before Small Arms Ammunition Labor Advisory Committee, 10 Jan 45, OHF.

While the Procurement Review Board was at work a representative of the Bureau of the Budget surveyed the small arms ammunition plants and reached similar conclusions. His report revealed that the existence of excess plant capacity was exacting a heavy toll in terms of production costs because the plants were operating far below their capacity. The most significant factor in the cost of production at any plant was found not to be the managerial skill of the contractor or the supervision by Ordnance representatives but the percentage of maximum capacity at which the plant operated. Efficiency rose and costs declined when a plant produced near its peak; the trends were reversed when the plant operated at a low level. The report recommended that five plants—Allegany, Eau Claire, Denver, Lake City, and Lowell—be shut down and that adjustments be made at the remaining plants to provide needed production.[92]

Before either of these reports was made, the process of reducing requirements and slowing down production had begun. Over-all requirements for small arms ammunition (1943–44 combined) dropped from the 1943 peak of about fifty billion in February to approximately thirty-six billion in September.[93] During the summer of 1943 Frankford eliminated its second and third shifts and returned to its traditional role of laboratory for development of improved ammunition and production techniques. In the closing months of the year six plants were shut down—Allegany, Utah, Eau Claire, Milwaukee, Lowell, and Scioto—and production rates were cut by one-third at most of the others. When ammunition production stopped, the plants were promptly converted to other war uses, and the machinery was transferred for use elsewhere, put in storage, or sold as scrap. Frankford Arsenal collected a great deal of technical information from every closed plant—reports of experiments, floor layouts, production processes, and related material.

Early in 1944 when ASF reduced requirements again, three more plants closed —Denver, Evansville, and Kings Mills— leaving only four of the original twelve plants in operation. At two of the remaining plants—St. Louis and Twin Cities —several buildings were converted to artillery ammunition manufacture. At the same time production of bullet cores at commercial plants stopped almost completely, and deep cuts were made in the schedules of the privately owned plants of the Remington and Winchester companies in Connecticut. Production of all types of small caliber ammunition dropped from nearly 20 billion in 1943 to 6.5 billion in 1944.[94] The effect of the 1943–44 reductions is

[92] (1) General Report on Production of Small Arms Ammunition, 16 Oct 43, War Projects Unit, Bureau of Budget; (2) Supplemental Report to the foregoing, 30 Oct 43, both in OHF. In 1942 Ordnance was directed to keep plants in operation part-time, rather than close them down, though it was recognized that some waste and inefficiency resulted. Review of Prod Plants, 20 July 1942.

[93] Supp. Rpt, 30 Oct 43, Bur of Budget. See also Munitions Assignments Board in Washington, Caliber .50 Ammo Program, 12 Oct 43, ASF Plng Div Theater Br, Box 389, 471 Ammunition, vol. I, N.A.

[94] Detailed information on all these actions is recorded in the reports of a board appointed by the Chief of Ordnance to review recommendations of the operating branches of the Industrial Division, by SO 265, par. 59, 5 Nov 42. See OO 334 (8150–8250). See also Interim Report on Small Arms Ammunition, 26 Dec 44, Bureau of Budget and comments on this report by General Kirk. On the private plants, see Memo of Clay for Charles E. Wilson, 25 Feb 44, OO 471.4/2568 Incl 2. Procurement deliveries of small arms ammunition in 1944 were valued at $649,600,000 as compared to $1,522,000,000 in 1943.

shown in the following tabulation of monthly production figures for combat types:[95]

	July 1943	*January 1944*	*July 1944*
Cal. .30 –	903,000,000	513,000,000	172,000,000
Cal. .50 –	455,000,000	210,000,000	168,000,000
Cal. .45 and carbine–	433,000,000	310,000,000	51,000,000

With the termination notices that went out in November and December 1943 the Chief of Ordnance sent a letter to each plant explaining the reasons for the action. These letters were placed on employee bulletin boards and published in local newspapers. They cited four factors that made it possible to reduce operations—the high rate of production attained by the plants, the virtual elimination of the submarine menace, the effectiveness of .50-caliber incendiary ammunition in downing enemy planes, and the Japanese evacuation of Kiska without a fight. General Campbell made it clear that the war was far from over but explained that the War Department had ordered the reductions because the worst phase of the ammunition crisis had passed.[96] He might also have added that the War Department had decided, in view of the huge stocks on hand, to depend on reopening closed plants to meet any emergency that might arise in the future.

Despite these efforts to explain the situation the announcement of cutbacks brought sharp criticism from organized labor, particularly the United Electrical, Radio, and Machine Workers of America, a CIO affiliate. In February 1944 the union charged that, in selecting plants to be cut back, the military authorities "are violating all considerations of national manpower allocation, are closing down the most efficient and maintaining in operation the least efficient small arms ammunition plants, and are closing the plants most favorably located from the standpoint of military security." [97] In reply, Under Secretary Patterson expressed regret that more advance notice had not been given to plant management and workers but declared that the Army, far from overlooking manpower, had made it "the dominating factor in our decisions." He defended the retention of small-scale production at the privately owned Remington and Winchester plants in Connecticut on the ground that these plants "are an integral part of the Nation's establishment available for the maintenance and continued development of the small arms ammunition art." In selecting plants to be retained, Patterson pointed out, the Army considered the kind of ammunition manufactured by each and retained only capacity needed to meet specific requirements. The Army's explanation did not minimize the effect on labor of the 1943–44 cutbacks.[98] The small arms ammunition plants in operation in the fall of 1944 employed only one-fourth the number employed in July 1943 when all plants were in production and nearly 170,000 were at work.

Along with the vertical drop in total requirements there were several significant lateral shifts as some types decreased in importance and others gained. The one

[95] Remarks by Brig Gen James Kirk before SA Ammo Labor Advisory Comm., 10 Jan 45, on the 1945 Small Arms Ammunition Program, OHF.

[96] Ltr, CofOrd for CO Milwaukee Ord Plant, 11 Nov 43, copy in History, Milwaukee Ordnance Plant, vol. V, p. 56.

[97] Ltr, United Electrical, Radio and Machine Workers of America (signed by Russ Nixon) to Wilson, WPB, 21 Feb 44, OO 471.4/1851 (c).

[98] Ltr, USW to Nixon, 27 Feb 44, OO 471.4/1851 (c).

most important shift, in terms of quantities, was the decline in .30-caliber machine gun ammunition and the rise in .50-caliber. Early combat experience showed that the smaller cartridge was far less effective, particularly against airplanes, than was the .50-caliber. This shift was accompanied by a rise in the demand for armor-piercing cartridges for both .30- and .50-caliber and for the .50-caliber incendiary cartridge. A newer type, the armor-piercing-incendiary for .50-caliber, came into production in 1943 and in 1944 accounted for more than half the total .50-caliber output. An even more complicated round, the .50-caliber armor-piercing-incendiary-tracer, came into production in 1944–45. Production of incendiary and AP cartridges was far more difficult than production of ball ammunition and created heavy new demands for machines, furnaces, and tools. The new types also had to undergo continuous testing to determine their performance under extremes of heat, cold, and humidity, and to check their stability in storage. Less difficult to manufacture was the .30-caliber carbine that entered the picture in 1942 and largely supplanted the .45-caliber pistol cartridge, though .45-caliber ammunition for the submachine gun continued unchanged. In 1944 a new type of smokeless powder —called ball powder because its grains were spherical—was adopted for carbine ammunition. A development of Western Cartridge Company, it could be manufactured much faster than ordinary powder. The largest small arms cartridge produced in World War II was the experimental .60-caliber of which six million were manufactured in 1944–45.[99]

The downward trend of requirements was temporarily reversed a few months following the long-awaited invasion of western Europe in June 1944. After two and a half years of building up stocks and using comparatively little small arms ammunition in combat, the Allied armies launched the climactic campaign of the war and began firing tremendous quantities of ammunition. In the single month of September 1944 the U.S. ground forces used nearly three-fourths as much small arms ammunition as the AEF expended in battle during the whole year 1918. The huge stocks rapidly dwindled, and in December 1944, when large quantities were lost in the German offensive, they fell below authorized levels in the European theater.[100] Further, much of the ammunition that had been shipped to overseas theaters in 1942 and 1943 was not available or not usable in late 1944 and early 1945. Lack of transportation, manpower, and handling facilities at Pacific Island bases sometimes made it impossible to retrieve leftover ammunition, and great quantities had deteriorated. In explaining the need for new production General Kirk said:

> Ammunition is a perishable commodity. The powder and the primer cap contain delicate chemical compounds. If the ammunition is exposed for considerable periods of time to hot weather, the chemical compounds will tend to change. The result is that the powder becomes less powerful. The primer is less sensitive and more likely to hang fire. If moisture gets into the inner package the brass will corrode. . . . Ammunition stored under good conditions of care for as little as two years in the tropics becomes questionable

[99] The most concise data on this subject appears in Whiting, Statistics, Procurement, p. 51. For Western ball powder, see *Army Ordnance*, XXVI, No. 142 (January–February, 1944), 126–27.

[100] Ammunition supply for European and Mediterranean Theaters, p. 3, ASF Contl Div, 15 Aug 45, OHF.

for issue in combat. . . . Much of the ammunition which was manufactured in 1943 and shipped overseas has had to be stored under conditions which are far from ideal. . . . The point is that we may expect that sizeable quantities of ammunition now overseas will have to be replaced with new ammunition. We will not risk American lives with questionable cartridges.[101]

By the end of October 1944 supply-control studies revealed greatly increased requirements for the year ahead, particularly for ground force weapons such as the rifle, submachine gun, and carbine. Ordnance promptly forwarded the new figures to ASF, asked for instructions, and commented that it considered the situation "one of the most serious facing the Army Service Forces." [102] There was no actual shortage in the theaters but General Campbell predicted that, if production were not speeded up at once, shortages would develop in the spring of 1945. ASF immediately issued a directive doubling the 1945 requirements for certain types. In contrast to actual production of about 6.5 billion rounds in 1944, the program for 1945 called for 12.4 billion. Schedules for the first half of 1945 called for a 50 percent increase over output during the last six months of 1944. None of the closed plants was to be reconverted to ammunition production, but the Toledo Core Plant, then in standby condition, was returned to full production. The new schedules were met by doubling the output for the four existing GOCO plants—St. Louis, Lake Gity, Des Moines, Twin Cities —plus Frankford and three plants owned by commercial producers— Winchester, Remington, and Western. In Canada the Dominion Arsenal and Defense Industries, Ltd., were brought into the picture. Capacity for producing brass strip was more than doubled and, to relieve the critical shortage of AP cores, a contract for their manufacture was placed in Canada with the York Arsenal.[103]

In March 1945, just as the accelerated program was getting into high gear, the production goals were cut by about 20 percent in view of the imminent defeat of Germany. In May, after the actual surrender, the program was further reduced. Two GOCO plants, St. Louis and Des Moines, were given termination notices in June and production at Winchester was discontinued. When the Japanese surrender was announced on 14 August production stopped at all plants except Lake City, where the .60-caliber line continued for two weeks, and Frankford Arsenal, where experimental types were being produced. Then began the tedious process of decontaminating equipment, preparing it for storage or sale, making final payments to contractors, and closing the books on all the plants. Soon Frankford Arsenal was once again the only producer of military ammunition in the United States. The Lake City and Twin Cities plants, with all their machinery and reserve stocks and with equipment from two core plants, were prepared for long-time storage and retained as reserves for the future.[104]

[101] Remarks by Kirk, 10 Jan 45, *op. cit.*

[102] Memo, CofOrd for CG ASF, 21 Nov 44, sub: Prod Rqmts for SA Ammo, OO 471.4/2271 (c). A detailed summary of theater stocks at the end of November 1944 appears in Incl to Memo, Director of Plans and Operations, ASF for CofOrd, 12 Jan 45, sub: SA Ammo Stocks, OO 471.4/2381.

[103] (1) SA Ammo, Highlights of Hist, 1 Jul 44–1 Apr 45, pp. 3–4; (2) Hiland G. Batcheller, Progress on Critical Programs, a Report to the WPB, 12 Dec 44, p. 35, WPB Doc. 317, WPB 210.3R, NA.

[104] (1) SA Ammo, Highlights of Hist, 1 Jul 44–1 Apr 45; (2) First Quarterly Report for FY 1946, SA Div, 1 Nov 45. These two reports are supplements to Small Arms Ammunition and are in OHF.

CHAPTER X

Preparation for Tanks and Other Fighting Vehicles

More than any other weapon of land warfare, the tank in World War II captured the imagination of soldier and civilian alike. Its roaring motors, inscrutable armor, and smoking guns added a new and terrifying element to the already grim life of the battlefield. It symbolized for the ground forces, as did the sleek bombing plane for the air forces, the revolution in warfare that had sprung from the union of military need with industry and technology. It was, by any standard of comparison, one of the most important weapons of the war.

But for Ordnance the tank was the source of more trouble and more criticism than any other item of equipment. Ordnance-procured small arms, artillery, and ammunition were generally praised, as were trucks and other transport vehicles, but all during the war American tanks were the objects of sharp verbal attacks. Army spokesmen, eager to build up public confidence, asserted time after time that U.S. tanks were superior to anything the enemy could produce. General Wesson and General Campbell strongly defended them against all criticism, and cited laudatory letters from combat commanders to prove the point.[1] But the secret reports on tank performance submitted by overseas commanders (both British and American) and the Armored Force Board told a somewhat different story. Along with frequent words of praise came many complaints,[2] ranging from the lack of good binoculars for tank commanders to the inferiority of U.S. tank guns and armor to the German guns and armor pitted against them. Unofficial observers were quick to take up critical comments from tank men returned from combat, sometimes to the neglect of less newsworthy praise for U.S. tanks. Why, it was asked, could not the United States, with its unrivaled industrial capacity for making cars and trucks of all kinds, produce better tanks than Germany? In particular, why

[1] Compare comments on these "testimonials" of combat commanders in Hugh M. Cole, *The Lorraine Campaign,* UNITED STATES ARMY IN WORLD WAR II (Washington, 1950), p. 604, and in "Our Tanks Are Without Equal," an editorial in *Army Ordnance,* XXVIII, No. 149 (March–April 1945), 265. For a typical example of Ordnance claims to tank superiority, see address by Maj Gen Gladeon M. Barnes, 19 Oct 44, Cleveland, Ohio.

[2] A notable example of praise is "Our Tanks Meet the Test," by Maj, Gen. Charles L. Scott, *Army Ordnance,* XXIV, No. 136 (January–February 1943), 67ff. Compare with 13-page Memo of complaints written by Maj S. B. Tatom, Hq Armored Force, to Col Morris K. Barroll, Jr., 25 May 1943, sub: Final Rpt on Accelerated Tests of 40 M4 Series Tanks, Gen. Christmas file, 451.3/M.

did the U.S. Army have no heavy tank to match the German Tiger? By 1945 the chorus of criticism reached a point where leading American newspapers were calling for a Congressional investigation of "a situation that does no credit to the War Department." [3]

Meanwhile in both England and Germany there were similar complaints. A Parliamentary committee roundly criticized the Churchill government in 1942 for failing to develop a tank that could hold its own on the battlefield and for losing precious time in getting production started. At the end of the war, when the government's white paper on tanks appeared, *The Times* of London observed editorially that, "If there was not a 'tank scandal,' there was certainly a good deal of tank muddle." [4] In Germany, where public criticism was less freely expressed, there was considerable dissatisfaction with both designers and producers. When German medium tanks encountered the Soviet T-34 in late 1941 the results were disastrous for the Nazi legions. Hitler personally ordered his designers to come up with a superior heavy tank at once and directed his production ministry to build it in hitherto unheard of quantities.[5]

The problems encountered in British, German, and American tank production stemmed chiefly from the fact that, at the start of World War II, the tank was essentially a new weapon with still untested tactical potentialities. Further, it was an enormously complicated machine, difficult to design and difficult to produce. The design phase has been described in some detail in the preceding volume of this series.[6] Here we are concerned less with design than with production, but it must be recognized that there is no sharp dividing line between the two processes. Design changes were constantly intruding into the manufacturing area, to the dismay of production engineers, and production techniques were always a limiting factor in design. The only satisfactory approach to the task of understanding the World War II tank experience lies in reviewing the two separate but intertwined threads of design and production from the late 1930's to the end of the war.

Early Plans and Preparations

Production of guns and ammunition rested on a solid foundation of more than a century of development and use, but production of tanks in World War II was based on twenty years of neglect. A few American tanks had been built in 1918 but none saw action in World War I. The Mark VIII's assembled at Rock Island Arsenal after the war were crude specimens with a top speed of only five miles an hour. All during the next two decades there was no real production, only the building of hand-tooled test models, some described as capable of "bursts of speed

[3] Hanson Baldwin in New York *Times* January 5, 1945, quoted in Green, Thomson, and Roots, *Planning Munitions for War,* ch. X. For a striking example of journalistic criticism and Army caution, see "American Locomotive," *Fortune* (February 1942), pp. 79ff. The views of some Army Ground Force officers appear in two historical studies: AGF Study No. 27, The Armored Force, Command and Center, dated 1946, and AGF Study No. 34, The Role of the AGF in the Development of Equipment, dated 1946.

[4] *The Times,* London, July 16, 1946. For a brief account of the deficiencies of British tanks, see Postan, *British War Production,* pp. 183–95.

[5] U.S. Strategic Bombing Survey (USSBS), Tank Industry Report, 2d edition, Jan 47.

[6] Green, Thomson, and Roots, *Planning Munitions for War,* ch. X.

up to 18 miles an hour." [7] From 1920 to 1935 no more than thirty-five tanks were built, every one a different model. The essence of mass production—acceptance of design and its exact reproduction in volume—was altogether lacking. Not until 1935–36 when sixteen medium tanks were made at Rock Island Arsenal was more than one tank of any specific model produced.[8] In England the situation was much the same. One recorder of British tank history described the events of the 1930's as follows:

> In 1931 a medium tank of superior design was issued, but the great depression and pacifist agitation on top of it prevented large-scale production. When this was finally decided in 1936 the tank proved to be out of date. There was debate and debate . . . and the tank has yet [1938] to reach the men.[9]

In the War Department plans of the 1930's, tanks were not very important. Army tacticians were not planning to use hundreds of hard-hitting, fast-moving tanks to spearhead lightning attacks. The Tank Corps of World War I had long since been abolished and control of tanks placed with the Infantry, which held armament down to machine guns, limited armor thickness to about one inch, and gave priority to small, light tanks.[10] Reflecting this attitude, Ordnance had no Tank Division, made no plans for wartime procurement of tens of thousands of tanks, and confined its development work to light tanks. The unit responsible for fighting vehicles was, until 1941, an appendage of the Artillery Division. Test models built at Rock Island were only a small part of that arsenal's over-all responsibility, which embraced tractors, armored cars, gun mounts, and recoil mechanisms. It is no exaggeration to say that, before 1940, tank procurement was but a drop in the Ordnance bucket.[11]

In the educational orders program of 1939–40, tanks were given scant attention. As the using arms had not adopted a clear statement of desired tank characteristics, nor assigned tanks a high priority, Ordnance did not consider it advisable to attempt much by way of educating industry in their manufacture. Further, the cost of tanks—between $25,000 and $50,000 each—was so high, and the funds for educational orders so limited, that a big program could not be considered. In contrast to the dozens of educational orders

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[7] Hist, Rock Island Arsenal, I (1919–39), p. 63. See also The Development of Combat Vehicles, a manuscript prepared in Oct 43 by Samuel H. Woods, chief engineer, Automotive Division, APG, and Evolution of American and German Medium Tanks by Lt. Col. Robert J. Icks, 20 Jan 43, both in OHF. Descriptions of the Mark VIII and other early vehicles may be found in Ralph E. Jones, George H. Rarey, and Robert J. Icks, *The Fighting Tanks Since 1916* (Washington: National Service Publishing Company, 1933).

[8] (1) Hist, Rock Island Arsenal, I (1919–39), pp. 61–66; (2) Campbell, *The Industry-Ordnance Team,* pp. 220-21. In the mid-1930's, Major Campbell, later to become wartime Chief of Ordnance, was in charge of manufacturing at Rock Island Arsenal.

[9] Maj. Eric W. Sheppard, *Tanks in the Next War* (London: G. Bles, 1938), pp. 77–80.

[10] In France, Italy, Russia, and Japan the same trend was followed. See Richard M. Ogorkiewicz, "The Ten Ages of Tank," *Armor,* LXI, No. 3 (1952), 10–18. Up to 1938 it was not much different in Germany. Only light tanks were built before that date, and not in large quantities. USSBS, Tank Industry Rpt, 2d edition, Jan 47.

[11] (1) Green, Thomson, and Roots, *Planning Munitions for War,* ch. VII; (2) Campbell, *op. cit.,* ch. 14; (3) Combat Vehicles 1940–45, MS study prepared by Daniel Chase, 31 Dec 45, OHF; (4) Hist, Rock Island Arsenal, I, pp. 61–66. In the 1930's the automotive section consisted of five officers, headed by Maj. John K. Christmas and including Capt. Emerson L. Cummings who later became Chief of Ordnance. Similar neglect of tank work in England is described in Postan, *op. cit.,* p. 7 and pp. 188–89.

placed for forging and machining artillery shells, and for making rifles, recoil mechanisms, and fire control instruments, only two small educational orders were placed for tanks. One went to the Van Dorn Iron Works for light tank hulls and the other to the Baldwin Locomotive Works for ten light tanks (M2A4). Design changes and slow deliveries of machine tools and armor plate, coupled with higher priority for medium tank orders, delayed the start of production at the Baldwin plant until after Pearl Harbor. In terms of production preparedness, the two orders brought no significant results.[12]

In time of emergency, Ordnance planned to place its tank contracts with firms that built railway equipment. Firms experienced in handling heavy rolling stock and in fabricating and assembling big steel components—such as American Car and Foundry, American Locomotive, and Baldwin—were considered the most suitable contractors. Further, because of the depressed state of the railroad industry, these companies were not very busy. Production plans provided that these firms were to make hulls, turrets, and numerous other parts, but major assemblies such as engines, transmissions, and guns were to be made elsewhere and shipped to the locomotive plants as "government free issue."

The first tank order of the World War II period illustrates the nature of the procurement plans and manufacturing procedures. It was a fixed-price contract for 329 light tanks, M2A4, awarded by Rock Island through competitive bidding to the American Car and Foundry Company (ACF) in early October 1939—the first American tank order placed with industry in twenty years.[13] ACF engineers immediately set to work checking more than 2,000 blueprints and placing orders for parts and materials. The 12-ton M2A4 required more than 2,800 different kinds of parts, totaling over 14,000 individual pieces—not counting engines or accessories. The aircraft type engine used in the light tank was made by Continental Motors. When ACF found that steel mills were unable to supply in time the type of armor plate required, it installed heat-treating furnaces to make its own face-hardened plate. The company delivered its first tank to Ordnance in April 1940, well ahead of schedule, and completed the entire order (meanwhile increased to 365) in March 1941.[14]

The most serious problem in the early stages of light tank production was change of design. As early as the spring of 1940, for example, the need for heavier armor plate was revealed by reports from the war in Europe, and the added weight required a stronger suspension system. In July 1940 a much improved light tank, known officially as the M3 and unofficially as the

[12] (1) Educational Orders folder, OHF; (2) Telcon with Brig Gen Burton O. Lewis (Ret.), 8 Mar 54; (3) Hist, Phila Ord Dist, vol. I, pt. 8, History of Eddystone Sub-Office.

[13] For a first-hand account, see "Light Tanks" by Charles J. Hardy, president of ACF, in *Army Ordnance,* XXII, No. 130 (January–February 1942), 568–69. See also PSP on Production Planning, OCO–Detroit, 16 Jun 45, dr. P4336, OCO–D files.

[14] (1) F. A. Stevenson (Vice President ACF), "Mass Production of Combat Tanks," *Army Ordnance,* XXI, No. 125 (March–April 1941), 485; (2) Hist, Rock Island Arsenal, II, ch. 5; (3) Hist, Phila Ord Dist, I, pt. 1, Contractor Histories, OHF; (4) Chase, Combat Vehicles 1940–45, p. 27 and pp. 47–48; (5) OCO–D History, Engineering and Manufacturing Division, vol. 7, pt. 1; (6) American Car and Foundry Co., The Armed Forces of ACF. For detailed characteristics, see Catalog of Standard Ordnance Items, Volume 1, Tank and Automotive Vehicles, OHF. For problems in administering the contract, see History, Philadelphia Ordnance District, I, pt. 7, Tank and Combat Vehicle Br, OHF.

General Stuart, was adopted, and orders for it went to American Car and Foundry. During the next twelve months the 7-sided riveted turret of the early model took on a rounded shape; welding took the place of riveting; a power traverse for the turret was added; armor thickness was increased; and a gyrostabilizer was installed to steady the 37-mm. gun while the tank was in motion. ACF received a steady stream of engineering change orders during 1940 and 1941, and, as the contract was of the fixed-price type, nearly every change required a change in the contract price.[15] When the new model (M3A1) was adopted in August 1941, ACF was directed to switch over to its production as soon as possible. In 1942 the M3A3 appeared with an all-welded hull, sloping frontal armor, and an improved radio compartment, but it was soon replaced by the M5.[16] This model, using two Cadillac engines and two automatic transmissions, required countless revisions in drawings and specifications. All these design changes added up to a steady trend of improvement, but they complicated the procurement task immeasurably and made field maintenance and spare parts supply extremely difficult. The process required balancing the value of each proposed improvement in battlefield performance against the delay it would cause in getting tanks to the troops. It was the eternal conflict that Under Secretary Patterson had in mind when he declared, "The best is the enemy of the good." [17]

While production of light tanks was getting under way, manufacture of medium tanks proceeded slowly at Rock Island Arsenal. After building 18 M2's in fiscal year 1939, Rock Island began work on an order for 126 mediums of improved design, M2A1. But in 1940, when much larger orders were being considered, Ordnance opposed further production of this model and urged adoption of a more powerful tank with a 75-mm. gun and heavier armor. As a result, the Army had on hand in May 1940, when the German Army launched its invasion of western Europe, only 28 new tanks—18 medium and 10 light—and they were soon to become obsolete, along with some 900 older models in stock.[18] Even more serious was industry's lack of experience in tank manufacture, and limited production facilities.

The Upswing in 1940

In mid-June 1940, Col. Alexander G. Gillespie of the Artillery Division reported to General Charles Harris that plans for tank production during the coming fiscal year were well in hand. Requirements for light tanks stood at 405. As American Car and Foundry was building this tank at the rate of one per day, no trouble was anticipated in getting production on the 1941 requirements. The medium tank program was much larger—1,741 to be built in eighteen months—but no difficulty was expected with it as both American Locomotive and Baldwin Locomotive had un-

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[15] For details, see Hist, Phila Ord Dist, I, pt. 7, pp. 115–20.

[16] Originally designated M4 but changed to M5 to avoid confusion with the M4 medium tank. The M3A2 never went into production. Hist, Engr and Mfg Div, OCO-D, Tank and Combat Vehicle Sec. See also Daniel Chase, The Design, Development and Production of Tanks in World War II, 15 Aug 44, OHF.

[17] See ch. III, above.

[18] (1) Statement of Gen George C. Marshall, Army CofS, before S. Appropriations Comm., 22 May 40, summarized in *Army Ordnance*, XXI, No. 121 (July-August 1940), 15; (2) Munitions Program of 30 June 1940 (corrected as of July 24, 1940) in ASF Contl Div, dr G43.

used capacity and were going to submit bids. Gasoline engines for these tanks were to be supplied by the Wright Aeronautical Corporaton and diesel engines by the Guiberson Diesel Engine Company.[19] But while Colonel Gillespie was writing his report, events at home and abroad were forcing a reconsideration of the whole tank program.

In May and June of 1940 the German Army, led by light and medium tanks and dive bombers, defeated the Belgian Army, drove the British Expeditionary Force from the Continent, and overwhelmed French resistance. In this blitzkrieg campaign, the Germans did not use heavy tanks, nor did they throw great numbers of tanks into the battle, but they employed their well-trained armored forces with great skill.[20] Their highly mobile attacking units won a decisive victory over immobile defenses, and brought tanks into a new position of prominence in military thinking. At the end of June a British tank commission arrived in the United States with plans to procure thousands of tanks from American factories as soon as possible.[21] On 10 July 1940 the U.S. Army announced creation of a separate Armored Force, thus ending the Infantry's 20-year control of tank doctrine and formally recognizing the fast-growing importance of tanks in warfare. With adoption of the Munitions Program of 30 June 1940 the War Department began to plan in earnest for mass production of all weapons, including thousands of tanks.[22]

As early as the first week in June, William S. Knudsen, newly appointed member of the National Defense Advisory Commission (NDAC), had looked over the Ordnance tank production plans and concluded they were totally inadequate for the big job that he saw ahead. Convinced that the locomotive companies, which normally built a few specially designed locomotives each year, would never be able to meet the emergency demand for high-speed tank production, he decided to bring the Detroit automobile industry into the tank picture.[23] Ordnance leaders were also aware of the need to widen the base for tank production and welcomed Knudsen's aid in persuading the automobile industry to join them. The big difficulty was that the industry could not be "converted" to tank production overnight, nor could tanks be built in a few odd corners of existing plants. Building tanks required a different set of tools and a complete new production layout; it could not be sandwiched in with automobile production.

Knudsen's proposal was not to convert

[19] Memo, Col Alexander G. Gillespie for Chief, Ind Serv, 17 Jun 40, sub: Tank Prod Plans for 1941 Program, OCO ExecO files.

[20] The 4 German tank models in 1940 were the light tanks, Pz. Kfw. I and II, and the mediums, Pz. Kfw. III and IV. They were little, if any, better than U. S. tanks of the same year. See Green, Thomson, and Roots, *Planning Munitions for War,* ch. X; Garrett Underhill, "Introduction to German Armor," *Armored Cavalry Journal,* LVIII, No. 4 (1949), 6; and Rcd of Army Ord Research and Development—Tanks, pp. 1A41ff.

[21] For one account of this commission, see Ltr, Michael Dewar, head of British Tank Commission, to Minister of Supply, London, 10 Mar 42, in Icks, *op. cit.* The progress and difficulties of British tank production in 1940 are described in Postan, *op. cit.,* pp. 183–95.

[22] For a popular history of the Armored Force, see Mildred Hanson Gillie, *Forging the Thunderbolt* (Harrisburg, Pa.: Military Service Publishing Company, 1947). The background of tank doctrine, 1919–40, is reviewed briefly in Green, Thomson, and Roots, *Planning Munitions for War,* pp. 189–94.

[23] For comment on the nature of peacetime locomotive production, see History, Philadelphia Ordnance District, I, Part 7, page 103.

existing auto plants but to build an entirely new plant in the Detroit area, a tank arsenal specially designed and equipped to make medium tanks. On 7 June he telephoned K. T. Keller, president of the Chrysler Corporation, and arranged a conference with him for the following weekend. When asked if he would consider building and operating such a plant for the government, Keller immediately agreed to put his production planners to work on the problem. Within forty-eight hours he was in Washington conferring with General Wesson and his staff.[24]

Not only had Chrysler never made tanks before, but few of its engineers had ever even seen a tank. They had to go at once to Rock Island Arsenal to examine a tank model and obtain the necessary blueprints —186 pounds of them. Back in Detroit on 17 June they began intensive work, behind closed doors, estimating the cost of buildings, machines, and materials. They worked from early morning until late at night, seven days a week. Finally, on 17 July, Keller delivered his completed estimate to Knudsen in Washington. A tank arsenal to produce ten medium tanks a day would cost $21,000,000, and each tank (complete except for guns) would cost about $30,000. Knudsen told Keller to give these figures to General Wesson and then make a recalculation on the basis of cutting the capacity to five tanks per day. Reporting this conference to General Charles Harris the same day, Colonel Lewis remarked, "It looks like a good proposition to me." [25]

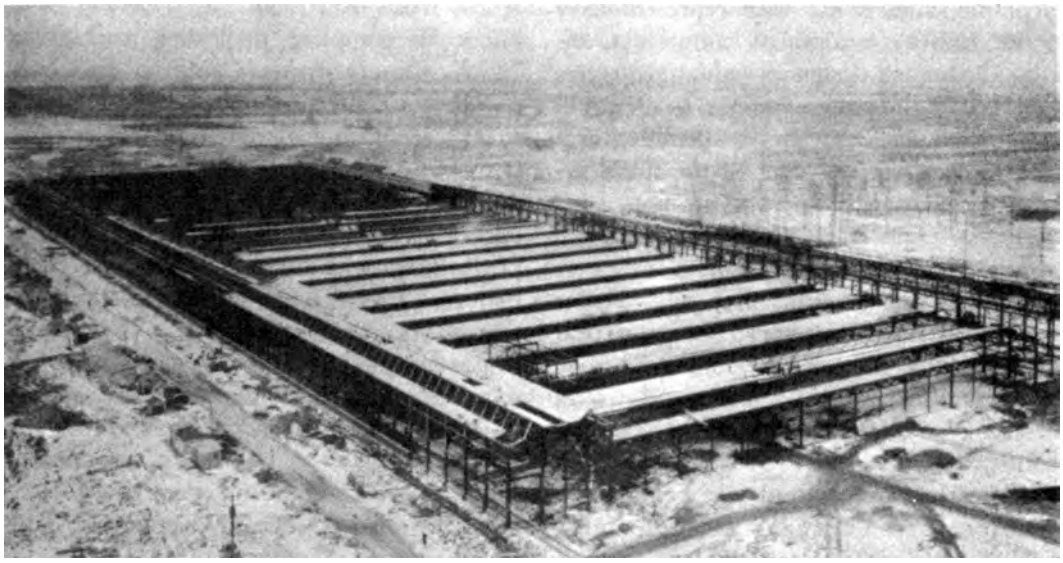
The only real trouble with the proposition was lack of a first-rate tank design. The Chrysler engineers started with the design of the M2A1, mounting only a 37-mm. gun, but reports from the European battlefront had already shown its inadequacy. To meet the crying need for tanks with bigger guns and tougher armor, the Armored Force and Ordnance collaborated in rushing through plans for a new tank, salvaging what they could from the existing M2A1 model and profiting from British battle experience. For the first time a turret basket, power operation of turret, and a gyrostabilizer were applied to an American tank. The 75-mm. gun was put in the right sponson, where it had limited traverse, because Ordnance had tried out such an arrangement some months earlier with good results, but it was understood at the time that a completely new design with the gun in the turret, giving all-round traverse, would be more desirable.[26]

Design of the tank, the M3, was still under way at the time the contract with

[24] Keller's own version of the incident is told in "The Detroit Tank Arsenal," *Army Ordnance,* XXII, No. 130 (January–February 1942), 545–46. Knudsen's account is in Lecture, Problems in War Production, ICAF, 18 Jun 46, p. 13; (1) Wesley W. Stout, *Tanks Are Mighty Fine Things* (Detroit: Chrysler Corporation, 1946); (2) Intervs with Generals Charles Harris and Burton Lewis, Mar 54; (3) Hist, Detroit Ord Dist, I; (4) Truman Comm. *Hearings,* 77th Cong., 1st sess., pt. 1, pp. 102–03.

[25] Memo, Col Burton O. Lewis for Chief Ind Serv, 17 Jul 40, sub: Chrysler Motor Co., ExecO file. See also: (1) Stout, *op. cit.;* (2) Lecture, K. T. Keller, Problems of Tank Production, ICAF, 17 Mar 48, ICAF Library L48–111; and (3) Testimony of John D. Biggers in *Hearings,* Truman Comm., 77th Cong., 1st sess., pt. 7, 13 Aug 41, pp. 2059–61.

[26] (1) Hist, Engr and Mfg Div, OCO–D, secs. entitled History of U.S. Medium Tank and Brief History of Medium Tanks from 1939 to 1942; (2) Brig Gen John K. Christmas, Development of the U.S. Medium Tanks M3 and M4, 20 Jul 43, OHF; (3) Icks, Evolution of American and German Medium Tanks; (4) Chase, Design, Development and Prod of Tanks in World War II, p. 21; (5) Lt. Col. John K. Christmas, "Our New Medium Tank," *Army Ordnance,* XXII, No. 127 (July–August 1941), 27–29.



DETROIT TANK ARSENAL UNDER CONSTRUCTION *on a 100-acre tract of farmland on the outskirts of Detroit.*

Chrysler was being negotiated.[27] At a meeting of top production officials on 1 August, General Wesson stated that the last of the ten thousand drawings required for the new design would not be completed for at least sixty days, but he nevertheless asked for authority to sign the contract with Chrysler so that work on the new plant could begin at once. "As far as it is humanly possible to say, the design is right and settled," Lt. Col. Walter W. Warner told the meeting. "This design is based on our best engineering knowledge, but I do not believe we have ever built a tank or anything else that did not have to be altered at first." In spite of the many uncertainties in the picture the conferees unanimously approved immediate action to close the contract for building and equipping the new tank arsenal and producing one thousand medium tanks of the new M3 design, soon to be nicknamed the General Grant. This meant that Ordnance was attempting to go into production, do the development work, and build new facilities all at the same time.[28]

The contract signed, and a 100-acre tract of farmland on the outskirts of Detroit selected as the site, ground for the tank arsenal was broken early in September 1940. A Chrysler engineer was meanwhile sent to Aberdeen where designs of the new M3 were coming off the drawing boards. He mailed copies of blueprints to Detroit, relayed other information by

[27] The Mead Committee in 1946 was sharply critical of the Army for its lack of tank drawings in 1940. See S. Rpt No. 110, pt. 7, p. 7, Additional Report of the Mead Spec S. Comm., 79th Cong., 2d sess., 1946.

[28] Min of a conf held in OCO, Munitions Bldg, 1 Aug 40, ExecO file. For a brief account of the development work, see Hist, Engr and Mfg Div, OCO-D, and other references in preceding footnotes. Design and production of the Churchill tank in Britain followed the same streamlined course, as did German production of Tigers and Panthers.

telephone, and, along with representatives of the railway equipment companies, offered Ordnance designers valuable suggestions on engineering changes that would mean cheaper and faster production.[29] Late in January the steel of the main arsenal building was up, and in mid-April 1941 the first tank was presented to Ordnance as the gift of Chrysler dealers throughout the country. By July, Keller wrote to Under Secretary Patterson that the tank arsenal was "beginning to look like a producing department" and would turn out 507 tanks during the next five months.[30]

While the tank arsenal was being built, Ordnance placed large orders for M3 tanks with the American Locomotive Company and the Baldwin Locomotive Works—685 to be built by American and 535 by Baldwin—bringing total orders up to 2,220. The British government meanwhile contracted directly with Baldwin, Lima Locomotive Works, and Pullman-Standard Car Company; the Canadian government contracted with the Montreal division of American Locomotive for 1,157 tanks of the M-3 design. The United States refused to permit the British to place contracts with American firms for British-designed tanks, thus forcing adoption of the M3 by the British and Canadian forces. This step greatly simplified production and maintenance, but the M3 design had been improvised so hastily, and with so little opportunity for test, that it soon had to be replaced by the M4.[31]

There was a strong spirit of competition among the three Ordnance contractors in early 1941, and each strove to win the honor of producing the first tank. There was also an extreme shortage of certain major components, particularly power trains (transmissions and final drives). In April, when American and Baldwin were about to complete their first tanks, the Mack Manufacturing Company had only one power train available. It was delivered to American, and completion of that company's first tank was heralded with a demonstration before Secretary Patterson and other high-ranking Army officials. The power train was then quickly removed and delivered by truck to the Baldwin Locomotive Works so that company could celebrate completion of its first tank a few days later. Meanwhile Chrysler, which built its own transmissions, had completed its first tank on 11 April but the acceptance ceremony did not take place until 24 April when General Wesson personally accepted two complete tanks. It was a photo finish with all three companies crossing the line at about the same time.[32]

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[29] (1) Hist, Engr and Mfg Div, OCO-D; (2) Stout, *op. cit.*, pp. 21–23; (3) Christmas, "Our New Medium Tank," *Army Ordnance,* XXII, No. 127 (July–August 1941), 27–29.

[30] Ltr, Keller to Patterson, 21 Jul 41, copy in ExecO file. The plant was officially designated Detroit Tank Arsenal in May 1941. See Ltr, TAG to CofOrd, 29 May 41, sub: Redesignation of Detroit Ord Plant, AG 680.9 (5-5-41). A pictorial section of *Army Ordnance,* XXII, No. 127 (July–August 1941) is devoted to the tank plants and their products. See also Charles O. Herb, "Tanks for the Democracies Roll from Chrysler's Arsenal," *Machinery,* vol. 48, No. 4 (December 1941).

[31] (1) Christmas, "Our New Medium Tank," *Army Ordnance,* XXII, No. 127 (July–August 1941), 27–29; (2) Memo, Lt Col William W. Knight, Jr., for Brig Gen Christmas, 16 May 45, sub: Informal Rpt on Early Phases of Tank Program, OHF; (3) PSP on Prod Plng, OCO-D, 16 Jun 45, P4336. Histories of the Rochester and Philadelphia district offices contain additional data on these early tank contracts. For a British report, see Ltr, Michael Dewar, head of British Tank Commission, to Ministry of Supply, London, 10 Mar 42, in Icks, *op. cit.*

[32] (1) Hist, Rochester Ord Dist, vol. 100, pt. 13; (2) Ltr, Keller to Thomson, 1 Apr 54, OHF; (3) Telcon with Gen Burton O. Lewis, 15 Apr 54; (4) Stout, *op. cit.*, p. 26.

The U.S. Army had no heavy tanks at the start of 1940, and little desire to acquire any. Its plans were oriented toward defense of the nation against invasion, not toward sending an expeditionary force overseas to attack strongly fortified positions. Ordnance tank experts consistently argued for heavy tanks, but the Infantry and other branches opposed the idea. Critics of the heavy tank argued that it was needed only for assaulting major fortifications and taunted the heavy tank advocates by reminding them that neither Canada nor Mexico, the nation's nearest neighbors, had erected Maginot Lines. But in the spring of 1940, largely due to the shock of the German successes—including exaggerated reports of the size of German tanks—work on development of a 60-ton heavy tank was approved.[33] The M6, powered by a 1,000-horsepower gasoline engine and mounting a 3-inch gun, was standardized later in the year, and one pilot tank was ordered from Baldwin in August, but production had to wait for another twelve months.[34]

It is worth noting that by the fall of 1940 the critics were already attacking the Army for its slowness in rearming, particularly in getting airplanes and tanks. They appeared not to understand that the huge sums appropriated for the so-called "defense program" could not be translated into military hardware overnight. Arthur Krock, writing in the New York *Times* on 1 October, declared the nation was totally unprepared to meet any challenge in the air, whether at home or abroad, and went on to say, "The Army has about 500 tanks, one-half of which are obsolete. It has ordered one heavy tank, but at the moment it does not own one." General Wesson declared the following day that U.S. tanks were not obsolete and added that no other country in the world was known to have heavy tanks in quantity.[35] By the end of December 1940 the score on tank procurement stood as follows: light tanks —325, mediums—6, heavies—0.

Doubling the Program in 1941

The first five months of 1941 were relatively uneventful, both at home and abroad. England had survived the bombing attacks of late 1940 and was receiving more American aid. The war against the U-boats in the Atlantic and the fighting in North Africa were both causing concern, but they were less spectacular than events in 1940. For Ordnance, requirements remained steady and production gradually gained momentum. ACF continued to produce light tanks, and the output of mediums rose steadily at Chrysler, American, and Baldwin. The worst bottleneck during this period was the supply of machine tools, with contractors sometimes finding that lack of a single machine prevented their completing an order. The difficulty in getting tools on time was due to the low-priority rating,

[33] (1) OCM 15842, 22 May 40; (2) Ltr, CofOrd for TAG, sub: Heavy Tanks, 27 May 40, OO 451.25/10292. The Germans had no heavy tanks in service in 1940. The *Pz. Kw.* IV weighed only 19 tons and mounted a 75-mm. gun. For an account of the heavy tank controversy, see Green, Thomson, and Roots, *Planning Munitions for War*, ch. X.

[34] For discussion of heavy tank potentialities in 1940, see Capt. Charles R. Kutz, "Break-Through Tanks," *Army Ordnance*, XXI, No. 123 (November–December 1940), 242–45. The Baldwin heavy tank contract is described in History, Philadelphia Ordnance District, Volume I, Part 7, pages 104 and 129. For an account of development, see History of the Heavy Tank, M6, n.d., in Ord R&D files, no author, OHF.

[35] (1) New York *Times*, October 1, 1940, editorial page; (2) Memo, CofOrd for ASW, 2 Oct 40, sub: Article by Arthur Krock, ExecO file.

A-1-g, applied to producers of medium tanks.[36]

The calm that prevailed in the tank program during the first half of the year was suddenly broken in July 1941—immediately following the German invasion of the Soviet Union—when President Roosevelt stepped into the picture and directed that production of tanks be expedited at once, "with the only limiting factor . . . the ability of American industry to produce tanks." [37] This was part and parcel of the President's plan to gear American production to a comprehensive Victory Program aimed at the defeat of all "potential enemies." Secretary Patterson gave the President a preliminary estimate that 1,600 medium tanks could be built by the end of the year and that the established objective was production at the rate of 1,000 per month. More than this could not be produced, OPM officials advised the President, "without considerable industrial dislocation." [38] A few days later, General Wesson stated that only 1,400 mediums could be produced by the end of the year—850 by U.S. contractors and 550 by British suppliers—plus 1,900 light tanks. But he warned that even this estimate could not be met if tools scheduled for tank plants were diverted elsewhere.[39]

During July and August, while General Staff planners were at work on the Victory Program, several important steps were taken to speed production. Ordnance created a separate Tank and Combat Vehicle Division[40] headed by Lt. Col. John K. Christmas, thus taking tanks out of the Artillery Division. A short time later, to eliminate conflict of responsibilities between Ordnance and the recently created Office of Production Management, the tank section of OPM, headed by Lt. Col. William W. Knight, Jr., was transferred to Ordnance. Further, control of all tank production, both American and British, was centralized in Ordnance.[41]

In the midst of this concerted drive to speed production President Roosevelt dropped a bombshell in mid-September. At a White House conference, where Generals Charles Harris and Burton Lewis represented Ordnance, the President reviewed current military production plans. When he came to the schedule calling for production of 1,000 medium tanks and 400 light tanks per month, the President paused, placed a cigarette in his famous long holder, lit it, and then calmly issued this cryptic directive: "Double it!" Monthly production was to be 2,800— or 33,600 per year. The cost would be close to a billion dollars for one year's production.[42]

Ordnance leaders, as conservative in their way as the President was bold in his, thought this decision ill-advised. From their point of view, doubling production goals meant a further worsening of the already critical machine-tool situation and meant bringing new, less experienced producers into the picture. Unlike the Presi-

[36] Memo, Knight, to Brig Gen Christmas, 16 May 45. See also ch. III, above.

[37] Ltr, President to SW, 9 Jul 41, ExecO file.

[38] Ltr, Sidney Hillman and Biggers, OPM, to President, 11 Jul 41, ExecO file.

[39] Memo, CofOrd for USW, 25 Jul 41, sub: Monthly Prod . . . Tanks, OHF.

[40] An oddly redundant title as tanks are combat vehicles. The new division was created by ODO 183, 29 July 1941.

[41] (1) Memo, Knight, for Brig Gen Christmas, 16 May 45; (2) Ltr, USW to CofOrd, 17 Jul 41, OO 451.25/7113; (3) PSP on Prod Plng, OCO-D, 16 Jun 45, P4336.

[42] Intervs with Generals Harris and Lewis in 1953-54. See also Smith, *Army and Economic Mobilization,* Chapter VI, for discussion of formulation of Victory Program.

dent, they were close to the practical problems of production and not up-to-date on plans to send military equipment on a vast scale to friendly powers, chiefly Britain and the Soviet Union.[43] But once the President had spoken Ordnance had no choice but to push ahead with the enlarged program. As a first step, an A-1-a priority was requested for all tanks. Ordnance estimated that with such a priority tank production could be increased 15 percent by 30 June 1942. When this estimate was reported to the President he upped the figure to 25 percent. The next steps were to increase existing tank orders, urge faster production, and build new capacity. Ordnance took over British orders with Pressed Steel, Pullman-Standard, and Lima, firms that had just come into production at old plants rehabilitated at British expense. Contracts for transmissions and final drives were placed with the Caterpillar Tractor Company and the Iowa Transmission Company, the latter a subsidiary of John Deere Company. Negotiations were started with steel foundries to increase their capacity for cast armor, then only half of estimated requirements. At the same time, capacity for producing both homogeneous and face-hardened armor plate had to be greatly increased, with such companies as Republic Steel, Carnegie-Illinois, and Henry Disston heading the list. In mid-November negotiations were completed for an entirely new tank arsenal at Grand Blanc, Michigan, to be operated by the Fisher Body Division of General Motors. Comparable to the Chrysler tank arsenal, it was to have capacity for one thousand M4 medium tanks per month and was to cost something over $37 million for buildings, machinery, and equipment.[44]

While these long-term projects were being launched, production from existing plants was disappointingly slow. For November, only 306 medium tanks were produced against a scheduled 490. The trouble was in the production of transmissions, with one leading source making only 33 units during the month. Considerable improvement was achieved in December when increased transmission production brought the figure on medium tanks up to 506. The December rate for light and medium tanks combined was a little over 900—far short of the President's new objective, though well ahead of the rate of 32 in the preceding December.[45] Most important, there were five competent producers of medium tanks in the field—American, Baldwin, Chrysler, Pressed Steel, and Pullman-Standard—and the huge new Fisher tank arsenal was under construction. By the end of the year the production score for all of 1941 stood as follows: light tanks—2,591, mediums—1,461, heavies—0.[46]

The All-Out Effort in 1942

At the start of 1942, while Ordnance leaders were pushing hard to reach the

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[43] For discussion of the strategic plans, see Watson, *Chief of Staff*, Chapter XI, and Maurice Matloff and Edwin M. Snell, *Strategic Planning for Coalition Warfare 1941-1942*, UNITED STATES ARMY IN WORLD WAR II (Washington, 1953), Chapter III. The British side of the picture is reported in Postan, *op. cit.*, Pages 238-39.

[44] (1) Chase, Combat Vehicles, 1940-45, *op. cit.*, pp. 101-02; (2) Military Tank Production, a progress report by War Projects Unit, Bur of the Budget, 24 Oct 44, OHF; (3) Hist, Chicago Ord Dist, I, pt. 2.

[45] Summary Report of Acceptance, Tank-Automotive Matériel, 1940-45, OCO-D, December 1945, OHF.

[46] Whiting, Statistics. A pilot model of the 60-ton heavy tank with a cast hull was accepted from the Baldwin Locomotive Company on the day after Pearl Harbor.

"double it" objective, President Roosevelt suddenly raised the requirements still higher. In a secret letter to the Secretary of War on 3 January he set the following tank production goals:[47]

	1942	*1943*
Total	45,000	75,000
Heavy	500	5,000
Medium	25,000	50,000
Light	19,500	20,000

Three days later the President made these figures public in his message to Congress and touched off a heated public discussion of the feasibility of the new goals—and as to the origins of the President's figures. On this latter point, one fact was crystal clear: they did not originate with the Ordnance Department. General Staff planners working on the Victory Program were dealing with such big, round figures, but Ordnance leaders were not. General Wesson and his staff not only doubted the need for such huge numbers of tanks but also felt they could not be produced without sacrificing other equally important munitions. Ordnance leaders assigned credit—or blame—for the new objectives to Lord Beaverbrook, British supply chief, and to such Presidential advisers as Harry Hopkins and Robert Nathan.[48] In support of this view they cited the conference on 29 December 1941 when Lord Beaverbrook's views were presented to Donald Nelson and others in the office of Vice President Henry A. Wallace. According to Nelson, the British supply chief stated "that in talking to Stalin, Stalin told him that Germany had thrown 30,000 tanks into the fight with Russia. . . . He made the statement that if an invasion of America was attempted we had no conception of the number of tanks we would have to cope with. . . . He thinks we should plan for the production of 45,000 tanks in 1942 against Mr. Knudsen's estimate of 30,000." [49] These exaggerated views were also impressed upon the President who not only recognized the need for "overwhelming superiority in munitions" but also valued the psychological effect of a dramatic gesture to instill confidence in the American people, and in their many allies throughout the world. When questioned on the industrial practicality of figures to be used in his message to Congress, he is said to have answered, "Oh —the production people can do it if they really try." [50]

Within two weeks of the President's directive, Ordnance had its plans drawn up and ready for presentation to the Office of Production Management and the Under Secretary of War for approval. For the medium tank, Colonel Christmas reported, the nine firms so far lined up were considered capable of producing the required 25,000 tanks during 1942, if they got the tools and materials needed. By far the biggest producer on the list was the Detroit Tank Arsenal, which was to be enlarged to make 7,765 units during the year, plus 500 transmissions to be used by other tank producers. It was followed by five railway equipment companies—American (both U.S. and Canadian plants), Baldwin, Pullman-Standard, Pressed Steel

[47] Ltr, President to SW, 3 Jan 42, copy in OHF. A similar letter went to OPM on 5 Jan 42. See CPA, *Industrial Mobilization for War*, p. 278.

[48] Intervs with Generals Harris and Lewis, Mar 54. For further light on this point, see Wesson's confs, Jan–Mar 42, particularly 27 Mar 42.

[49] Quoted in CPA, *Industrial Mobilization for War*, p. 277. See also Robert E. Sherwood, *Roosevelt and Hopkins: An Intimate History* (New York: Harper & Brothers, 1948), pp. 473–74. According to the U.S. Strategic Bombing Survey, Germany had only 4,500 tanks in service on 1 June 1941—not 30,000.

[50] Sherwood, *op. cit.*, p. 474.

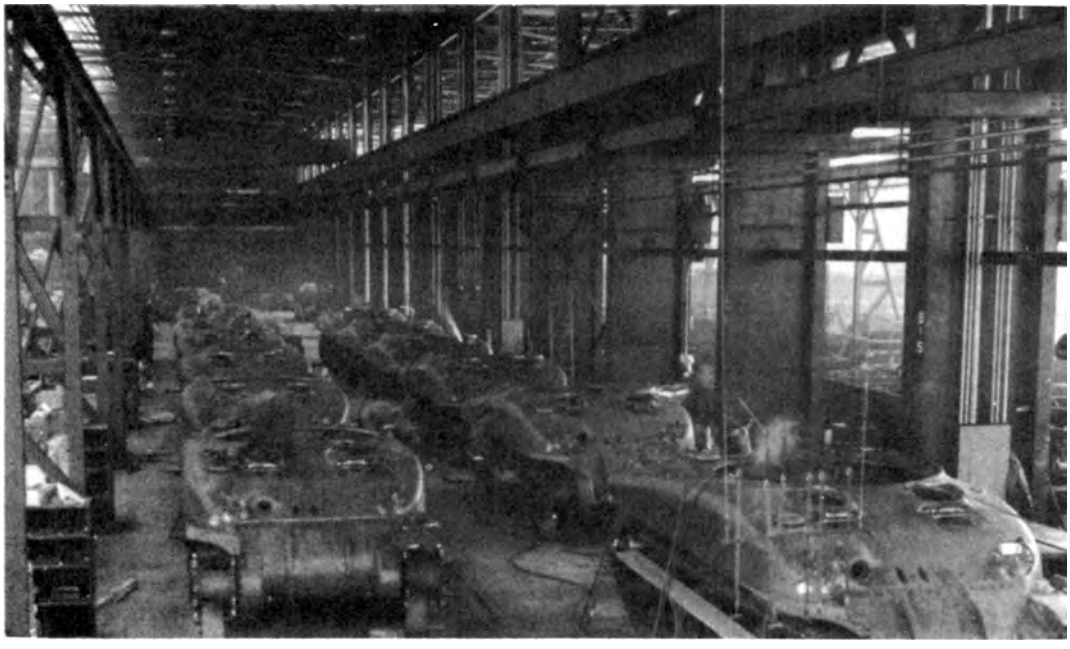
Car, and Lima Locomotive—and the new Fisher tank arsenal. The Ford Motor Company was also to start building tanks and was scheduled to reach a 500-per-month rate in November 1942. On a smaller scale, the Pacific Car and Foundry Company of Renton, Wash., was to come into production in 1942. The conferees concluded that Ordnance had the tank program well in hand but recommended adding two more sources for medium tanks.[51]

In February Colonel Christmas made a strong case for revising the President's light tank requirements so that fewer would be produced in 1942 and more in 1943. "There is no doubt that we could achieve these objectives [19,500 in 1942 and 20,000 in 1943]," he explained to a conference attended by Patterson, Harrison, Knudsen, and others, "but there is this major objection to it—if we set up facilities to do that, they will be idle in 1943 to a considerable extent." Producing 19,500 tanks during 1942 would mean building up to a high capacity in the latter part of the year, capacity far in excess of that needed to produce virtually the same number of units in twelve full months of 1943. But the conference gave no positive answer to the queston before passing on to the medium tank. Here, with eleven firms at work, some on the M3 (General Grant) and others on the M4 (General Sherman), Ordnance expressed confidence that the Presidential objectives could be reached, both for 1942 and 1943, if given a high priority. Engines, transmissions, and guns were the critical components, but vigorous efforts were being made to speed their production. As for the heavy tank, it presented the same problem as the light tank—production was too much concentrated in 1942. There was also a further question as to the real need for such tanks, as they were desired only by the British, not by the U.S. Army. "I haven't found an officer yet in the U.S. Army that proposes that we get these heavy tanks," commented Deputy Chief of Staff General Richard Moore. "I think that should be deferred until this British tank committee gets over here." The decision was that Ordnance should "proceed as planned and no further," and await the joint British-American conferences scheduled for March.[52]

Two weeks later, Colonel Christmas presented additional thoughts on the tank program. He reported that the prospects of achieving the Presidential objective for medium tanks—25,000 in 1942 and 50,000 in 1943—were good. But, he warned, this could be done only at the cost of other items, particularly armored cars and self-propelled artillery. He therefore recommended that the 1942 objective be cut from 25,000 to 20,000, and heavy tanks be reduced proportionately. This would help balance production by making it possible to produce a proper complement of scout cars, half tracks, and self-propelled artillery. Colonel Christmas also raised a question as to the reasonableness of the over-all tank objectives, pointing out that they would supply light tanks for 123 armored divisions, medium tanks for 216 armored divisions, plus 100 percent

[51] Conf held in Wesson's office, 16 Jan 42, sub: Proc Plan for Tanks Covered by the President's Dir, ExecO file. On Pacific Car and Foundry, see Hist, San Francisco Ord Dist, I, Seattle Regional Office, pp. 7–15.

[52] Review of the Prod Plans of the Tank and Combat Vehicle Div, 25 Feb 42, T676A. General Moore apparently overstated the case somewhat. There certainly had been some heavy tank advocates in the Army in 1941 when the pilot model of the M6 was authorized.



GENERAL SHERMAN M4A1 MEDIUM TANK ASSEMBLY LINE *at Lima Locomotive Works, 1942.*

replacement for one year's operation. He questioned whether the United States, Britain, and the Soviet Union could organize and otherwise equip and transport such huge numbers of tank units, and suggested that each nation would do better if it planned to equip more modest forces, perhaps 25 armored divisions each for 1942. Even this figure was nearly three times the number actually activated by the U.S. Army in 1942.[53]

Later in March the British Tank Mission and the U.S. Tank Committee held a number of conferences to work out detailed plans for co-ordinating American, British, and Canadian production. A major product of these meetings was the decision to recommend a program of balanced production, as Colonel Christmas had urged. Basically, this meant cutting the President's tank objectives and boosting those for armored cars and self-propelled artillery. As early as September 1941, when General Wesson was in London, the British had urged the need for self-propelled artillery, citing the "startling successes gained by the German assault artillery." [54] But the President's January program called for only 2,539 self-propelled weapons in 1942—all of the relatively ineffective 37-mm. type. The British-American conference recommended production of

[53] (1) Memos of Col Christmas for CofOrd, 10 and 11 Mar 42, sub: President's Objectives for 1942 and 1943: Prod of Tanks. ExecO file; (2) Memo, Maj Gen Brehon B. Somervell for CofOrd, 6 Mar 42, sub: Presidential Objectives . . . , in folder ASP. The number of armored divisions actually organized by the U.S. Army throughout World War II was 16. Palmer, Wiley, and Keast, *Procurement and Training of Ground Combat Troops,* pp. 491–92.

[54] Min of Mtg held at Claridge Hotel, London, 30 Sep 41, p. 17, OHF.



GENERAL GRANT M3 MEDIUM TANK ASSEMBLY LINE *at Detroit Tank Arsenal.*

more than 15,000 self-propelled weapons, ranging from 40-mm. to 105-mm. Production of these weapons was nearly equivalent to production of the same number of tanks, for they consisted of artillery pieces mounted on tank chassis. Known variously as self-propelled mounts, gun motor carriages, or howitzer motor carriages, they served in many different roles, chiefly as antitank, antiaircraft, and mobile field artillery weapons.[55]

In spite of the evidence that was piling up, both Somervell and Patterson were reluctant to advise the President that the objectives needed revision. At a conference in General Wesson's office late in March, when the U.S. Tank Committee's proposed changes in the objectives were discussed, Mr. Patterson stated that he could not report to the White House that certain items in the program were superfluous and not useful.[56] General Wesson was less restrained, bluntly declaring that the program should be "balanced" and "in line with actual requirements," even if it meant informing the President that his objectives were unsound. When reminded that the President had set his production goals on the basis of Lord Beaverbrook's advice, General Wesson replied that "he sometimes disagreed with statements made by Lord

[55] (1) Findings and Final Min of the Joint British Tank Mission and the U.S. Tank Comm., 30 Mar 42, p. 8, OHF; (2) Statement by Col Christmas, 15 Apr 42, copy in app. to PSP 55, Ord Rqmts 1939-46, by Maj Paul D. Olejar and others, Jul 45. See also Ltr, CofS for President, 1 Apr 42 in ASF Director of Matériel file marked Presidential Objectives, dr G1591.

[56] Min, Wesson Conf, 25 Mar 42. See the President's letter to WPB Chairman Nelson, 1 May 42, reiterating his desire to meet the January objectives, quoted in CPA, *Industrial Mobilization for War*, pp. 281–82.

Beaverbrook." The conferees then considered sugar-coating the proposed changes by adopting a new nomenclature for tanks, self-propelled mounts, armored cars, and other fighting vehicles. General Harris remarked that a heavy armored car was virtually a light tank, and Secretary Patterson agreed. General Clay proposed calling a self-propelled mount an "artillery tank." General Somervell observed that the Ordnance Technical Committee could hold a meeting that afternoon and rename all its combat vehicles to bring them under the heading of tanks, but General Wesson objected on the ground that any such move would lead to confusion.[57] The conference adjourned without reaching a final agreement, but when the Army Supply Program appeared early in April it embodied most of the changes under discussion. Tank requirements for 1942 were cut deeply and large quantities of self-propelled artillery added. With the medium tank, for example, the 1942 requirements dropped from 25,000 to 14,000, but 6,580 self-propelled weapons —built on medium tank chassis—were added. As the self-propelled weapons were nearly the same as tanks, Colonel Christmas described the shift as "a virtual renaming of part of our product." He estimated the net over-all effect was to reduce the 1942 program by 10 percent to 15 percent, and to raise the 1943 program in proportion. The money value of the new 1942 program was approximately $3 billion, and for 1943 about $8 billion. This shift was of great benefit from the production standpoint because it eased the load in 1942 and transferred some of it to 1943 when new and expanded facilities would be better able to handle it.[58]

The production problems were nevertheless ominous, for the total tank schedule to mid-1944 called for expenditure of over $16 billion. In February 1942 the difficulty of obtaining machine tools appeared to Ordnance as the most serious problem. In April the supply of materials moved into first place on the critical list, and stayed there for the rest of the year. In the tank program, nine-tenths of the material needed was steel, much of it high-grade steel. Nickel, copper, aluminum, and rubber were also required. "Even now," Colonel Christmas reported in April, "shortages of material are holding back our production." [59] This was further evidence to justify reducing requirements, and it invalidated earlier Ordnance estimates of production potential. In spite of shortages throughout 1942, production rose month by month from 954 in January to 4,853 in December. But the total for the year was only 25,000 instead of 45,000 as directed by the President in January 1942. The failure to produce more tanks was due in part to reduction of requirements but chiefly to shortages in material, irregular deliveries of material, and increasing emphasis on spare parts.[60] Of the vehicles produced, roughly 11,000

[57] Min, Wesson Confs, 25 Mar 42.

[58] (1) Review of the Prod Plans for the Tank and Combat [Vehicle] Div, 18 Apr 42; (2) PSP 55, Ord Rqmts 1939–46, by Maj Paul D. Olejar ant others, Jul 45.

[59] (1) Review of the Prod Plans for the Tank and Combat [Vehicle] Div, 18 Apr 42; (2) Tank-Automotive Center Production Review, 11 Dec 42, ASF Prod Div file 470.8 Tanks; (3) Rpt of Principal Accomplishments and Difficulties, 30 Sep 42, OO 400.12. For discussion of conservation measures to save scarce materials, see Chapter XVIII in Green, Thomson, and Roots, *Planning Munitions for War*. For production problems on a by-item basis, see Production Analysis Notes, TCVD, 30 Apr 42.

[60] For a summary of factors affecting production, see Memo, Brig Gen Christmas for Lt Col Wallace E. Niles, 16 Sep 42, copy in OHF. On spare parts, see Chapter XIII, below.

were light tanks, 14,000 were mediums (mostly Grants), and 1 was a heavy tank M6. In addition, there were 11,420 self-propelled weapons, 9,846 half tracks, and 7,366 scout cars. The total for all combat vehicles combined, including self-propelled weapons, armored cars, cargo carriers, loading vehicles, and others, was about 58,000.[61]

British and German Efforts in 1942

Meanwhile British tank production came under fire in the House of Commons, with critics citing difficulties not unlike those encountered in the United States. In March 1942 the Select Committee on National Expenditure declared that: ". . . in the matter of settling the design for the weapons of war and the relative quantities of each that are required . . . the programme for manufacture as transmitted to industry shows signs of inadequate foresight and sureness of decision, as well as a tendency at times to give consideration to producing the maximum volume of certain articles rather than the exact types required by the fighting forces." [62] Aside from lack of a first-rate design, British tank production suffered from poor coordination between the War Office and the civilian Ministry of Supply. British production rose in 1942 to 8,611 units, but the quality of the tanks produced brought forth a good deal of criticism.[63]

Two trends dominated German tank production in 1942—increased production, and emphasis on heavier tanks. In January 1942, three weeks after announcement of President Roosevelt's objectives, Chancellor Hitler decided to expand German tank production—then running at about 4,000 a year—in view of the disastrous losses his armies had suffered in Russia late in 1941. He also directed his generals to begin producing heavy tanks that could cope with the Russian T–34's. While American tank men were trying out the heavy M6, and preparing to discard it, Hitler set in motion the machinery that brought the powerful German heavy tanks, the Tiger and the Panther, onto the battlefield in small numbers about a year later. Less concerned with mechanical perfection than the U.S. Army, the Germans rushed these tanks from drawing board to battlefield in record time.[64] In September 1942 Hitler set a goal of 800 tanks per month to be attained by the spring of 1944—less than 15 percent of President Roosevelt's objective for 1943. After the tremendous German tank losses at Stalingrad later in 1942, the Adolf Hitler Panzer Program was drawn up by Albert Speer, Minister of War Production, calling for 1,200 per month by the end of 1944. Hitler immediately told Speer this figure was too low and called for sharp increases which production officials regarded as fantastic. Hitler nevertheless issued a decree on 22 January 1943 that all necessary measures be taken to increase tank production "even if by these measures other important branches of the armament industry are adversely affected for a time." The result was that production rose from about

[61] (1) Whiting, Statistics; (2) OCO–D Summary Rpt, pp. XX–XXIV.

[62] *War-Time Tank Production, Report by the Select Committee on National Expenditure . . .*, p. 3, Jul 46, London. This is frequently referred to as the British White Paper on Tanks. A summary of it appeared in The *Times*, London, July 16, 1946, p. 5.

[63] *Ibid.* This report includes criticisms by the Select Committee and defenses by the War Office. For a brief historical summary of British tank production, see Postan, *op. cit.*, pages 183–95.

[64] Green, Thomson, and Roots, *Planning Munitions for War*, ch. X.

9,300 tanks during 1943 to about 17,500 in 1944, with the monthly production rate reaching a peak of 1,600 in July 1944.[65]

The Tank-Automotive Center

Administratively, the most important development affecting U.S. tank production in 1942 was the creation of the Detroit Tank-Automotive Center (T-AC) later named Office Chief of Ordnance-Detroit (OCO-D). General Campbell took this step in September 1942 when responsibility for trucks and other transport vehicles was shifted from the Quartermaster Corps to Ordnance. He had a dual purpose in mind: to combine truck and tank procurement in one office and at the same time decentralize it to Detroit. Congestion in Washington had reached an acute stage in the summer of 1942, with both office space and housing at a premium. General Campbell made Brig. Gen. Alfred R. Glancy, a newly commissioned industrialist-in-uniform, chief of the center, aided by Brig. Gen. John K. Christmas, former chief of the Tank and Combat Vehicle Division, and Brig. Gen. Donald Armstrong, former chief of the Chicago Ordnance District. Creation of the T-AC, along with the simultaneous transfer to St. Louis of artillery ammunition procurement, made Ordnance the leader among the Army technical services in decentralization.[66]

Three months after the Tank-Automotive Center was formed, and nine months from announcement of the President's objectives, the pressure on the production front was relieved by a sharp cut in requirements. In the revised Army Supply Program issued in November 1942 the 1943 figure for Sherman tanks dropped from 46,500 to 24,582, and that for the 105-mm. howitzer motor carriage from 4,400 to 1,200. The only major increase was for 3,000 of the 3-inch gun motor carriages recently adopted as "tank destroyers." The net effect of all changes was to reduce the requirement for medium tanks and allied vehicles by more than 21,000 units. This sudden drop in requirements marked the end of the "all-out" effort. Although there were few immediate cancellations of tank contracts, General Christmas remarked in December that the cutback had had a bad effect on industry morale, and concluded, "I doubt if we will ever get industry back to its enthusiasm of last fall." [67]

[65] USSBS, *op. cit.* Brief comment on German production appears also in Gordon A. Harrison, *Cross-Channel Attack,* UNITED STATES ARMY IN WORLD WAR II (Washington, 1951), pp. 34–35.

[66] For details on the organization of T-AC, and its administrative problems, see Green, Thomson, and Roots, *Planning Munitions for War,* Chapter IV. For a brief summary of tank procurement procedures, see Outline of Tank Procurement, May 1942, Report No. 7, ASF Control Division, copy in OHF. Creation of the T-AC is described in *Army Ordnance,* XXIII, No. 135 (November-December 1942), 501.

[67] The background for this phase of tank procurement is discussed above in Chapter IV. See also T-AC Prod Review, 11 Dec 42, and Chase, Combat Vehicles 1940–45, pp. 73–74.

CHAPTER XI

Production of Tanks

In a general way, tank building followed the methods of automobile production. Major components were produced in widely separated plants and then brought together and assembled at an assembly plant. Although some tank contractors made more components in their own shops than did others, none made them all. Armor plate and castings, for example, came from Pittsburgh or Chicago steel mills and foundries in a rough or semifinished state. The guns were supplied by Ordnance arsenals or commercial producers. Rubber-bushed tracks came from one of the major rubber companies in Ohio.[1] Within the tank's enveloping armor the two most important major assemblies were the engine and the transmission, but there were also radios, periscopes, ammunition racks, and countless other items. Most tank parts had two things in common—they were very heavy, and they were made chiefly of steel. More than any other factors, these two determined the pattern of tank production. They required plants with big cranes to handle heavy assemblies, ingenious fixtures to hold parts in position, and a great variety of huge machine tools for cutting and shaping the material. (*Table 19*)

The Schenectady plant of the American Locomotive Company was such a plant. Its tank assembly line—adjacent to continuing locomotive production areas—was a series of seven stations at each of which a major component was added. Starting with the lower hull, or chassis, the gas tanks and the mount for the big gun were first put in place. At the next station the giant transmission was added. At the third stop an overhead crane lowered the engine into place and the drive shaft was connected with the transmission. As the hull moved slowly from station to station it gradually took on the appearance of a fighting tank, finally rolling onto its tracks and receiving its big gun and turret.[2]

Although the locomotive companies were able to use much of the equipment they had on hand, many new machine tools were required, as well as additional handling equipment. American Locomotive not only needed over one hundred new machine tools for its first tank order but also had to rearrange its entire plant layout to make room for them.[3] For its first light tank order, American Car and Foundry installed seventy-five new tools and a series

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[1] For an account of tank track development, see Green, Thomson, and Roots, *Planning Munitions for War*, Chapter XI.

[2] *Fortune*, February 1942, p. 79. This article shows the early influence of military "censorship." After it had been blue-penciled by the War Department, *Fortune* published the article with the word *CENSORED* covering each deletion.

[3] History of Combat Tank Production at the Schenectady Plant of the American Locomotive Company, 1 Aug 45, prepared by the company, OHF.

TABLE 19—TANK PRODUCTION BY FACILITY, 1940–1945

BREAKDOWN OF LIGHT, MEDIUM, AND HEAVY TANKS BY FACILITY BUT DOES NOT INCLUDE EXPERIMENTAL TANKS BY DEVELOPMENT DIVISION.

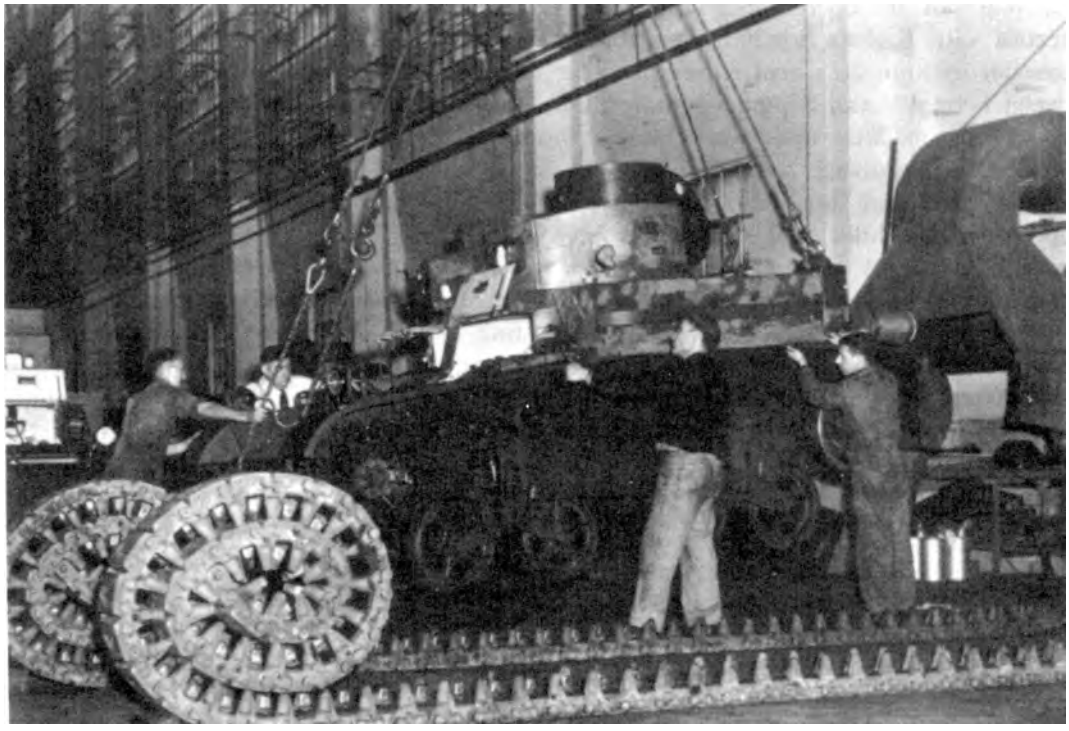
Facility	Total Production Through 31 Dec 45	Percent of Total
Total Tank Production—1940–1945	88,410	100.0
Detroit Tank Arsenal	22,234	25.2
American Car & Foundry	15,224	17.2
Fisher Tank Arsenal	13,137	14.9
Cadillac Motor Company	10,142	11.5
Pressed Steel	8,648	9.8
Pullman-Standard	3,926	4.4
American Locomotive Works	2,985	3.4
Baldwin Locomotive Works	2,515	2.9
Massey Harris Company	2,473	2.8
Ford Motor Company	1,690	1.9
Lima Locomotive	1,655	1.9
Montreal Locomotive Works	1,144	1.3
Marmon-Herrington	1,070	1.2
Pacific Car and Foundry	926	1.0
Federal Machine	540	0.6
Rock Island Arsenal	94	(a)
International Harvester	7	(a)

[a] Less than 0.05 percent.

Source: Tabulation dated 14 Jan 46 in folder, Col. Colby charts, OCO Detroit files.

of heat-treating furnaces.[4] The Detroit Arsenal required over 1,000 machine tools and some 8,500 specially designed jigs and fixtures. All the companies had to pioneer in developing new techniques as well as new tools and fixtures, particularly for

[4] Rpt by ACF, 3 Mar 44, in Hist, Phila Ord Dist, vol. 100, pt. 1.



OVERHEAD CRANE LOWERING A GENERAL STUART M3 LIGHT TANK *onto its tracks at Rock Island Arsenal.*

welding, cutting, and straightening heavy armor plate.

The Detroit Tank Arsenal stood in sharp contrast to the locomotive plants, for it was built from the ground up for the sole purpose of building tanks. But it nevertheless went through a series of rather drastic changes. Before the arsenal was built, Knudsen's idea of having it produce its own armor plate—and practically all other parts—was abandoned, the first step in a long process of decentralizing tank production. The year before, American Car and Foundry had installed furnaces for face-hardening its own plate because other sources were not readily available, but the planned production schedules for the Detroit Arsenal were so high—and the use of thicker homogeneous plate was rising so fast—that Chrysler decided to buy its armor plate and heavy steel castings from other firms. Nearly all other parts, except guns, were made at the arsenal during 1941, including the famous 30-cylinder engine built by gearing five Chrysler truck engines to a single drive shaft, and hundreds of extra transmissions for other tank contractors. The arsenal became a well integrated basic pilot plant.[5]

In 1942, as tank requirements zoomed and automobile manufacture stopped for the duration of the war, Chrysler began

[5] For a description of arsenal methods, see Herb, "Tanks for the Democracies Roll from Chrysler's Arsenal," *Machinery*, vol. 48, No. 4 (December 1941).

farming out its operations. This was in accord with Keller's original plans for expansion in time of a real emergency. Between February and September more than 700 large machine tools were moved to other Chrysler plants, some of which machined gears and suspension wheels while others welded hulls and still others performed a variety of machining, forging, and assembling jobs. More and more, the tank arsenal became a final inspection and assembly plant supplied by scores of other production units.[6] Looking back on the experience from the vantage point of the year 1948 Keller observed that

> . . . the job experienced all the standard hardships of World War II production. The first design was scrapped before we could begin. Despite the early start made, the value of priorities for machine tools and equipment quickly melted away like snow on a hot day. Frantic calls for increased production alternated with drastic cutbacks. Disappearance of critical materials held it up. Sudden changes in design upset ability to deliver, and broke the planned flow of operations. We never once had all of the machine tools and equipment that our schedules called for.[7]

In tank production, as in other phases of Ordnance procurement, industry integration committees played an important role in bringing manufacturers together to eliminate bottlenecks and speed production.[8] Beginning with the medium tank committee in 1942, a total of twenty-seven were created by April 1943 when the last one was organized. Many committees were active only for short periods because the problems they dealt with were successfully solved. But some lasted all during the war years. Speaking of the medium tank committee, one Ordnance officer aptly described the work of them all. "You might think of this committee," he remarked, "as being a great merger of tank plants all combined under the trade mark of the Ordnance Department and all making the same product—the American medium tank." [9]

Engines

Tank engines constituted one of the worst bottlenecks early in the war.[10] Before 1940, Ordnance tank designers had planned to use both diesel engines made by the Guiberson Company and "Whirlwind" gasoline engines made by the Wright Aeronautical Corporation, but as the defense program got under way these firms could not meet the tremendous demand for tank, plane, and ship engines. As airplanes and ships had top priority, Ordnance had to look for other sources. In the fall of 1940 Ordnance contracted with the Continental Motors Company to rehabilitate its old Detroit plant to produce the Wright aircraft engine, under a license arrangement, at the rate of twenty engines per day. Early in 1941 Ordnance felt that, with more than six thousand engines con-

[6] (1) Stout, *Tanks Are Mighty Fine Things*, pp. 44–45; (2) Ltr, Keller to Thomson, 1 Apr 54; (3) Hist, Detroit Ord Dist, vol. I, pp. T–20–25. The latter reference gives names of plants and products of each, based on production progress reports.

[7] Lecture, K. T. Keller, Problems of Tank Production, 17 Mar 48, ICAF.

[8] For the origins of integration committees, see Chapter III and Chapter VI, above.

[9] Press release, 8 Dec 42, T–AC, quoting General Glancy, copy in Hist, Engr and Mfg Div, OCO–D. See also History, Ordnance Department Industry Integration Committee for Medium Tanks, by Maj Louis Antol, Jr., 1 Jun 45, (P4332).

[10] For the research and development background on tank engines, see Green, Thomson, and Roots, *Planning Munitions for War*, pp. 202–03 and 287–301.

tracted for, it faced no real problem, but as the tank program was doubled and redoubled in ensuing months, the need for engines far exceeded earlier calculations.[11]

In the winter of 1941–42 there was no time to design and test a completely new tank engine, and build new plants for its manufacture. Substitute engines that could be produced at once, using tools already at hand in existing plants, had to be adopted, including the Chrysler multibank, the GM twin diesel, the Ford V–8, and the Caterpillar RD–1820—an air-cooled radial diesel. The Guiberson diesels were manufactured for a time at a new plant in Garland, Texas, but the contract was later terminated and the plant taken over by Continental Motors to make gasoline engines.[12] The picture was further complicated by the preference of the British and Soviet governments for diesel engines in lend-lease tanks, and by differences of opinion among U.S. Army authorities as to the relative merits of gasoline and diesel engines for tanks. As early as April 1942 Maj. Gen. Jacob L. Devers of the Armored Force had urged elimination of both the Guiberson and Chrysler engines.[13] But the demand for engines was so great that every reasonably acceptable type had to be used, even though this practice played hob with field maintenance and spare parts supply.

Meanwhile engines scheduled for tanks were diverted to the Navy or the Air Forces, sometimes without consulting the Ordnance Department. At a production conference in June 1942 General Christmas reported that since the first of the year, 2,500 GM diesel engines had been diverted to the Navy, and General Clay added that 1,100 more had recently been diverted. General Christmas bluntly warned the conference as follows:

> We cannot stand any more diversions of engines and still meet the 1942 tank objectives. . . . They are continually calling me into meetings where they want to take the Wright engine and put it into training planes. Fifty percent of the tanks made this year will have Wright engines, 34 percent will have General Motors engines, 10 percent will have Chrysler and six percent will have the Ford. So if they start taking away General Motors' and Wright's engines, they are taking away the foundation of the program.[14]

The supply of engines improved gradually during the year, but remained a problem even in the early months of 1943.

In June 1943 General Christmas reviewed the whole engine problem in a

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[11] (1) Memo, Knight, to Brig Gen Christmas, 16 May 45, sub: Informal Rpt on Early Phases of Tank Program, OHF; (2) The Design, Development and Production of Tanks in World War II, I, sec. EB Medium Tanks, p. 10, EE Components, and PE Components, prepared by OCO–D [1945]. On engine development in the 1930's, see History of Development of the Wright-Continental R–975 Radial Engine, Feb 47, both by Edward Promack, OHF. See also the difficulties of engine design and production faced by the British, as described in Postan, *British War Production*, pp. 187–88.

[12] (1) Memo, Brig Gen Christmas for CofOrd, 25 May 42, sub: Guiberson Engine Contracts, OO 160/160298; (2) Memo, Col James E. B. McInerney for CofOrd, 8 Jun 43, sub: History of Authorizations and Cancellations . . . Diesel Engines, OHF. See also Green, Thomson, and Roots, *Planning Munitions for War*, ch. X.

[13] Ltr, CG Armored Force to CG SOS, 29 Apr 42, sub: Engine for Tanks. . . , Ord ExecO file. The development of tank engines is treated at length in Green, Thomson, and Roots, *Planning Munitions for War*, Chapter X. See also Daniel Chase, Design, Development and Production of Tanks in World War II, 15 Aug 44, pp. 102ff; Statement by Colonel Christmas in Review of the Prod Plans of the TCVD, 25 Feb 42, pp. 13–14; Tank and Combat Vehicle Sec of Hist, Engr and Mfg Div, OCO–D; and AGF Study No. 27, 1946, pp. 85, 95.

[14] Review of the Prod Plans of the TCVD, 19 Jun 42, p. 8.

letter to General Clay. He pointed out that the War Department goal was to use only one type of medium tank engine and then outlined the reasons for continuing with the half-dozen existing models. He cited the "wide divergence of reliable opinion" on two points: the relative merits of diesel and gasoline engines, and the merits of liquid-cooled versus air-cooled engines. Furthermore, he pointed out that none of the American engines had yet seen extensive battle service, and all were still in various stages of engineering development.[15] Considering all factors, ASF approved the continued use of all existing engines, but their number was soon reduced by elimination of the less desirable types.[16]

Transmissions

Transmissions and final drives—described together as power trains—were, at the start of the rearmament program, as troublesome as tank engines, but they were well under control by the first anniversary of Pearl Harbor. The gears and castings needed for tank transmissions—of special Ordnance design and much larger than commercial products—were not easily manufactured. When American Car and Foundry began production of the light tank in 1940 it obtained transmissions from the Timken-Detroit Axle Company, a firm that had shared in their development and had specially equipped itself for their production, and from Spicer. In 1941, when production began on the General Grant, the railway equipment companies, as noted in the preceding chapter, obtained transmissions from the Mack Manufacturing Company, a pioneer in this field, and later also from the Iowa Transmission Company. The Detroit Arsenal not only made its own transmissions but also supplied other contractors. At the outset, Ordnance purchased transmissions from the producers and furnished them as "government free issue" to tank contractors, but later Ordnance stepped out of the picture and let the tank builders buy transmissions direct. During the winter of 1941–42, as requirements mounted, Ordnance took steps to create monthly capacity for over five thousand medium tank transmissions. The Buick Division of General Motors, the Ford Motor Company, the Reed Roller Bit Company, and Caterpillar Tractor all came into the program and by the end of 1942 production had caught up with demand.[17]

Lack of machine tools was at the root of the delay in transmission production

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[15] Ltr, Brig Gen Christmas, T-AC, To Maj Gen Clay, ASF, 17 Jun 43, sub: Medium Tank and Allied Vehicle Engine Installations, OO 470.8/75. See also Min of Tank Engine Conf held by the Director of Matériel, ASF, 29 Jun 43, copy in OCO-Detroit file in folder marked Tank, Medium.

[16] 2d Indorsement, Brig Gen Christmas, T-AC, to Col McInerney, 9 Jul 43, on basic Memo, CG ASF for CofOrd, 26 Jun 43, sub: Review of Tank Program, OO 470.8/929. For detailed discussion of tank engine development and test, see Green, Thomson, and Roots, *Planning Munitions for War*, Chapter X.

[17] (1) D. J. Crowley, Report of Production—Transmissions and Final Drives, T643-c; (2) Hist, Chicago Ord Dist, I, pt. 2, pp. 368–76 and 107, ch. 2; (3) Hist, Detroit Ord Dist, 100, pt. 2, summary history of Timken-Detroit Co., 22 Feb 45; (4) 2d Indorsement, CG T-AC to CofOrd, 9 Jul 43, on Memo of CG ASF for CofOrd, 26 Jun 43, sub: Review of Tank Program, OO 470.8/929; (5) Historical Record World War II, by Mack Manufacturing Corporation, p. 3 and pp. 47–48, [hereafter cited as Hist, Mack Mfg Corp.], filed as Hist, New York Ord Dist, vol. 100, pt. 10, OHF; (6) The Design, Development and Prod of Tanks in World War II, PE Components. For further data on Mack power trains for medium tanks, see History, New York Ordnance District, 100, Part 14.

during 1941. In the case of one contractor, the Mack Manufacturing Corporation, production was hindered by the firm's inability to get delivery on four vertical boring mills. In the fall of 1940 Mack had made the first two M3 medium tank transmissions for Ordnance by hand, but volume production had to await the installation of special equipment. The first two Mack transmissions were described at the time as "the most traveled transmissions in the history of Ordnance," for they were sent to tank plants all over the country as pilot models. Mack and other contractors could not get the machine tools they needed before Pearl Harbor because their contracts carried a relatively low priority, but the high tank production goals set early in 1942 brought higher priorities and eventually eased the machine tool problem.[18]

Armor

Pre-1940 tank production did little to prepare American industry for manufacture of tank armor in World War II. The few tanks built in the 1930's were made with comparatively thin steel plates of high nickel content, face-hardened on the outside. To protect light vehicles against small arms fire—the function of armor in the 1930's—these face-hardened plates were the best known material, for they had a hard, bullet-resistant surface and a tough back. Because the metallurgical composition of face-hardened plates made welding extremely difficult, the plates were riveted or bolted together. As a result, tanks of the 1930's were not only lightly armored but had a boxlike shape, were studded with rivets—two thousand in every light tank—and offered many flat surfaces to enemy fire.[19]

All these characteristics went out the window before the war was over. Suddenly faced in 1940 with a demand for armor protection against artillery fire, Ordnance had to develop and produce a radically new type of tank. One-inch armor gave way to 3-inch and 4-inch steel hulls, and by 1945 study was being made of armor from five to ten inches thick. Face-hardened plates were supplanted by homogeneous armor that permitted the welding of joints and speeded production.[20] Flat, angular surfaces gradually disappeared as cast hulls and turrets with rounded contours—less vulnerable to enemy fire—came into production. Meanwhile the use of nickel and other scarce alloys was reduced, and new techniques were developed for welding, casting, and heat-treating tank steel. The armor on 1945 tanks was as different from that on 1939 models as the 90-mm. gun was from the 37-mm. on prewar tanks. More than any other factor, it accounted for the doubling and tripling of tank weights, for armor accounted for more than half the weight of World War II tanks.[21]

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[18] (1) Knight Memo, 16 May 45; (2) Hist, Mack Manufacturing Corporation, pp. 3–4, and 47–48.

[19] (1) Brig. Gen. Gladeon M. Barnes, "Supertanks," *Army Ordnance*, XXII, No. 131 (March–April 1942), 735–37; (2) PP 77, Armor Plate, Development and Production, 1940–45, by Daniel Chase, Jul 45, OHF.

[20] Homogeneous armor has, insofar as possible, the same physical and chemical composition throughout, unlike face-hardened armor that is harder on one side than on the other.

[21] For an account of armor research and development, see Green, Thomson, and Roots, *Planning Munitions for War*, Chapter XIII. For conservation of alloy steel, see Chapter XVIII. Progress in armor development is described briefly in Summary of the War Department Metallurgical Research during World War II, n.d., Pages 19–22, R&D files, OHF, and in History, Watertown Arsenal, XV, OHF.

As early as 1938 Ordnance had achieved some success, after years of experimentation, in welding a medium tank turret of face-hardened plate. The advantages of welding over riveting were readily recognized, but the difficulty of the process delayed its adoption until 1941. Early that year two welded M3 medium tank hulls were produced, one by the Carnegie-Illinois Steel Corporation and the other by Rock Island Arsenal.[22] The most troublesome problem at the start was finding a way to keep the plates from buckling during the welding process, and to eliminate cracks that appeared in the armor. Working on the light tank, the Cadillac plant tried reinforced fixtures but the plates buckled even in the strongest frames. To aid in overcoming these difficulties the Ferrous Metallurgical Advisory Board formed a subcommittee on the welding of armor. Composed of industry and Army members, this subcommittee studied methods, procedures, and specifications and periodically submitted its recommendations. It was only after countless experiments by all the producing firms that a complicated procedure of welding operations was devised that partially solved the problem, but the real solution lay in switching to homogeneous plate.[23]

The switch to homogeneous armor was prompted by several factors in addition to the welding problem. For one thing, face-hardened armor was so difficult to produce and hard to machine that its use in the expanded tank program of 1941–42 was out of the question. Building thousands of tanks with face-hardened plate would have made impossible demands on an economy in which manpower and machine tools were at a premium. Homogeneous armor was not only easier to produce but could be produced either by rolling or casting. The case for homogeneous armor was further strengthened when test firing showed that, if properly sloped, it had resistance to penetration substantially equal to face-hardened armor. An additional advantage was that homogeneous armor had less tendency toward "back spalling," i.e., splintering of the back under impact of a projectile. As a result, homogeneous armor was authorized for all areas where a sloped surface could be presented to the enemy.[24]

The next step in the process of tank armor development came with the use of cast armor. Before 1940 neither the U.S. Army nor any other army in the world had made use of such armor except at points, such as the transmission housing, where the shape and contour were such that plates could not readily be used.[25] In 1939 the General Steel Castings Corporation of Eddystone, Pa., designed and produced for Ordnance a one-piece cast upper hull, claimed to be the first of its kind ever produced.[26] In June 1940 procure-

[22] The Design, Development and Prod of Tanks in World War II, vol. II, EE Components, p. 29. For an account of the welding methods adopted, see the article by William Osha, "Transition from Riveted to Welded Tank Construction," *Army Ordnance*, XXVI, No. 142 (January–February 1944), 120–22. Mr. Osha was general welding foreman at Berwick plant of ACF.

[23] (1) Hist, Engr and Mfg Div, OCO–D, sec. on light tanks; (2) Cadillac Motor Car Division History of World War II, pp. 22–27; (3) Chase, PP 77, pp. 32–44. For history of the Ferrous Metallurgical Advisory Board's subcommittee on welding of armor, see History, Watertown Arsenal, 105, OHF.

[24] (1) Chase, PP 77, pp. 15–16; (2) Hist, Chicago Ord Dist, I, pt. 1, pp. 169–70.

[25] Hist, Chicago Ord Dist, I, pt. 1, pp. 156–57.

[26] (1) Hist, Phila Ord Dist, vol. 100, pt. 1, Historical Report of General Steel Castings Corporation; (2) Knight Memo, 16 May 45, pp. 8–9; (3) M. H. Pettit, In Review, 1945, a personal historical narrative in History, Industrial Service, Executive Division, vol. 100, OHF.

ment of a 6-ton cast upper hull for the new M3 medium tank was authorized. When ballistic tests of the first models—described as resembling "inverted bathtubs for elephants"—showed excellent results the cast hull was adopted as an alternate type, and further development was pushed. In September 1940 the Ferrous Metallurgical Advisory Board formed a subcommittee on cast armor to draft specifications and to advise on production techniques. The cast hull, formed all in one piece, not only eliminated the need for riveting or welding together over one hundred separate plates and castings, but also facilitated the production of hulls with rounded contours.

In the fall of 1941, and again in January 1942, when tank requirements were doubled and redoubled, the chief armor procurement problem was enlarging production capacity for armor of all kinds—face-hardened and homogeneous plate and castings of many shapes and sizes. Some armor-making capacity had been created in 1939 and 1940 but it was wholly inadequate to meet the needs of 1941–42.[27] Beginning in September 1941, Ordnance arranged for the expansion, with Defense Plant Corporation financing, of nearly all existing cast armor plants, notably American Steel Foundries, Continental Foundry and Machine Company, and the General Steel Castings Corporation. The Ford Motor Company built a foundry with a capacity of ten thousand tons per month, of which nearly half was to be cast armor.[28] Two safe manufacturers, Diebold and Mosler, produced face-hardened plate. Early in 1942, when production of rolled armor also had to be increased, leading steel producers, such as Republic Steel, Henry Disston and Sons, and Carnegie-Illinois, expanded their rolling mills. The latter corporation not only operated the government-owned Gary Armor Plant in Indiana next to its Gary steel mill, the largest of its kind in the world, but also enlarged its plant at Farrell, Pa. American Car and Foundry, a pioneer in the field, expanded its capacity for making armor plate for light tanks and eventually became the largest producer of face-hardened armor plate in the United States. The Pacific Car and Foundry Company of Renton, Washington, enlarged an existing foundry to make its own armor and thus avoid heavy shipments from the Chicago area to the West Coast.[29] The Standard Steel Spring Company of Detroit contributed greatly to the program when it became the co-ordinating agency for a pool of firms that normally made automobile springs, bumpers, and related equipment. The need to build a new plant was avoided when the facilities of these firms were used

[27] Knight Memo, 16 May 45, p. 9. On production of heavy homogeneous plate for the Navy, see Lt. Cmdr. Buford Rowland and Lt. William B. Boyd, *U.S. Navy Bureau of Ordnance in World War II*, Chapter 3.

[28] For a tabulation of all cast armor foundries, see ex. 1 in D. J. Crowley and Lt. W. Cadogan, Narrative History of Cast Armor Procurement Program 1940–45, 30 Jun 45, filed in study Development and Procurement of Cast and Rolled Armor Plate, OCO–D, Jul 45, OHF. See also editor's note in *Army Ordnance*, XXII, No. 130, (January–February 1942), 539, and monthly Production Analysis Notes, TCVD, 1942.

[29] D. J. Crowley, History of Rolled Armor Plate Procurement for the Ordnance Department Tank and Combat Vehicle Program, [30 Jun 45], filed in study Development and Procurement of Cast and Rolled Armor Plate, OCO–D, Jul 45, OHF. This history contains a chronological list of all armor plate facility expansions. For detailed information, see weekly reports by General Christmas in History, OCO–D, Volume 107, OHF.

to cut, harden, straighten, and machine rolled plate received from steel mills.[30]

By the time plans for armor production were well in hand the first cutbacks came in September 1942. The Army Supply Program published at that time dropped the requirement for heavily armored assault tanks, thus reducing the cast armor requirement from about 77,000 tons per month to 57,000. When the over-all program for tanks and other combat vehicles was further cut in November the armor-producing plants felt the effect immediately. Expansions under way were abruptly canceled, and Ordnance began a detailed review of its future needs.[31] In selecting plants to be closed down, Ordnance was guided by the desire to retain in production three types of plants: the older facilities, those in advanced state of completion, and those with excellent production records. Wherever possible, excess plants were converted to other war production through transfer to the Air Force, Navy, or Maritime Commission.[32]

Light Tanks: M2A4 to M24

In terms of numbers produced, light tanks led the procession in 1939, 1940, and 1941. These 13- to 18-ton machines mounting 37-mm. guns were the first American tanks to come into production in 1940 and in 1941 outnumbered medium tanks by nearly two to one. They were used effectively by the British in North Africa in 1941–42, particularly as reconnaissance vehicles. But in 1943 they fell behind as the demand for more powerful tanks continued and production of Grants and Shermans gained momentum. In 1945 the number of light tanks produced was less than half the number of mediums.[33]

In the spring of 1941, while American Car and Foundry was producing early model light tanks at its Berwick plant in Pennsylvania, the Cadillac Division of GMC proposed to Ordnance that a light tank be built with twin Cadillac engines and automatic transmission, then a new development in the automotive industry. Ordnance was reluctant to change from the air-cooled engine, but the need for tank engines was acute and test reports on a Cadillac-powered model were favorable. Furthermore, the Cadillac engine was easier to start; it operated better at idling speeds; and the hydramatic transmission made the tank driver's job much easier. In October 1941 a Cadillac-powered tank proved its durability by running under its own power all the way from Detroit to Aberdeen, a distance of over five hundred miles. In the course of installing its engine and transmission in the standard M3 light tank, Cadillac had made so many design changes that, when adopted, the tank was given a new model number, M4, later

[30] (1) Campbell, *The Industry-Ordnance Team*, pp. 227–28; (2) PP 77, p. 75; (3) Cadillac Motor Car Division Hist of World War II, pp. 35–36; (4) Knight Memo, 16 May 45; (5) E. L. Warner, Jr., "Changing over to Tanks," *Automotive and Aviation Industries*, 86, 15 Apr 47, p. 17.

[31] Memo, Maj Gen Clay for Lt Gen Somervell, 14 Dec 42, sub: Construction Stopped by Ord, Folder 400, Rqmts–Gen–1943, ASF Prod Div. See also Memo, Col C. D. Wiman for Brig Gen Christmas, 1 Nov 42, sub: Survey of Problems Relative to Manufacture of Medium Tanks with Cast Upper Hull, copy in Gen Glancy's file, OCO–D, D56–347.

[32] For a listing of facilities and Ordnance plans for closing each, see Memo, Brig Gen Christmas, T–AC, to CofOrd, 5 Dec 42, sub: Revision of Armor Plate Facilities, with Incls, OHF, folder marked Armor Plate Facilities.

[33] Whiting, Statistics. For correspondence, see folder marked Tank, Light in OCO–Detroit file.

changed to M5 to avoid confusion with the M4 Sherman tank.[34]

The M5 was the first combat vehicle to use the new automatic transmission, which soon gained widespread acceptance.[35] The first tank came off the Cadillac assembly line in Detroit at the end of March 1942, and in July the Cadillac plant at Southgate, California, turned out its first tank. Meanwhile another producer, the Massey-Harris Company, a farm implement firm, came into the picture. It took over the former Nash-Kelvinator plant in Racine, Wis., rounded up the needed machine tools, and, with the aid of Cadillac, got into production as an assembly plant for the M5. In October 1943, American Car and Foundry switched to the M5 and production of M3's stopped altogether.[36]

The changeover from automobiles to tanks at the Cadillac plant was accomplished speedily, but not without the usual conversion problems. Makeshifts were the order of the day, for new equipment specially designed for tank production was virtually unobtainable. Because jigs and fixtures, so essential to mass production, take a long time to make, Cadillac did without them at the start, building its first tanks almost by hand. The company sent representatives all over the country to look for used machine tools, and, as it did not itself plan to manufacture scores of tank parts, to discover sources of parts supply. In January 1942 it set up a "parts clinic" in its new car show room exhibiting 189 tank parts and inviting potential suppliers to examine them and quote prices on such items as oil pumps, axle housings, clutch drums, herringbone gears, and axle shafts.[37]

In the post-Pearl Harbor drive to build twenty-five thousand light tanks a year, Ordnance created another new facility, the Quad Cities Tank Arsenal at Bettendorf, Iowa. Purchasing adjoining plants owned by three private firms—one in bankruptcy—Ordnance contracted with the International Harvester Company to operate them as an integrated unit. The roof was repaired, new concrete flooring laid, and new wiring installed throughout so that International Harvester could build a new model tank known as the T-7 at a rate of 750 per month. The arsenal was intended to be purely an assembly plant, with engines, transmissions, final drives, and all other components coming in from subcontractors, but the arsenal did some machining and welding of hulls, turrets, and rings.[38]

The history of the Quad Cities arsenal during 1942 shows the tank program in its worst light. At the start there was great demand for speed, high rates of production, and a "cost be damned" attitude. The company placed orders for two thousand

[34] For an account of the conversion of the M3 to the M5, see Cadillac Motor Car Division History of World War II, pp. 140–51; Cadillac—From Peace to War, booklet prepared by GMC, 14 Apr 44, filed as History, Detroit Ordnance District, Volume 110, and Chase, The Design, Development and Production of Tanks in World War II, 15 Aug 44. All in OHF.

[35] See praise for the M5 in letter, Devers to Maj Gen Campbell, 24 Oct 42, copy in Gen Glancy's file, OCO-D, D56-347.

[36] (1) Chase, The Design, Development and Prod of Tanks in World War II, 15 Aug 44; (2) Memo, Brig Gen Christmas for Maj Gen Hayes, acting CofOrd, 9 Nov 42, sub: Revised ASP: Light Tanks, Gen Glancy's file, OCO-D, D56-347.

[37] Cadillac Motor Car Div Hist of World War II, pp. 20–42. This history provides the best account of specific production problems and methods to be found in the Ordnance historical files.

[38] Hist, Chicago Ord Dist, vol. 107, ch. 2, sec. entitled Quad Cities Tank Arsenal, OHF. See also John C. Furnas, "Good-by Contract!" *Saturday Evening Post*, June 2, 1945, p. 18.

new machine tools with firms that were already swamped with tool orders and could not promise delivery for months. More than three thousand drawings were needed for the complete tank but, as Rock Island was still at work on the pilot models, the drawings were not available. As the priority rating for the plant was not high enough to give it a green light, countless hours were spent in trying to expedite the project. Then in the middle of the summer Ordnance decided upon a major change of design—equipping the tank with a 75-mm. rather than a 57-mm. gun. This meant redesigning the turret and adding to the over-all weight of the vehicle. Even before the gun was changed, the tank, originally expected to weigh between eighteen and twenty tons, was up to twenty-five tons. The added weight was too much for the engine and made the tank slow and hard to steer. To remedy the deficiencies as they appeared, Rock Island issued hundreds of revised drawings every month, and continued to do so until near the end of the year when the contractor and Ordnance representatives finally agreed to freeze the design. The first essentially complete tanks were shipped in December 1942 just as cutbacks in all tank production were taking effect. Scheduled production at Quad Cities was then scaled down and discontinued completely in April 1943, after completion of only thirteen tanks.[39]

Meanwhile the Marmon-Herrington Company of Indianapolis undertook production of the M22, an 8-ton airborne tank, and Ordnance began planning to switch from the M5 to a more powerful light tank, the M24. In the spring of 1944 manufacture of the M5 at ACF, Cadillac, and Massey-Harris was discontinued. ACF dropped out of tank production at this time after having produced over fifteen thousand tanks, more than half the entire wartime output of light tanks. In 1944 and 1945, Cadillac and Massey-Harris, the only two producers, turned out a total of 4,731 M24 tanks mounting the 75-mm. gun and weighing approximately 20 tons.[40]

The Shift From Grants to Shermans in 1942

The most far-reaching change in production plans for medium tanks during 1942 was the shift from the Grant (M3) to the Sherman (M4).[41] From the very start, the Grant had come in for a lot of criticism. It had been hurriedly designed in 1940, after the German offensive had demonstrated the unsuitability of existing mediums. It went into production in spite of inadequate test and development because it was more advanced than the design that later became the Sherman.[42] During its initial production, when the

[39] (1) Hist, Chicago Ord Dist, vol. 107, ch. 2, sec. entitled Quad Cities Tank Arsenal; (2) General Report on Military Tank Production, 20 May 43 (revised 14 Aug 43), War Projects Unit, Bur of the Budget, OHF; (3) Abstracts of Field Reports on Tank Production, Jan 44, Bur of the Budget, OO 470.8/927 Tanks.

[40] Chase, The Design, Development and Prod of Tanks in World War II, 15 Aug 44. For description of the M24, and comparison with M5A1, see Catalog of Standard Ordnance Items, vol. I. Procurement of the airborne tank is described in Green, Thomson, and Roots, *Planning Munitions for War*, Pages 318–20.

[41] For figures showing requirements and scheduled production of the two models, see Master Schedule, 25 Nov 42, prepared by Ord Ind Div, p. 20, copy in OCO–D file. See also Memo, Brig Gen Christmas for Maj Gen Hayes, acting CofOrd, 8 Nov 42, sub: Revised ASP: Medium Tanks, Gen Glancy's file, OCO–D, D56–347.

[42] The British Churchill tank had a similar history. See Postan, *op. cit.*, pp. 192–93.

inevitable "bugs" were being eliminated, engineering changes were authorized at the rate of three thousand per month. They ranged from minor modifications in track design to major changes in the shape of the hull or turret. The riveted hull of the early Grants gave way to a welded hull on later models, and the welded hull on the first Shermans eventually gave way to a cast upper hull.[43]

The shift from Grants to Shermans was gradual, starting in July 1942 when the first Shermans were made by the Fisher Tank Arsenal, which, unlike the Chrysler arsenal, had been designed with production of Shermans in mind. Chrysler produced its first Sherman in July 1942 and closed out production of Grants on 3 August and the railway equipment companies followed suit. The nearly five thousand Grant tanks built in 1942 remained in service during 1943 as "limited standard" and were not declared obsolete until early in 1944. They posed a major problem of disposal for Ordnance. "We are beginning to run into the motor car dealer's problem," Colonel Christmas commented. "Our customers, the fighting men, want only the latest models." [44] Some Grants were converted to tank recovery vehicles, i.e., their heavy guns were removed and replaced by powerful winches for towing disabled tanks. Others were used for instructional purposes by Ordnance evacuation companies and by Engineer training centers. The rest of the Grants were dismantled, with usable parts salvaged and the remainder disposed of as scrap.[45]

Discontinuance of the Grant models did not completely simplify the matter by any means, for there were five different models of the Sherman tank in production in the United States by the end of 1942.[46] The essential differences were in the engines. The original M4 was powered by a Continental radial aircraft engine. The M4A1 also used the Continental radial engine but had a cast rather than a welded upper hull, and improved surface contour. The M4A2, shipped in large quantities to the Soviet Union and the British, was powered by twin General Motors diesels. The M4A3 had a Ford GAA, and the M4A4, which went to the British, had the multibank Chrysler engine. The designation M4A5 was assigned a model with a 57-mm. gun produced in Canada for Canadian use, often called the Canadian Ram. The M4A6 was powered by a radial air-cooled diesel-type engine manufactured by the Caterpillar Tractor Company.[47]

The armament of the M4 tanks introduced further complications. The original design mounted a 75-mm. gun as its main weapon, but later models were equipped with the high velocity 76-mm. gun, and a few were supplied with 105-mm. howitzers. Early in 1944 limited procurement of a heavily armored "assault tank" known as

[43] For a brief summary of the shift from Grants to Shermans, see appendix A of Outline of Tank Procurement, May 1942, Report No. 7. See also Warner, "Changing Over to Tanks," *Automotive and Aviation Industries,* vol. 86 (April 15, 1942), 17.

[44] Review of Production Plans of TCVD, 21 May 42. See also Ltr, Maj Gen Hayes, acting CofOrd, to Brig Gen Christmas, 5 Nov 42, sub: Mtg held in Gen Somervell's Office, 4 Nov 42, in Gen Glancy's file, OCO-D, D56-347.

[45] OCM 23185, 16 Mar 44.

[46] Memo, ACofS (Maj Gen T. T. Handy) for CG AGF, 28 Dec 42, sub: Assignment of Tanks, AGF file 470.8. For discussion of modifications desired by the Armored Force, and the production problems they entailed, see The Design, Development and Production of Tanks in World War II, sec. EB Medium Tanks, pp. 20–21.

[47] For data on production and distribution of these tanks, see Statistical Work Sheets, 1 September 1945, Volume 42, the final report in this series of monthly reports by OCO-D.

the M4A3E2 was authorized.[48] As production of the new heavy tank M26 got under way early in 1945, production of mediums was gradually scaled down and ended in July 1945 after some 57,000 had been built.

Tank Depots

The experience of 1940–41 demonstrated that it was not practical for the tank plants to install the scores of minor accessories—radios, spare parts, small arms, first aid equipment, interphones, and Chemical Warfare items—needed to make a tank fully ready for battle. Unavoidable delays in getting delivery on all such items slowed down production at the factories, and the spectacle of scores of nearly complete tanks standing for weeks outside factories waiting for some small parts had a bad effect on labor morale. Further, as supply of many of these accessories was the responsibility of the Government, not of the contractor, Ordnance considered it more sensible to install this "On Vehicle Matériel" itself rather than disperse it to the contractors' plants. It was for this purpose, along with others, that the tank depots were established.[49]

The depots were intermediate facilities that received tanks from manufacturers in a reasonably complete condition, installed required items, made any special modifications needed, prepared tanks for shipment, and stored them until shipping instructions were issued. In January 1942 Ordnance took over the New York Central Railroad shops in Toledo as its first tank depot, and soon contracted with the Electric Auto-Lite Company for its operation. Two others were opened shortly, both operated by the Ford Motor Company. The first was at Chester, Pennsylvania, and the second at Richmond, California. Both were Ford assembly plants and were well located for both rail and water shipment. In December 1942, when work on a proposed gun plant at Lima, Ohio, was discontinued, the plant was taken over as a tank depot, soon replacing Toledo. It was operated by the United Motors Service Division of GMC. The Longue Pointe depot at Montreal, Canada, was a Canadian Army installation used by Ordnance primarily for processing tanks and other vehicles shipped to the United Kingdom on lend-lease.[50]

Early in the war, when most overseas shipments of tanks went to other nations on lend-lease, it was discovered that some standard U.S. equipment was not suitable for those countries. British rather than American radios had to be put in tanks going to the United Kingdom or Russia, and all tanks destined for British Army use were equipped with sand shields, smoke generators, and a smoke bomb thrower. To avoid confusion at the plants, the depots were given responsibility for installing this special equipment. Meanwhile field reports on defects and proposed modifications were received by Ordnance, and, on tanks already built, the approved changes were made at the depots. In addition, major modifications were made on certain vehicles to meet special needs, as when some

[48] Catalog of Standard Ord Items, vol. I, pp. 18–22, 1 Mar 44, and pp. 23–24A, 1 Oct 44. For correspondence on the change-over to 76-mm. guns, see G–4 file 472—vol I.

[49] (1) Tank Depot sec. in Hist, Engr and Mfg Div, OCO-D, vol. 7, pt. I; (2) Campbell, *op. cit.*, p. 229; (3) C. H. Coster, PSP 74, Report on Industrial Service Tank Depots, 8 May 45, OHF; (4) Industrial Service Tank Depot Operations, Final Issue (January 1942 through December 1945) prepared by OCO-D, OHF.

[50] Coster, *op. cit.*

medium tanks were converted to mine exploders and other tanks and gun motor carriages were converted to prime movers.[51]

The early experience with shipment of vehicles overseas "in accord with best commercial practice" was disastrous. The tanks arrived in badly damaged condition after a long sea voyage. Special techniques had then to be worked out to protect the engines, fire control instruments, and other parts from damage by rough handling or exposure to salt water. Accessories were individually packed in boxes and stowed inside the vehicles. Engines were protected with an internal coating of preservative oil and an external rust-preventive spray. After a desiccant was hung in the engine and crew compartments, these sections were sealed with a waterproof tape. The guns were treated with a heavy rust preventive and sealed at the muzzle. To permit the vehicle to be towed and steered without breaking the sealing tape, cables were attached to the steering levers and brought out through the bow gun mount.[52]

The worst problem for the depots at the peak of tank production was the failure of accessory shipments to keep pace with tank shipments. Tanks reached the depots with innumerable shortages of tools, equipment, and supplies. The situation grew more critical all during 1942, with more than ten thousand tanks deadlined in November when tracks were in extremely short supply. The shortage of tracks stemmed chiefly from lack of alloy steel and the doubling of demand for spares. The tank producers appealed directly to the WPB for more track steel, and Ordnance assigned expediters to follow up all types of parts.[53] In January, General Christmas forbade manufacturers to ship tanks to depots unless completely equipped according to the latest On-Vehicle Matériel List. By March 1943 the shortages on vehicles at depots, which had averaged forty items per vehicle in November, had dropped to three.[54]

The 1943–45 Period

By the spring of 1943 light and medium tanks were rolling off the assembly lines of sixteen plants at the rate of about four thousand per month. This was roughly half the designed capacity of the plants, not counting Quad Cities Arsenal, which stopped producing tanks in April. The over-all capacity of 7,705 tanks per month had been created during the preceding two years at a cost to the government of approximately $250,000,000 for tools, equipment, and buildings. In May 1943 a representative of the Bureau of the Budget was able to report that, all things considered, the tank program had "gone very well," with most of the contractors getting into production with surprising promptness. But he raised serious questions on two points: the wide variations among the

[51] Lecture, Lt Col George W. White, Wartime Difficulties in the Production of Combat and Motor Transport Vehicles, p. 4, 16 Feb 48, ICAF, L48–87.

[52] (1) Hist, Phila Ord Dist, vol. 104, pt. 1, containing Inspection Dir of the Chester Tank Depot; (2) Intraoffice Memo, Maj Samuel R. McCluney to Lt Gerber, 22 Jun 42, sub: Intermediate Depot Opns, Hist, OCO–D, vol. 107.

[53] Ltr, C. M. Burgess, president Burgess-Norton Mfg. Co. to Donald M. Nelson, WPB, 4 Sep 42, sub: Failure of Tank Prod, copy in Hist, Ord Dept Industry Integration Comm. for Medium Tanks, sec. IX, by Maj Louis Antol, Jr., 1 Jun 45, P4332. Development and production of tank tracks are discussed in Green, Thomson, and Roots, *Planning Munitions for War,* Chapter X, and in weekly reports by General Christmas in History, OCO–D, Volume 107.

[54] Tank Depot secs. of Hist, Engr and Mfg Div, OCO–D.

producers in the cost of tanks, as shown in contracts, and the need for closing plants no longer necessary to meet falling requirements.[55] General Glancy and other officials of the Tank-Automotive Center strongly objected to this report on the ground that it contained factual errors and drew unwarranted conclusions.[56]

The estimated costs of medium tanks under contract in the spring of 1943 showed a wide spread, from $33,500 for the Grant tank and $42,400 for the Sherman tank at the Chrysler arsenal to $70,000 for the Sherman tank at the Federal Machine and Welder Company. Both firms had so-called fixed price contracts, but, General Glancy pointed out, the prices were actually not fixed at all because they were subject to redetermination and were, in fact, little more than estimates. Further, the operating conditions of the two firms were not comparable as the arsenal was completely government-owned and the Federal plant was privately owned, and the prices cited were for different models of tanks. The contract price for the Sherman tank at the Fisher arsenal was high, $67,173, but was undergoing substantial reduction to bring it into line with cost data resulting from actual production experience. The Fisher arsenal soon proved to be one of the lowest-cost producers in the whole program. The other medium tank producers, holding cost-plus-fixed-fee contracts, showed estimated costs per Grant tank ranging from $58,850 at Baldwin to $67,860 at Lima. The fixed fees on these contracts ranged from a low of $2,860 per tank at Lima to $3,850 at Baldwin. The cost figures in these contracts—but not the fees—were clearly estimates and had no binding effect. They were generally based on toolroom production experience only, and the assumption was that they would be revised later as assembly line production brought the cost down. The companies with cost-plus-fixed-fee contracts were eventually reimbursed for all approved costs incurred in producing tanks, plus the stipulated fee for each tank. With both CPFF and fixed price contracts the problem of keeping costs down was extremely complicated and continued so to the end of the war when final adjustments were made.[57]

The underutilization of plants was one of the most striking features of tank production all during 1943 and early 1944. "It has been evident," wrote a Bureau of the Budget representative, "that too much production capacity was provided. . . ."[58] The sixteen plants placed under contract in 1941–42, when tank requirements were sky high, continued in operation until the last quarter of 1943 when four were eliminated — Lima, Pullman - Standard, Ford, and Pacific Car and Foundry.[59] These cancellations reduced over-all capacity from approximately 8,000 to 6,600, but capacity was still more than double the

[55] Gen Rpt on Mil Tank Prod, 20 May 43 (rev'sed 14 Aug 43), War Progress Unit, Bur of the Budget, OHF. This agency reached the same conclusions after another survey in 1944.

[56] Ltr, Brig Gen Alfred R. Glancy to Bur of the Budget, 5 Jul 43. See also Memo, Oscar A. Kaufman, staff assistant, for Glancy, 28 Jun 43, sub: Gen Rpt on Mil Tank Prod. . . . . Both in 319.1 Bur of the Budget Rpt, OCO–D, Glancy's file.

[57] (1) Military Tank Production, An Industry Review, 10 Mar 44, Bur of the Budget, OHF; (2) The Design, Development and Prod of Tanks in World War II, vol. II, MB Cost Data. For further analysis of this topic, see Smith *Army and Economic Mobilization*, Chapters XII and XIII.

[58] Military Tank Production, Progress Report, 24 Oct 44, War Projects Unit, Bur of the Budget, D50–49 dr 2, copy in OHF.

[59] The Ford plant was needed to produce bombers and the locomotive plants to make railroad equipment. Pacific Car and Foundry was in an area of labor shortage.

rate of production. In 1944, four more plants stopped building tanks—American Car and Foundry, Baldwin, and Marmon-Herrington in April, and Fisher in October. By the end of the year capacity was down to about 4,000—half what it was at the start of 1943—but still more than double the rate of production.[60]

The excess of production capacity during 1943-44 eliminated some problems and created others. By and large, shortages of machine tools and materials—the two major bugbears of 1941-42—eased considerably in the spring of 1943. So did the manpower problem in the tank industry, although there were always difficulties in some areas. The output of spare parts rose rapidly in relation to complete vehicles.[61] Among the new problems was that of arranging for the orderly transfer of plants and workers to other war production. Similarly, the accumulation of surplus parts and raw materials was becoming a problem at plants where schedules were cut back. Efforts were made to divert such matériel to other tank manufacturers, but a report in the spring of 1944 on one plant that had been closed for months showed that millions of dollars worth of critical matériel—guns, gun mounts, cable, tools, motors, welding rods, and so on—was still on hand.[62]

Production declined during each of the first five months of 1944, but invasion of Europe in June reversed the trend. The rise in output during the latter half of the year was gradual, for, in spite of excess capacity, manufacture of specific models could not be increased overnight—or even over a period of several months—to meet sudden increases in theater demands. In May 1944, for example, the ASF Requirements Division declared that restudy of the tank picture had shown that, "we should push at once for as many additional medium tanks as we can get in 1944." [63] The change in calculations stemmed chiefly from two factors: an unexpected increase in the overseas replacement rate, and the large proportion of old tanks counted as resources in the February 1944 supply program. After conferring with Ordnance officers in Detroit, the head of the ASF Production Division, Brig. Gen. Hugh C. Minton, reported that from three hundred to five hundred additional Sherman tanks could be produced in 1944 but only "by applying all possible pressure to the producers." [64] Ordnance was immediately directed to apply the necessary pressure, but, because of changes in design and the need for retooling, production rose slowly.[65] The measures taken by General Campbell to increase output included personal visits to the tank plants, publicity, recruitment of labor, and "every other known means of stimulating production." [66] To break the bottleneck that developed in production

[60] The Design, Development and Prod of Tanks in World War II, PB Medium Tanks and Tank Chassis Vehicles. See also Mil Tank Prod, 24 Oct 44.

[61] For further discussion of spare parts, see Chapter XIII, below.

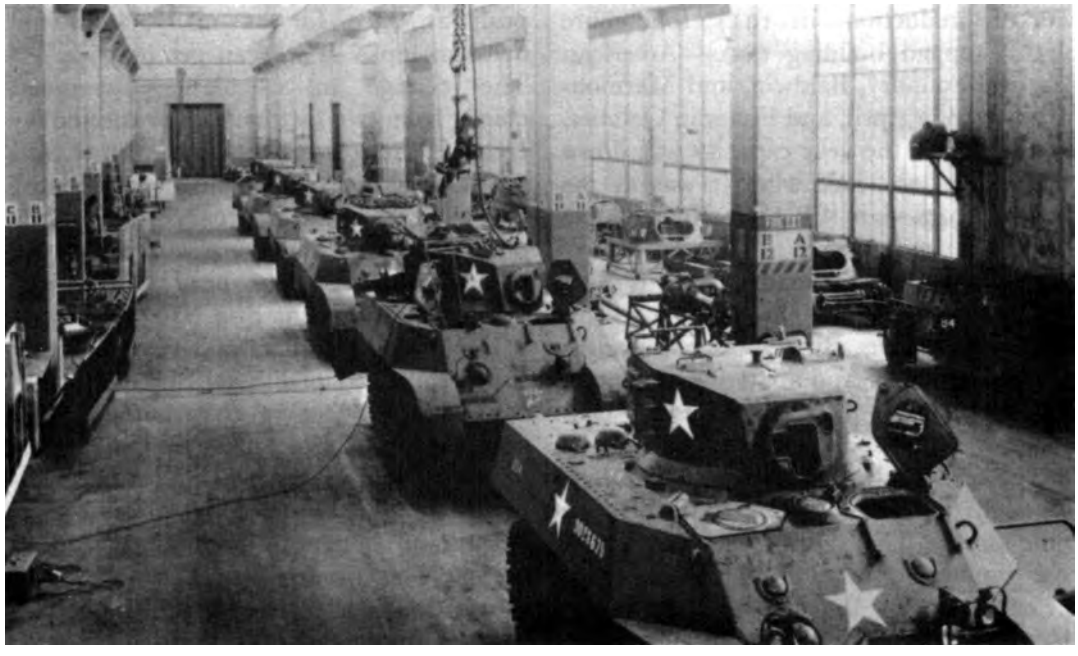
[62] Mil Tank Prod, An Industry Review, 10 Mar 44. For an excellent case history of disposition of excess property, see History, Philadelphia Ordnance District, Volume 100, Part 10, Baldwin.

[63] Mem, Dir Rqmts Div ASF for Clay, 22 May 44, sub: Additional M4 Tank Prod in 1944, ASF Prod Div file 470.8.

[64] Memo, Director Prod Div, ASF for Col Lee A. Denson, 27 May 44, OO 470.8/1192. There were only three medium tank producers at this time—Chrysler Tank Arsenal, Fisher Tank Arsenal, and Pressed Steel Car Company.

[65] For a brief summary of production bottlenecks, see Hiland G. Batcheller, A Report to the War Production Board, 14 Nov 44, WPB doc. 365, ASF Director of Matériel file.

[66] Memo, Howard Bruce, Acting Director of Matériel, for Wood, 4 Jan 45 sub: Tanks, ASF Prod Div 470.8—Tanks.



REMANUFACTURING LIGHT TANKS M3A3 *at Red River Arsenal, Texarkana, Tex.*

of wide tracks, the "special directive treatment" was resorted to, giving wide tracks an overriding WPB priority that put them in the same class with landing craft, heavy artillery, and the Dukw.[67] Meanwhile, as theater commanders called for more and more tanks, Ordnance was instructed to launch a supplementary program for tank "remanufacture."

This new process—the complete overhaul of combat vehicles—was, in the summer of 1944, a natural solution to the problem of how to increase the supply. During the preceding months, as one armored unit after another had been shipped overseas, the tanks they had used during long months of arduous training were withdrawn and replaced by new vehicles, with the result that large numbers of used tanks accumulated. Occasional criticism of the Army resulted when irate taxpayers saw these tanks standing idle in storage and concluded that they represented waste of valuable war matériel. As early as the summer of 1943 General Campbell, during a trip to the West Coast, had explored the possibility of contracting with industry to recondition these tanks. In October 1943 he formally recommended to ASF that a reconditioning program be authorized, including a balanced withdrawal of tanks from troops for this purpose. It was not until June 1944, when the quantities of tanks left behind by troops going overseas had reached high levels, that Ordnance was assigned the job of overhauling and modernizing them so they could be shipped overseas in new-

[67] Memo, Director ASF Prod Div for CofOrd, 10 Jul 44, sub: Prod . . . Medium Tank. . . , ASF Prod Div file 473.

tank condition.[68] The process was to start with a thorough cleaning of each tank and partial disassembly, followed by an overhaul of its engine, replacement of worn tracks, reconditioning the guns, adding improvements made since the original design, and giving the whole vehicle a new coat of paint. The total cost of remanufacture was estimated to be about half that of building a new tank. After teams of Ordnance technicians visited Army Ground Forces camps to select the tanks to be overhauled, the work began in August and proceeded at the rate of six hundred medium tanks per month for the rest of the year. Light tanks, half tracks, gun motor carriages, and scout cars were also remanufactured, bringing the total for 1944 up to more than eleven thousand combat vehicles. The bulk of the work was done at the Quad Cities Tank Arsenal, Evansville Ordnance Plant (converted from production of small arms ammunition), and the Montreal plant of the American Locomotive Company.[69]

By January 1945, the demand for more tank production became intense and industry was once again called upon to make an all-out effort. Requirements for all types of tanks went up from 18,000 to 22,000, and then to 25,000 in February, including nearly 10,000 heavy Pershing (M26) tanks armed with 90-mm. guns or 105-mm. howitzers.[70] In February, Ordnance reported that even though all tank producers were scheduled to capacity the procurement goals could not be reached. General Hayes, chief of the Industrial Service, stated that the tanks required for 1945 could be produced only by bringing back into production all former tank producers—a slow process that would not yield any results until near the end of the year, and would be prohibitively costly. Considering the two most critical components—Ford engines and torquematic transmissions—General Hayes observed that it was "extremely doubtful" if production could be further increased in 1945 by any means.[71]

By March the storm had subsided. As the defeat of Germany appeared more and more imminent, tank requirements were cut back and manufacturers received cancellation notices. The planned expansions at various plants were halted. From the peak of 2,268 tanks accepted in March, production declined to about 1,800 in both April and May and then dropped to 456 in July. By November it had stopped altogether.[72]

Shift to Heavy Tanks in 1944–45

Of all the various shifts and trends of tank production in the later war years, both in Germany and the United States,

[68] (1) Memo, Maj Gen Clay, ASF Director of Matériel, for CofOrd, 6 Mar 44, sub: Factory Overhaul. . . , OO 470.8/854 Misc.; (2) Memo, CofOrd for CG ASF, 9 Jun 44, sub: Tank . . . Overhaul, OO 470.8/1153; (3) Memo, CG ASF for CofOrd, 13 Jun 44, sub: Overhaul and Rebuilding of Tanks . . . and correspondence therein cited, OO 451/2834; (4) Mil Tank Prod, Progress Rpt, 24 Oct 44.

[69] (1) Rpt for SW on Ord Dept Activities, 2 Aug 44, ExecO file; (2) Mil Tank Prod, 24 Oct 44; (3) The Design, Development and Production of Tanks in World War II, PB Medium Tanks; (4) Summary Rpt of Acceptance . . . , 1940–45, OCO–D, Dec 45, p. XII.

[70] Memo, Acting Director of Matériel for CG ASF, 24 Jan 45, sub: Lighter Medium and Heavy Tank Prod, ASF Prod Div 470.8 Tanks.

[71] Memo, Maj Gen Hayes for CG ASF, 7 Feb 45, sub: Prod Rates for Medium and Heavy Tanks, OO 470.8/1793.

[72] Summary Rpt of Acceptance. . . , 1940–45, OCO–D, Dec 45, p. XVII. See also Rpt of Board to Review Recommendations of the Operating Divs of the Ind Serv. . . , 12 Apr 45, sub: Readjustment of Tank Production Schedules, OO 470.8/2037.



HEAVY TANK M6, *mounting a 3-inch gun, produced by Baldwin Locomotive Works, is inspected by (from left) Lt. Col. David N. Hauseman, Brig. Gen. Gladeon M. Barnes, William H. Harmon (Baldwin official), and Capt. Arthur J. Seiler, December 1941.*

none was more important than the coming into its own of the heavy tank. And none illustrates more clearly the problems faced by Ordnance in developing new matériel under pressure and meeting rapidly changing requirements. To see the full picture of changes in U.S. requirements we must look at two separate stages in the history of heavy tanks: the 1940–42 period, and the eleventh hour demand for heavy tanks in 1944–45.[73]

During the 1930's no one had shown much interest in heavy tanks, but in the spring of 1940 Ordnance was authorized to proceed at once with development of a 50-ton tank mounting a 3-inch gun. An appropriation was soon made to build fifty tanks; a contract for their manufacture was placed with the Baldwin Locomotive Company in August 1940; and the pilot model was finally unveiled in a public ceremony on the day after Pearl Harbor.[74] The M6 heavy tank, as it was called, had a cast hull between three and four inches thick, a 925-horsepower engine, and weighed over sixty tons. It still needed a lot of development work to improve its suspension, transmission, brakes, and other

[73] For an account of tank development, see Green, Thomson, and Roots, *Planning Munitions for War,* Chapter X.

[74] (1) Hist, Phila Ord Dist, vol. I, pt. 7, p. 129; (2) Barnes, *Weapons of World War II,* pp. 210–13.

vital parts, but time was at a premium in the winter of 1941–42—and the President's program announced in January called for building five hundred heavy tanks in 1942 and five thousand in 1943. Two models of the tank were quickly standardized and Ordnance contracted with the Fisher Tank Arsenal as well as Baldwin to build them at the combined rate of 250 per month.[75]

The Army Supply Program of September 1942 took the steam out of this ambitious plan by cutting heavy tank requirements from more than 5,000 to only 115. Ordnance immediately canceled its contract with Fisher and curtailed production at Baldwin. In December 1942, on the first anniversary of Pearl Harbor, General Devers of the Armored Force declared that, because of the M6's great weight and limited tactical use, the Armored Force had no requirement for it and recommended that its production be stopped.[76] The British later agreed, apparently because the M6 had been intended for North Africa, where bridges were not a problem, and by early 1943 the end of the North African campaign was in sight.[77] In the summer of 1943 the Armored Force Board reported, on the basis of service tests, that the heavy tanks M6 and M6A1 were not acceptable because they lacked firepower commensurate to their weight, had obsolete fire-control equipment, were equipped with unsatisfactory transmissions, and had awkwardly arranged crew compartments.[78] As a result, only forty heavy tanks of the M6 series were built, nearly all of them in 1943. The Germans, meanwhile, were throwing the bulk of their tank-producing capacity into building the heavy Tiger (63-ton) and Panther (47-ton) tanks, in spite of their many mechanical deficiencies.

While the M6 tanks were running into trouble, Ordnance was attempting to give its medium tanks more punch by equipping them with the 76-mm. high velocity gun and the 105-mm. howitzer, and improving their suspensions and tracks. It was also trying to win acceptance for the T-20 series of new and more powerful tanks to replace both the M6 and the Sherman, but the Army Ground Forces strongly opposed these efforts.[79] Then in June 1944, after a demonstration at Aberdeen before high-ranking War Department officials, Ordnance finally won approval of its plan to mount a 90-mm. gun on the experimental medium tank T26 and reclassify it as a heavy tank.[80] This marked

[75] (1) History of the Heavy Tank M6; (2) The Design, Development and Prod of Tanks in World War II, EC Heavy Tanks and PC Heavy Tanks; (3) OCM 18283, 26 May 42, standardized the M6 and M6A1. The latter had a welded rather than a cast hull. The M6A2, adopted later, had an electric drive and a cast hull.

[76] Ltr, L. Devers, CG Armored Force to CG AGF, 7 Dec 42, sub: Heavy Tank, copy in History of Heavy Tank M6, OHF. The attitude of the Army Ground Forces toward Ordnance heavy tanks is presented in AGF Study No. 34, The Role of the AGF in the Development of Equipment, 1946, Chapter 6.

[77] Memo, Col Raymond R. Robins, ASF Development Br for ACofS, G-4, 3 May 43, sub: Further Notes on African Trip, G-4 file 472.2 vol. I—Arty.

[78] Final Rpt, Test of Heavy Tanks M6 and M6A1, AFB, 12 Jul 43, copy in Hist of Heavy Tank M6.

[79] (1) Green, Thomson, and Roots, *Planning Munitions for War*, ch. X; (2) Chase, The Design, Development and Prod of Tanks in World War II, 15 Aug 44, pp. 39–40; (3) Memo, CofOrd for CG ASF, 23 Mar 44, sub: Heavy Tank T 28, OO 470.8/905 Tank. This memo describes unsuccessful Ordnance efforts to gain approval for an 80-ton tank, with 8-inch armor and 105-mm. gun.

[80] OCM 24277, 29 Jun 44. See also Tank Report, 1944–45, OCO-D, DC-Heavy Tanks, OHF, and Chase, The Design, Development and Prod of Tanks in World War II, 15 Aug 44, p. 41.

TABLE 20—U.S. TANK PRODUCTION, 1944–1945

Type	1944	1945
Total	17,565	11,968
Light Tanks	[a]4,043	[b]2,801
Medium Tanks	[c]13,468	[d]6,793
Heavy Tanks	[e]54	[e]2,374

[a] M5's and M24's. [c] Nearly all M4's. [e] Nearly all M26's.
[b] All M24's. [d] All M4's.

Source: Summary Report of Acceptances Tank-Automotive Matériel 1940–45, by OCO–D.

the beginning of a new cycle in heavy tank production, inspired largely by the appearance during 1943 in Africa and Italy of heavy German tanks that were more than a match for the American mediums. Thus, long after the M6 series went by the board, the T26 was permitted to take its place in 1944, but only ten of these 45-ton heavyweights were delivered during the first half of 1944. After extensive tests and modifications, the new tank went into limited production in November 1944 and was standardized early in 1945 as the heavy tank M26. Nicknamed the General Pershing, it was probably the best heavy tank to see action in World War II. But it did not arrive in Europe until after the worst of the fighting was over. Only fifty were built in 1944, and, all told, only seven hundred were built before Germany surrendered in May 1945.[81] (*Table 20*)

The Balance Sheet

Arguments about American tanks in World War II will no doubt continue as long as veterans of that conflict survive to continue the discussion. They will continue because the subject is so involved, with so much to be said on all sides, that no simple analysis can encompass the whole. To draw up a balance sheet fairly representing the views of all concerned, and weighing every factor in due proportion, is extremely difficult, if not impossible. But at this point some of the essential data may be mentioned on which there is likely to be general agreement.

Had the war been fought with light tanks the U.S. Army would have been as well equipped at the start as any army in the world. The M3 light tank that emerged in 1941 from the experimental work of the 1930's gave a good account of itself in North Africa, and its successors, the M5 and M24, were well received in the field. But the war was not fought with light tanks. Medium and heavy tanks predominated, and the U.S. Army had no first-rate medium or heavy tanks on hand in 1940. When the 1940 campaign in

[81] (1) Green, Thomson and Roots, *Planning Munitions for War,* ch. X; (2) Barnes, *Weapons of World War II,* pp. 214–18; (3) Col. Joseph M. Colby, "From Designer to Fighter," *Armored Cavalry Journal,* LIX, No. 1 (1950), 12–18. An even heavier tank, the T28, weighing 100 tons, carrying 12 inches of frontal armor, and mounting a 105-mm. gun, was designed in 1944 but never reached the production stage.

TABLE 21—COMPARATIVE TABLE OF GERMAN, BRITISH, AND AMERICAN TANK PRODUCTION, 1940–1945

Date	German [a]	British [b]	American [c]
Total	24,360	24,803	88,410
1940	1,459	1,399	[d] 331
1941	3,256	4,841	4,052
1942	4,098	8,611	24,997
1943	6,083	7,476	29,497
1944	8,466	2,476 (6 months only)	17,565
1945	988 (1st quarter only)	—	11,968

[a] USSBS—Tank Industry Report, ex. A.
[b] Great Britain, Central Statistical Office, Statistical Digest of the War (London: His Majesty's Stationery Office, 1951), Table 126.
[c] Whiting, Statistics, Table PR-7.
[d] Includes procurement from 1 July 1939 to 31 December 1940.

France revealed the need for tough-skinned, hard-hitting tanks, Ordnance had to rush through a drastic redesign of its existing medium model and begin work on a new heavy tank. Both the Grant medium and the M6 heavy were hasty improvisations that brought little credit to Ordnance, in the eyes of the Armored Force, and were regarded even by Ordnance engineers as makeshifts. The M6 never got into volume production, and the Grant was soon replaced by the Sherman—a well-designed vehicle that could hold its own with any medium tank on the battlefield. The Sherman was more mobile and mechanically more reliable than German medium tanks, and had greater flexibility and rapidity of fire. The trouble was that it too often found itself up against heavy Panthers or Tigers.[82]

The lack of heavy tanks to match the German heavies was the crux of the problem. In summing up the reasons for this lack, two items are reasonably clear: (1) the using arm's lack of interest in heavy tanks during the prewar and early war years, and (2) Ordnance's failure to come up with something better than the M6 in 1941. The two items are closely related and mutually supporting. Because the using arm expressed no desire for heavy tanks in the prewar years Ordnance made no effort to carry on the elaborate design and development work such tanks required. Because Ordnance in December 1941 could produce no heavy tank better than the primitive M6 model, the Armored Force was more than ever convinced that heavy tanks were impracti-

[82] For comparison of the medium Sherman with the heavy Panther in battle, see Cole, *The Lorraine Campaign*, pp. 603–04. For a collection of Ordnance records, see Comparison of American, German and Japanese Ordnance, I, 6 May 45, OHF.

cal and could be dropped. Meanwhile the Germans, who in 1941 had no tank comparable even to the M6, launched a heavy tank program after their encounter with the Russian heavyweights. The result was that the Germans in 1944 were able to oppose American Shermans with heavy tanks which, though far from perfect, had much tougher protective armor and more powerful guns than did the Sherman. Only then was Ordnance given a green light to proceed with production of the Pershing—too late to have much effect on the fighting in Europe.

The best way to take the quantitative measure of U.S. tank production in World War II is to view it in comparison with German and British production. Qualitative considerations aside, the following table clearly reveals the extent to which the United States outproduced Germany. In every year except 1940 the United States produced more tanks than Germany and in the middle years of the war turned out from five to six times as many. (*Table 21*) Even Britain, while subjected to intensive bombing, produced almost as many tanks as Germany did in 1940, and in 1941 Britain turned out more tanks than either Germany or the United States. These figures should serve to demolish some of the myths that have grown up around German tanks. They should demonstrate for all to see that German tank successes were due more to skilled tactical use, and the employment of heavy German tanks against Allied mediums, than to any failure of American industry to produce in quantity the tanks desired by the using arms.

CHAPTER XII

Motor Transport Vehicles

Military historians of the future may some day label World War II the "gasoline engine war," or, if they prefer a more exact but more cumbersome title, the "internal combustion engine war." As the twentieth century neared its midpoint, military forces everywhere, on land, at sea, and in the air, depended for their mobility on internal combustion engines, both gasoline and diesel. Three of the most spectacular weapons—the tank, the airplane, and the submarine—were powered chiefly by internal combustion engines, as were the millions of hard-working military trucks that bore the brunt of the task of supply distribution in the field. Although some experimental efforts were made to use new techniques such as jet propulsion and rocket power, they had limited application. The immense power of the atom, utilized in World War II only for the A-bomb, was not harnessed for submarine propulsion until the mid-1950's. But in all the leading armies of the world, gasoline and oil provided the energy—still commonly measured in terms of horsepower—to drive the wheeled and tracked vehicles that made for a war of movement.

In World War II the U.S. Army was better able than ever before in its history to take to the road on gasoline-driven wheels. The purchase of more than three and a half million motor cars and trucks —not counting thousands of tanks and other combat vehicles—marked the end of the horse and mule era of the Army's history. Although infantrymen in World War II still had to march mile after weary mile, they had at their disposal, for transport of both men and supplies, more trucks, cars, buses, and other vehicles than ever before. As in Napoleon's day, the armies of the world still marched on their stomachs, but their mobility had come to depend more and more on rubber tires and gasoline engines.[1]

The motor truck was not by any means a new item of military equipment in the 1940's. Two decades earlier thousands of trucks went to France with the AEF and played a minor role in winning the war, but it was not until the 1940's that the U.S. Army really became "motorized." In France in 1918 the U.S. forces had, roughly speaking, one truck for every forty men; in the European theater in 1945 the ratio was about one to four.[2] In the latter stages of World War II it was theoretically possible, if not feasible for practical reasons, to put an entire army on wheels—pile everyone into trucks, buses, ambulances,

[1] For a detailed discussion of this development, see Capt. Charles R. Kutz, *War on Wheels* (Harrisburg, Pa.: Military Service Publishing Company, 1940).

[2] Chester Wardlow, *The Transportation Corps: Responsibilities, Organization and Operations,* UNITED STATES ARMY IN WORLD WAR II (Washington, 1951), p. 14 and docs. therein cited.

and other vehicles, and all take to the road at once.

In one respect truck supply differed from every other type of Ordnance activity: it was suddenly transferred—lock, stock, and barrel—from one technical service to another in the midst of war. On 25 July 1942 War Department Circular 245 formally announced the coming transfer from Quartermaster to Ordnance of responsibility for transport vehicles—research and development, procurement, storage, maintenance, and distribution—virtually everything except the operation of the vehicles, which continued for a time with the Quartermaster Corps and other user arms and services. To see this transfer in proper perspective and to measure its impact on Ordnance we need to review Quartermaster efforts during the 1920's and 1930's to standardize military trucks and in 1940–42 to procure the thousands of transport vehicles needed by the rapidly growing Army.[3]

The Struggle for Standardization

The experience of World War I had clearly revealed the need for rugged Army trucks that could operate over the worst of roads, ford shallow streams, and be easily repaired in the field. It had shown the value of the 4-wheel drive—used mainly in Ordnance vehicles—and the need for a 4-speed transmission, maximum ground clearance, towing hooks and pintles, sturdy bumpers and radiator guards, electric lights, and many other features.[4] But most of all it had shown the need for standardization of Army vehicles and an improved system to provide spare parts for maintenance. The mechanical limitations of the 1917 model trucks were gradually eliminated in the postwar years as production of improved motor vehicles became one of the nation's most important industries, but standardization of parts was a more stubborn problem. Motor Transport officers fought so long and hard for their ideal, as one of them put it, "Standardization became almost a cuss-word in the Army." [5] The history of Army motor transport from World War I to World War II is largely the record of the Quartermaster Corps' unsuccessful efforts to achieve standardization. In the failure of these efforts lie the roots of the spare parts problem inherited by the Ordnance Department in 1942.[6]

[3] The QMC volumes in THE UNITED STATES ARMY IN WORLD WAR II series do not cover this subject except for a brief summary in Erna Risch, *The Quartermaster Corps: Organization, Supply and Services,* Volume I (Washington, 1943), Pages 139–43, but the author is indebted to the QMC Historical Branch for permission to use the manuscript study by Vernon Carstensen, Motor Transport Under The Quartermaster General, 1903–42, copy in QMC Historical Br, and for other assistance.

[4] For discussion of Ordnance vehicle characteristics, see pars. 87–89 of Westervelt Board Report. Development of the Ordnance 4-wheel drive truck is described by L. C. Freeman in *Journal of the SAE* (later the *SAE Journal*), V (1919), 281–87. For opinions of officers opposing use of 4-wheel drive vehicles, see answers to questionnaire described in manuscript entitled World War I by Harry Roberts, pp. 313–16, in OCMH files. The Roberts file is an extensive collection of notes, documents, and draft manuscripts on the history of motor transport.

[5] Address by Lt Col Edwin S. Van Deusen before the metropolitan chapter, SAE, New York City, 19 Feb 42, copy in MTS files, Speeches, P4244. See also Maj. Gen. Edmund B. Gregory, "Army Motor Transport," *Army Ordnance,* XXII, No. 131 (March–April 1942), 731.

[6] For an able review and analysis of the problem by a leading motor transport officer, see Ltr, Col Brainerd Taylor, CO Holabird QM Depot, to QMG, 16 Dec 35, sub: Standardization. . . , QM451 Proc Standardization Policy, NA. Carstensen, *op. cit.,* provides an excellent comprehensive history of the struggle for standardization. There is a collection of Colonel Taylor's articles and speeches in History, Holabird Ordnance Depot, Volume 102.

Quartermaster officers consistently advocated the standardization concept in the postwar years but found their hands tied by Army Regulations and the laws governing procurement. These laws and regulations, as interpreted by the Comptroller General, required that contracts be awarded to the lowest responsible bidder and forbade the QMC to issue detailed engineering specifications for trucks. There was to be no Army truck of special design but only commercial trucks with a few military trimmings. Nor could the Army adopt as standard any vehicle under its trade name. Specifications were limited to such general matters as carrying capacity, speed, and weight; those intended to secure uniformity of design, materials, or dimensions could not be allowed.[7] Each time the Army announced its intention of buying new trucks, scores of manufacturers submitted bids. Nearly every time a different company was the low bidder and got the contract. As a result, the Army continued to add new makes and models to its heterogeneous collection of trucks left over from World War I. These vehicles generally performed well enough but they made maintenance and spare parts supply continuously more complicated.

Purchase of commercial types through competitive bidding was defended on many grounds. It was, for one thing, the accepted way of doing government business, and was designed to guard against favoritism or fraud. It enabled private industry to fill government orders from regular production lines and thus obviated the need for costly, time-consuming retooling of factories to meet special military requirements. In a war emergency, it was argued, speedy production would be more important than perfection of design. The Army would simply buy vehicles it could "pick up on the street." The delay in getting the specially designed Class B truck into production in World War I was cited as an object lesson, as was the Ford Motor Company's experience in shifting from the Model T to the Model A.[8] Finally, competitive bidding was defended on the ground that it enabled the Army to profit from competition among truck manufacturers and thus keep abreast of the latest engineering achievements without carrying on an elaborate research and development program of its own.

While recognizing the validity of some of these arguments, advocates of standardization maintained that the real problem was ease of maintenance in the field, not ease of procurement. They insisted that standardization of parts would speed, not hinder, procurement in an emergency, for it would permit all truck makers to use parts already in production. They contended that the advantages of competitive bidding were far outweighed by the simplification of maintenance and parts supply that standardization would bring. They further asserted that use of commercial types made it impossible for the Army to develop vehicles specially designed to meet military requirements.[9]

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[7] Proposed statement on Proc of Spare Parts for . . . Vehicles, prepared in August 1944 by Lt Col Daniel J. Clifford and Maj J. A. Norman, OHF. See also Carstensen, *op. cit.*, pp. 57–58, and World War I, Roberts file.

[8] (1) Memo, ACofS G–4 for CofS, 2 Feb 32, sub: Rqmts for Motor Transport. . . , G–4/20052-56; (2) Memo, ACofS G–4 for CofS, 10 Jun 32, sub: Rqmts for Motor Transport. . . , G–4/20052-56. For an influential journalistic statement of the case against standardization, see W. F. Bradley, "Automobiles in the Great War—I," *Scientific American Supplement*, No. 2117, 29 Jul 16, and "Automobiles in the Great War—II," *Ibid.*, No. 2118, 5 Aug 16.

[9] The files of the QM Motor Transport Service contain many documents covering the standard-

At the end of the 1920's the Quartermaster Corps attempted to develop a standard fleet by building on its experience with the Class B truck. Although forbidden by law to purchase complete vehicles according to detailed specifications, the Army was permitted to buy vehicle components any way it chose. In 1928, therefore, the QMC decided to buy enough commercial unit assemblies—engines, transmissions, axles, and so forth—to build two complete trucks at its Holabird depot. This was a step toward standardization of vehicles through adoption of standard commercial parts and assemblies, a principle that the Quartermaster Corps was to fight for all during the 1930's.[10] In the next four years Quartermaster engineers studied and tested enough major components and assemblies to make up a standard fleet of eighteen truck chassis designed to cover all Army requirements. These eighteen chassis were divided into five groups, according to size, with all major parts in each group completely interchangeable. Most important, all components could be bought from industry and assembled either at privately owned plants or at Quartermaster motor depots.[11] Here was a workable plan that applied one of the most important lessons of World War I. But, in spite of being ably defended by Maj. Gen. John L. DeWitt, The Quartermaster General, it soon had to be abandoned.[12] It was, for one thing, opposed by the Chief of Ordnance on the ground that it was impractical, would entail too much delay in procurement in time of war, and would not improve maintenance as much as General DeWitt thought it would.[13] The Chief of Staff considered standardization unwise in view of the continuous engineering advances made by industry. Manufacturers of parts liked the Quartermaster plan, but many vehicle manufacturers strongly opposed it.

In September 1933 the views of the vehicle manufacturers triumphed when War Department General Orders No. 9 appeared, virtually forbidding purchase of parts and assembly of vehicles by the Quartermaster Corps. It was followed in the spring of 1934 by a decision of the Comptroller General that further hampered the Quartermaster program by attacking the practice of buying parts for assembly.[14] The prevailing view was that

ization question, as do the QM unclassified files under 451 Standardization. Specific answers to the G-4 memos cited above are in QM 451 Proc Standardization Policy, NA.

[10] In his annual Report for 1930 The Quartermaster General described the standardization plan, listed its advantages, and concluded they were "beyond dispute." The commanding officer of Holabird QM Depot in 1932 hailed it as "the most important step in the advancement of military motor transport that has ever taken place." Col. Edgar S. Stayer, "The Year's Advancement in Military Motor Transport," *Quartermaster Review*, XII, No. 1 (1932), 33.

[11] Memo, QMG for TAG, 5 Oct 31, sub: Standardization of Motor Truck Chassis. . . , QM 451 Proc Standardization Policy, NA.

[12] Special Report of the QMG on Procurement of Motor Transportation for War, Incl to Ltr QMG to ASW, 12 Oct 33, same sub, photostat copy in Roberts file. See also Carstensen, *op. cit.*, wherein much of General DeWitt's correspondence is cited, particularly his Special Report. General DeWitt outlined the plan in *Hearings, WDAB*, H.R., 2 December 1932, 72d Cong., 2d sess., Part 1, pages 214ff. See also Stayer, "The Year's Advancement in Military Motor Transport," *Quartermaster Review*, XII, No. 1 (1932), 33, and Maj. E. H. Holtzkemper, Standardization of Quartermaster Corps Motor Vehicles, n.d., in folder marked Standardization Policy, P4338, OCO-D files.

[13] Memo, CofOrd for Maj Gen George V. H. Moseley, 7 Feb 31, sub: Motor Vehicle Proc Policy, quoted in Carstensen, *op. cit.*, pp. 39–40.

[14] Decisions of the Comptroller General of the U.S., vol. 13 (1933–34), pp. 284ff (A-53405 and A-54540).

the Army should stay out of the business of manufacturing and assembling trucks, and should not carry on any automotive research and development. Appropriation acts in the middle thirties specifically forbade spending money for research on motor vehicle standardization.[15] These measures, backed by political pressure from competing truck manufacturers, not only closed the door on General DeWitt's standardization plans but also locked and barred it. One motor transport officer tartly observed that this government policy was based on belief that "vehicle types and models that fully meet military requirements are not practicable of production in quantity in time of war nor legally procurable in time of peace." [16]

As the Army continued to add to its polyglot fleet, the spare parts problem got completely out of hand. The commanding officer at Holabird reported in 1935 that, "the 360 different models of vehicles now in the Army . . . involve nearly a million items of spare parts which neither the War Department nor any other authority can control." [17] Two years later the Assistant Secretary of War termed the situation "absurd" and blamed Congress for requiring the Army to buy from the lowest bidder.[18] Meanwhile, the German Army adopted a standard fleet which, Motor Transport Division officers believed, was initiated by a German officer who had studied the proposed American standard fleet in 1932. German industry in the 1930's was permitted to produce only those types of trucks that were approved for military use.[19]

When new Army Regulations on the subject appeared in September 1939, just after the outbreak of war in Europe, they declared that procurement of trucks for the U.S. Army would be limited to "models produced commercially by two or more competing companies. . . ." The Army was to use commercial trucks with only a few modifications such as brush guards and towing pintles to fit them for military use. All parts and assemblies were to be standard production items in the automotive industry, but there was to be no specially designed vehicle such as the

[15] H.R. Rpt No. 1215 on H.R. 11897, p. 13, 72d Cong., 1st sess., *WDAB,* 1933. See also MS study by Harry Roberts, The Two-and-One-Half-Ton Truck, p. 10, Roberts file.

[16] Col. Brainerd Taylor, "Military Motor Transport," *Army Ordnance,* XVII, No. 99 (November–December 1936), 156. Colonel Taylor, CO of the Holabird Depot, stated his views at length in a letter to the QMG, 16 December 1935, sub: Standardization. . . , QM 451 Proc Standardization Policy. For similar comments, see lengthy statement by Maj Rex J. Howard, 12 Aug 44, Re Standardization During Last War and Through 1940, copy in OHF. These events are also discussed in Record of U.S. Army Ordnance Combat and Motor Transport Vehicle Spare Parts Policies and Operations from 1940 to 1945 by Lt Col Daniel J. Clifford and Maj Robert O. Alspaugh, OCO-D, Nov 45, copy in OHF.

[17] Memo, Taylor to QMG, 27 Feb 36, sub: Policy on Purchase of Motor Vehicles, quoted in Carstensen, *op. cit.,* p. 59.

[18] Address by Louis Johnson, ASW, to convention of the Motor and Equipment Wholesalers Association, Chicago, 3 Dec 38, quoted in Carstensen, *op. cit.,* p. 69.

[19] (1) Proposed Statement on Procurement Spare Parts for Combat and Wheeled (Tank-Automotive) Vehicles Prepared for Possible Use in Testifying Before Senate Investigating Committee in August 1944 by Lt Col Daniel J. Clifford and Maj J. A. Norman, OCO-D files, P4338; (2) Maj Paul D. Olejar and R. F. McMullen, Motor Transport Vehicles 1940–45, MS study, OCO, 31 Dec 45, pp. 12–14, OHF; (3) Carstensen, *op. cit.;* (4) Roger Shaw, "Mars Motor East," *Quartermaster Review,* XVIII (March–April 1939), 7–10; (5) Roberts, World War I. For a German view, see the article "Commercial Motor Vehicles in War," by W. Kempf, a major in the German Army, *Army Ordnance,* X, No. 59 (March–April 1930), 324.

Class B truck, nor any Standard Fleet.[20] This policy was intended to assure speedy production at the outbreak of war, regardless of the maintenance and spare parts problem that might develop later. To minimize the maintenance problem the War Department limited procurement to five chassis types—1/2-ton, 1-1/2-ton, 2-1/2-ton, 4-ton, and 7-1/2-ton.[21] As a result of this policy, the only thing standardized about Army trucks at the start of the defense period was their size. The door was still wide open for the procurement of dozens of different makes and models.

The Defense Period, 1939–41

In the late 1930's the Quartermaster Corps kept in touch with all the leading manufacturers of cars and trucks through its procurement planning office in Detroit. This office surveyed plants, filed allocation requests with the Army and Navy Munitions Board, and drew up estimates of emergency production. It counted on the "Big Three" of the industry—General Motors, Chrysler, and Ford—to carry most of the wartime load, but also gave attention to other concerns such as International Harvester, Mack, Willys, and American Bantam, and to suppliers of special components such as the Timken-Detroit Axle Company.[22] Only for the latter type of firm did the Detroit office consider plant expansion. It assumed that other plants could easily shift from civilian to military production and could produce all the trucks the Army would need in time of war. With excess capacity throughout the industry in the 1930's there was little reason to believe that some day the automobile plants would have more orders than they could fill. The worst deficiency in this prewar planning proved to be the failure to plan on a realistic basis for mass production of the special components needed for tactical vehicles and for greatly enlarged production of heavy trucks.[23]

From a virtual standstill in the 1920's, truck procurement built up slowly in the 1930's, pushed along at first by measures to counteract the depression. The Quartermaster General reported in 1935 that he had on hand about eleven thousand trucks, most of them left over from World War I, and that nearly sixteen thousand new vehicles had been purchased during the year, mostly for the Civilian Conservation Corps and the Public Works Administration. These were all commercial types with only minor modifications required by the government. After 1935, when Congress declared the World War I vehicles obso-

[20] AR 850-15, 29 Sep 39. "SAE in National Defense," an address by Lt Col Edward E. MacMorland printed in *SAE Journal,* XLVII, No. 1 (1940), 18. See also address by Hon. Robert P. Patterson, ASW, "Motorization Policy of the Army" in *SAE Journal,* XLVII, No. 5 (1940), 18–19.

[21] Ltr, TAG to QMG, 12 Aug 39, sub: Standardization of Motor Vehicles, AG 451 (6–15–39) Misc D. The tonnage figures indicate the approved carrying capacity of the vehicle, not its own weight.

[22] The status of this activity in May 1940 is briefly summarized in Letter, Capt. Clarence E. Jones to Maj. George E. Hartman, OQMG, 4 March 1940, copy in Roberts file. This file contains many letters that passed between the Detroit office and the OQMG on the subject of procurement planning in the pre-1941 years.

[23] Evidence along this line appears in the contractor histories on file in OHF. For example, the request of the Mack Manufacturing Company for an educational order to develop capacity for rear axles and transmissions was denied on the grounds that in time of war Mack would be called upon to build only dump trucks and fire apparatus for the Army. Hist, Phila Ord Dist, vol. 100, pt. 12, pp. 1–2. For a brief review of the immediate prewar situation, see PSP on Prod Plng, 16 Jun 45.

lete, procurement for "remotorization of the Army" was in full swing. In July 1940 it was estimated the Army would spend nearly $60 million for new cars and trucks in the year ahead.[24]

Although these vehicles were not to be of standard design their variety was far less than in World War I. In addition to the 1939 order limiting procurement to five standard sizes, the Quartermaster Corps had taken two other steps to avoid the mistakes of 1917–18. First, it had tried, within the framework of competitive bidding, to keep to a minimum the number of makes and designs, and in 1941 was actually buying only sixteen different makes. Second, it had urged manufacturers to adopt a wide variety of interchangeable small parts such as batteries, spark plugs, generators, fan belts, speedometers, and gas tanks.[25] But the one big step that would have made these efforts really effective was not taken. That was the switch from competitive bidding to the negotiated contract.

By June 1940 the Quartermaster Corps had tested and approved three commercial trucks, the Dodge 4x4, 1-1/2-ton, the GMC 6x6, 2-1/2-ton, and the Mack 6x6, 6-ton.[26] In view of the big procurement program getting under way, it earnestly requested authority to purchase these vehicles from the firms indicated instead of advertising for bids and awarding contracts to the lowest bidder. The purpose, it explained, was "to take advantage of the lessons of motor vehicle maintenance learned from our World War experience," and avert a breakdown of field maintenance in an emergency.[27] But the request was denied. The Assistant Secretary of War recognized the value of standardization but pointed out that there were also other things to consider. He particularly opposed any action that would "give manufacturers a feeling of monopoly as applied to any particular type of truck." [28]

When it enacted Public Law 703 on 2 July 1940 Congress opened the door for the military services to negotiate contracts with firms of their own choosing instead of making awards to the lowest bidder. But

[24] (1) Memo, Brig Gen Richard H. Jordan to QMG, 18 Jul 40, sub: Final Rpt, Transportation Div, copy in Roberts file; (2) Ann Rpts QMG, 1935, 1936, 1937. This period is reviewed in some detail by Thomas E. Downey in draft manuscript prepared for QM Historical Branch, undated, entitled Procurement, pages 19–24, copy in OHF and in OQMG historical file. See also Herbert R. Rifkind, The Jeep—Its Development and Procurement under the Quartermaster Corps, 1940–42 (1943), pp. 43–45, copy on file in Historical Br, OQMG; and testimony of Craig, 24 Jan 39, *Hearings, WDAB*, 1940, H.R. pp. 11–12.

[25] (1) Brig Gen Frank F. Scowden, Lecture, The Quartermaster Corps, 14 Feb 41, ICAF.; (2) Remarks by Brig Gen Joseph E. Barzynski at conf of Corps Area Quartermasters, 28 Jan 41, copy in OHF.

[26] The designation 4x4 meant the vehicle had four wheels and that all four were power driven; 6x6 meant 6 power-driven wheels. The description 4x2 meant that only two of the four wheels were driven, as 6x4 meant that only four of six were driven. For a brief but comprehensive explanation of military automotive terms, see *Handbook of Motor Vehicles Used by the U.S. Armed Forces*, published by the Timken-Detroit Axle Co., Detroit, Mich., 1944, copy in OHF.

[27] Memo, QMG to ASW, 19 Jun 40, QM 451 T-M (Proc FY 41). Representatives of the Infantry, Cavalry, Field Artillery, and Coast Artillery concurred in this request. For another such instance, see PSP on Prod Plng, 16 Jun 45.

[28] 1st Indorsement, 3 Jul 40, to Memo cited in preceding footnote, copy in OHF. See also Carstensen, *op. cit.*, Page 74, and Clifford and Alspaugh, Record of U.S. Army Ordnance Combat and Transport Vehicle Spare Parts Policies and Operations from 1940 to 1945, Pages 109–10. As late as September 1940, the report of a conference in the OASW stated, "It was the consensus of the meeting that advertising for bids should not be abandoned in favor of negotiated contracts." Memo, QMG to ASW, 13 Sep 40, sub: Proc of QM Supplies. . . , QM 400.13 (Proc Program–1941).

the War Department was slow to permit its procurement agencies to exercise this new freedom when buying commercial-type items. More than a year passed after Congress opened the door before the Quartermaster Corps was permitted to cross the threshold.[29] In that delay the last chance to standardize Army trucks for World War II was lost.

Not until the summer of 1941 did truck procurement by negotiated contract come into its own. Even then it was looked upon with some disfavor because it ran counter to the Army's efforts to distribute contracts as widely as possible. It continued as a subject of discussion between Secretary Patterson and The Quartermaster General up to Pearl Harbor. By that time the procurement pattern was set and Army trucks had to remain pretty much what they were. Thereafter it was largely a matter of continuing to procure models already in service.[30]

Getting Production Started

Early in the defense period The Quartermaster General was not in any great hurry to buy new trucks. In May 1940 he proposed that bids for the smaller sizes be held back until September to allow time for testing the new models.[31] Although overruled on this point by the Secretary of War, some months later he reported to a meeting of the Society of Automotive Engineers, "We are buying them gradually to make them available only as rapidly as the divisions and other troop units spring into being." This was done, he explained, to lighten the burden on the automotive industry and "to interfere as little as possible with its regular commercial program." [32] The industry was able to handle without difficulty both civilian and military orders during 1940, but during 1941 the picture changed swiftly. As estimates of future needs rose faster than expected, and also shifted from one type to another, military truck production began to lag behind schedule. From about 30,000 in July 1940, the total number of Army trucks on hand rose to more than 70,000 early in 1941 and exceeded 250,000 by the end of the year.[33] By peacetime standards this was a notable achievement but it was not enough to keep pace with the Army's demands. To ease the drain on scarce materials and speed military production, the Office of Production Management announced in August 1941 a 50 percent cut

[29] PSP on Prod Plng, 16 Jun 45.

[30] (1) Memo, Maj Charles J. Norman for Director, Prod Br, OUSW, 18 Jul 41, ASF Prod Div, Job 19B; (2) OQMG Daily Activity Reports, 27–28 Nov 41 and 5 Dec 41. For an authoritative statement of the delay in adopting negotiated purchasing, see remarks by Col Edwin S. Van Deusen appended to Rifkind, The Jeep—Its Development and Procurement. . . . The matter is also discussed, and numerous documents cited, in incomplete MS on Truck Procurement by Thomas E. Downey in QM Historical Br files.

[31] Memo, QMG for ACofS G–4, 4 May 40, QM 451–T–M (Proc FY 41), photostat in Roberts file.

[32] Maj Gen Edmund B. Gregory, Address to SAE, 7 Jan 41, in Detroit, reprinted in *Quartermaster Review,* XX (January–February 1941), 66–67. The Secretary of War's instructions were issued in Ltr, TAG to QMG, 17 May 40, sub: Purchase of Gen Purpose Vehicles, FY 1941, AG451 (5–15–40) M–D.

[33] Address by Brig Gen Joseph E. Barzynski, asst to QMG, 20 Feb 41, reprinted in *Quartermaster Review,* XX (March–April 1941), 37. Similar figures appear in Scowden, ICAF lecture, The Quartermaster Corps, 14 Feb 41. See also Whiting, Statistics, Proc sec., pp. 38–41; George W. Auxier, Truck Production and Distribution Policies of the WPB and Predecessor Agencies, July 1940–December 1944, WPB Spec Study No. 17, 1946, pp. 14–15, copy in Army Library; and testimony of Patterson before Truman Comm., 15 Jul 41.

in production of cars and trucks for civilian use during the ensuing six months.[34]

After the Assistant Secretary of War ruled in July 1940 that competitive bidding would continue to be the rule and negotiated contracts the exception, the Quartermaster Corps was unable to implement its prewar plans for placing orders with allocated plants. Selection of contractors was determined by the play of competitive forces, rather than by prearranged plan. General Motors, Chrysler, and Ford received the first major contracts. For a brief period in the latter part of 1940 the Ford Motor Company was denied government business because it would not accept the labor policy adopted by the National Defense Advisory Commission (NDAC) and approved by the President, but this barrier was soon removed.[35] Among the more specialized producers were Mack, Federal, Studebaker, Willys, White, Diamond T, Corbitt, Bantam, Autocar, Four Wheel Drive, International Harvester, Yellow Truck and Coach, and Ward LaFrance. Behind these firms—all of whom assembled complete vehicles—were hundreds of parts makers such as Timken-Detroit Axle Company, Bendix Products Division of Bendix Aviation Corporation, Borg-Warner Corporation, Budd Wheel Company, Spicer Manufacturing Corporation, Kelsey-Hayes Company, Hercules Motor Company, and many others.[36]

Critical Components

Most of the production problems of the Quartermaster Corps stemmed from the fact that Army trucks with all-wheel drive required three important components not used to any great extent in commercial trucks—constant velocity joints, transfer cases, and bogie rear axles—and they used two or three times as many driving axles. The constant velocity joint was a device that permitted use of a driving and steering front axle. Intricate in design, its manufacture called for many complicated machining operations and the use of large forgings made to exact specifications.[37] In 1939 only two firms, Bendix Products Division and Gear Grinding Machine Company, produced constant velocity joints, and both had but small capacity. By the

[34] Auxier, WPB Spec Study No. 17, 1946, pp. 3ff. On conservation of rubber and other scarce materials, see PSP on Prod Plng, 16 Jun 45. For a broad survey of the automotive industry's role, see The Automotive Industry in War Production, 10 May 44, typescript by Policy Analysis and Rcds Br, WPB, copy in WPB file PD 033.309 Automotive, N.A. For criticism of the industry's failure to convert more fully to war production, see Additional Rpt of Truman Comm., 15 Jan 42, Rpt No. 480, pt. 5, 77th Cong., 2d sess.

[35] Memo, QMG for USW, 1 Apr 41, sub: Proc Cir 43 WD 1940, QM 451 Proc FY 1941.

[36] *Freedom's Arsenal, The Story of the Automotive Council for War Production* (Detroit, Mich.: Automobile Manufacturers Association, 1950) (hereafter cited as *Freedom's Arsenal*), p. 82. See extensive correspondence between Jones, QM Motor Procurement Planning Office, Detroit, and OQMG in the late 1930's, copies in Roberts file. Contracting procedures are described in Memo, QMG for USW, 9 January 1941, sub: Procurement Activities under the Various 1941 Appropriations, QM 400.13 (Proc Program 1941). Contractor histories in the OHF give detailed data on most of the manufacturers, including contract information, specifications, and rate of production.

[37] For brief description and illustrations of Bendix-Weiss, Rzeppa, Tracta, and helical joints, see Lt. Col. William C. Farmer, *Ordnance Field Guide*, II, 725–31. For detailed discussion of constant velocity joint production, see Memo, Col. Van Deusen for Procurement Contl Div, OQMG, 4 Jan 41, QM 400.13 (Procurement Program, 1914). See also, Memo, QMG for USW, 23, Oct 41, sub: Priorities . . . Constant Velocity Joints, QM 161 M–P (Gear Grinding Machine Company) and Memo, William W. Knight to Knudsen, 16 July 1940, WPB file PD 631.241C. The OQMG Daily Activity Reports and Weekly Progress Reports mention this subject frequently in 1940–41. The achievements of the Chevrolet Division of GMC in producing joints is detailed in History, Detroit Ord Dist, Volume 100, pt. 14.

spring of 1942 three additional firms, Ford, Dodge, and Chevrolet, had come into production and boosted capacity to more than one hundred times what it was in 1939.[38] Transfer cases were sometimes called "power dividers" because they permitted transmission of power from the engine to both front and rear axles. They also required a great deal of gear cutting and machining, and to supply them in quantity several axle and transmission builders pushed their output far above peacetime levels. Bogie rear axles required heavy parts not previously made in any quantity by the automotive industry and also greatly increased the quantities of axles normally used. Before Pearl Harbor the Quartermaster Corps arranged for two leading manufacturers of axles and transmissions —Timken-Detroit and Fuller—to expand their capacity to meet anticipated requirements, but all such expansions took many months to complete.[39]

The largest truck contract awarded in the summer of 1940 went to Chrysler's Fargo Division for more than 14,000 1/2-ton 4x4's. A smaller contract went to Chevrolet for the 1-1/2-ton 4x4. As these vehicles were similar to standard commercial designs, except for the 4-wheel drive, there was no need for new plants or extensive retooling, and both concerns got into production quickly. The chief bottleneck at the start—lack of constant velocity joints—was broken when Chevrolet and Fargo went into production of joints to supplement the output of Bendix and Gear Grinding Machine Company. Licensing agreements were worked out to permit production of the patented items.[40]

Workhorse of the Army: the 2-1/2-Ton

Meanwhile the Quartermaster Corps placed contracts for several thousand 2-1/2-ton 6x6 trucks with the Yellow Truck and Coach Company[41] in accord with earlier plans, and in September 1941 the contracts were greatly increased. When Yellow Truck started production in January 1941 it found that its chief bottleneck was procurement of axles and transfer cases from the Timken-Detroit Axle Company. To meet the demand, Timken had to buy new gear-cutting and gear-grinding equipment, make new patterns and dies, and spend months training additional workers. Other parts manufacturers, notably the Clark Equipment Company, Borg-Warner Corporation, and the E. G. Budd Company also increased their production capacity to keep pace with the Army's truck demands.[42]

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[38] (1) Memo, Col Herbert J. Lawes, OQMG, to OUSW, 23 Oct 41, sub: Priorities. . . , copy in Roberts file; (2) Survey of ASP by QMC Motor Transport Serv, 8 Mar 42, MTS file.

[39] (1) Survey of ASP by QMC Motor Transport Serv; (2) Memo, Maj Ralph G. Boyd to William L. Marbury, SOS, 7 Apr 42, sub: Fuller Mfg. Co., QM 161 M-AL (Fuller), copy in Roberts file; (3) Ann Rpt QMG FY 1942, MTS files, P4233, pp. 65ff; (4) Progress Rpt QMC MTS, 2 Jul 42, P4229. For a discussion of the bogie axle, see Sergeant Morgan O'Connor's "Bogie—The Army's Baby," *Quartermaster Review*, XXI, No. 2 (1941), 22.

[40] (1) Hist, Detroit Ord Dist, vol. 100, pt. 14, Chevrolet; (2) Lt Col Douglas Dow, Draft of Rpt on inspection trip to Detroit and South Bend, 1–9 Oct 40, copy in Roberts file. For a detailed account of the 1-1/2-ton truck, see The Design, Development, and Production of Trucks and Semi-Trailers, Ord PP 47, Oct 44, pp. 21–26, OHF. The Fargo negotiations are described in detail in Downey, *op. cit.*, pp. 50ff, as are patents, pp. 70ff.

[41] Yellow Truck and Coach was an independent company until 1943 when it was taken over by General Motors Corporation and became the General Motors Truck and Coach Division. Its plant was at Pontiac, Mich.

[42] Dow, *op. cit.* For a tabulation of contracts by number, amount, date, type, and cost, see Procurement of Motor Vehicles.

The 2-1/2-ton truck, a military adaptation of a commercial model, was an immediate success and remained unsurpassed as a general purpose vehicle throughout the war. "I have seen nothing belonging to our enemies or our Allies that can compare with it," wrote one combat observer.[43] The most widely used truck in the Army's fleet, it could carry on good roads far more than its rated capacity and soon earned the nickname "workhorse of the Army." Its six driving wheels were mounted on three axles, each having its own differential. Power could be applied to all six wheels for steep hills or rough cross-country travel, or the front axle could be disengaged on smooth highways.[44]

The demand for the 2-1/2-ton was so great by the end of 1941 that it ranked as the most serious production problem in the entire truck program. As Yellow Truck could not handle it alone the Quartermaster Corps turned to the Studebaker Company to augment the supply; later two smaller producers—Reo and International Harvester—came into the picture. At first the plan called for Studebaker to make an exact copy of the Yellow model, but this idea was dropped because it would delay the start of production and would cost several million dollars for new tooling. Although most components of the model built by Studebaker were identical with those in the Yellow version, many parts were not interchangeable. For example, Studebaker used engines made by the Hercules Motor Company of Canton, Ohio, while Yellow Truck made its own engines. No serious difficulties developed in this score because the Studebakers were shipped to lend-lease countries—chiefly the Soviet Union, which received over 100,000—and the Yellow models were issued to the U.S. Army.[45]

Heavy-Heavy Trucks

While the largest orders were going for light, medium, and light-heavy vehicles, the smallest orders went for so-called heavy-heavy trucks capable of carrying payloads of from four to six tons.[46] Officers of the Motor Transport Division were convinced that in time of war the Army might find itself operating a long-distance trucking service over improved roads as well as conducting the usual short, cross-country tactical movements. For long hauls the big trucks, labeled strategical vehicles by Motor Transport officers, would be needed in quantity. But the using arms were not interested in such trucks in 1940–41. The Quartermaster Corps was permitted to place a few orders with Mack, Federal, Corbitt, White, and Diamond T, but the quantities were in the hundreds rather than the thousands. This failure to recognize the importance of heavy trucks later proved to be one of the most costly mistakes of the prewar and early war years.[47]

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[43] Lucas quoted in Memo, CG ASF for Deputy CofOrd, 10 Sep 43, sub: Rpt on Motor Vehicles in Sicilian Campaigns, OO 451/2038.

[44] For description of performance, see O'Connor, "Bogie—The Army's Baby," *Quartermaster Review*, XXI, No. 2 (1941), 22, 107. The 2-1/2-ton truck was also built in 6x4 and 4x2 types, but the great majority of the 2-1/2-ton vehicles were 6x6's.

[45] (1) Anticipated Production Difficulties—QM Vehicles for Delivery in 1942, 24 Jan 42; (2) Olejar and McMullen, Motor Transport Vehicles, 1940–45, pp. 49–54; (3) PP 47, pp. 27–32; (4) Roberts, The Two-and-One-Half-Ton Truck; (5) Stat Work Sheets, 1 Sep 45, final rpt in series by Engr and Mfg Div, OCO–D.

[46] Light trucks had capacity for 1 ton or less; medium for 1-1/2; light-heavies for 2-1/2; and heavy-heavies for more than 2-1/2.

[47] See ch. XIII, sec. on Heavy-Heavy Trucks, 1943–44. This matter is clearly illustrated in History, Mack Manufacturing Corporation.



ASSEMBLING 2½-TON TRUCKS *at Ford Motor Company plant in Antwerp, Belgium, December 1944.*

The Versatile Jeep

The only really new vehicle to come into the picture in 1940 was the 1/4-ton 4x4 truck, better known as the jeep. The Army, which had begun to think about such a vehicle in the 1930's as a fast reconnaissance car, focused its attention in the summer of 1940 on a lightweight car built by the American Bantam Car Company of Butler, Pennsylvania.[48] After representatives of the Ordnance Technical Committee visited the Bantam plant and studied its product, seventy of the Bantam cars were purchased for testing purposes. Built to Army specifications, these cars were purely military vehicles. Only eleven feet long and three feet high, they weighed about two thousand pounds but had plenty of power, stamina, and maneuverability.[49]

After successful tests of the Bantam vehicles the Army was ready to buy jeeps in quantity, and directed The Quartermaster General to procure 1,500 from Bantam. But Maj. Gen. Edmund B. Gregory was

[48] For the early history of the jeep, see Rifkind, The Jeep—Its Development and Procurement Under the QMC, 1940–42. Supporting documents for this study are in OHF. See also Lt. Eugene P. Hogan, "The Story of the Quarterton," *Quartermaster Review,* XXI, No. 2 (1941), 53ff. The name "jeep" was originally applied to the 1/2-ton 4x4 truck, and the 1/4-ton vehicle was at first dubbed "peep." When the 1/2-ton truck was discontinued the smaller vehicle became the "jeep." One theory is that the name "jeep" came from a slurring of the letters GP used to designate general purpose vehicles, and another is that it came from a comic strip character created by E. C. Segar.

[49] Rpt Subcomm. on Auto Equipment to The Ord Comm., 22 Jun 40, sub: Light Infantry and Cavalry Vehicles, and Indorsements, copy in Rifkind notes on jeep, OHF.

reluctant to place the entire order with Bantam, describing it as "a small firm with no productive facilities of any importance." [50] As Willys and Ford had meanwhile shown considerable interest in producing such a vehicle, and were then building pilot models, the Quartermaster Corps was permitted to place a contract in November with Bantam for 1,500 jeeps and soon thereafter to make similar awards to Willys-Overland and Ford.[51] These were negotiated, not competitive bid contracts, and were concurred in by the National Defense Advisory Committee, subject to delivery of acceptable pilot models by Ford and Willys. When Bantam protested bringing in other concerns that had not shared in the earlier work, and allowing them to observe the Bantam model, the Quartermaster Corps replied that it preferred to have more than one company share in this stage of design and development and be ready to produce in time of war. Protests came also from pro-labor interests who pointed out that the Ford Motor Company had been repeatedly charged with violations of the Wagner Act. In newspapers, magazines, and Congressional committees the arguments raged for some time, but the contracts remained in force.[52]

After rigorous tests of Bantam, Willys, and Ford jeeps—tests that revealed structural weaknesses in all three and led to many design changes—the Willys jeep was standardized. When the QMC was authorized to procure sixteen thousand it called for bids on an all-or-none basis. Although Willys submitted the lowest bid, by a narrow margin, the QMC preferred Ford as a larger and more dependable producer and recommended that it be given the contract. But when the Office of Production Management refused to go along with this recommendation the contract went to Willys.[53] The order was not split up among the three potential producers because it was desired that all jeeps be of identical make, and Motor Transport officers argued there was no time to arrange for identical production by two or more firms. But a few months later, when Willys proved unable to keep pace with fast-mounting requirements, another producer had to be added. A contract then went to Ford to produce jeeps exactly according to Willys blueprints. Willys turned over to Ford copies of its drawings, specifications, and patents, and for the rest of the war

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[50] Memo, QMG for Brig Gen Richard C. Moore, Deputy CofS, 6 Nov 40, QM 451 (Proc 398-41-9), copy in Rifkind notes. See also testimony of Col Edwin S. Van Deusen and John D. Biggers before Truman Comm., Aug. 6, 1941, 77th Cong., 1st sess., pp. 1978ff.

[51] For discussion of Bantam production, see memo, Curley, consultant, for Col Sidney P. Spalding, 25 Apr 41, sub: Status of Prod . . . at Bantam . . . , ASF Prod Div 451.2 Motor and Auto Trucks, Job 19B. See also testimony of Francis H. Fenn, president of Bantam, in *Hearings,* Truman Comm., Aug. 6, 1941, 77th Cong., 1st sess., pt. 7, pp. 1967ff; also, Van Deusen, pp. 1978ff and Biggers, pp. 2067ff. An excellent summary of these events appears in *Federal Trade Commission Decisions, 1947-48* (Washington, 1950), vol. 44, pp. 572-90.

[52] (1) Ltr, Charles H. Payne, American Bantam Car Co., to SW, 14 Oct 40, QM 451 (Proc 398-41-9); (2) Articles by I. F. Stone in *PM,* December 14 and 30, 1940 and January 24, 1941, copy in Rifkind notes; and in *The Nation,* December 30, 1940, quoted at length in Rifkind, pp. 77-80; (3) Proceedings of Motor Transport Sub-Comm. QM Tech Comm., 18 Oct 40, QM 451 (Proc 398-41-9), copy in Rifkind notes; (4) Ltr, Dow, OQMG, to ASW, 20 Dec 40, sub: Contract No. W398-qm-8887 . . . , QM 161 (Ford), copy in Rifkind notes, OHF.

[53] Ltr, QMG to CO Holabird QM Depot, 1 Aug 41, sub: Award under Informal Request for Bids . . . with 12 incls, QM 451-M-P (Proc 398-42-NEG-1). See also Interim Gen Rpt, H.R. Comm. on Mil Affairs, Jun 23, 42, Rpt No. 2272, 77th Cong., 2d sess., pp. 285-87.



JEEP, ¼-TON 4 x 4 TRUCK, *on display during a talk given to the employees of Willys-Overland Motor Company by Brig. Gen. Burton O. Lewis.*

the two firms turned out thousands of jeeps with interchangeable parts. Both firms, it should be noted, bought many of their major components from the same sources—frames from Midland Steel, wheels from Kelsey-Hayes, axles and transfer cases from Spicer, and so on. Both companies also contributed to developing and improving the jeep throughout the war.[54]

Award of the contract to Ford excluded Bantam from the picture entirely and thus denied to the firm that had pioneered the vehicle any share in its wartime production. Bantam was later given a contract to produce small trailers, but it built no more jeeps for the Army. Enlistment of big producers was defended on the ground that Bantam could never have turned out jeeps in the quantities needed for World War II. From a production viewpoint this decision may have been sound but it brought upon the Army a great deal of criticism that might have been avoided if Bantam had not been entirely excluded from jeep production.[55]

[54] For an excellent brief summary of the early contract awards and the reasons for them, see Memo, Chief MTD Legal Sec for chief, MTD, 27 Mar 42, sub: American Bantam Motor Car Co., Rifl ind notes.

[55] Rifkind discusses the controversy over award of the jeep contracts in detail, and his notes contain copies of pertinent documents. The subject was also reviewed by the Truman Commmittee in August 1941 and by the House of Representatives Military Affairs Committee, Interim General Report, June 23, 1942, Report 2272, 77th Congress, 2d session. See also (1) Hist, Detroit Ord Dist, vol. 114 (Ford); (2) The Automotive Industry in War Prod, 10 May 44; (3) PP 47, pp. 1–10; (4) Nelson, *Arsenal of Democracy*, pp. 177–78; and (5) A. Wade Wells, *Hail to the*

As the jeep skyrocketed to world-wide fame controversy naturally arose as to its genesis. In the keenly competitive automotive industry, where all companies had their eyes on the postwar market, the rivalry was intense. Willys-Overland advertisements claimed that its engineers, working with their counterparts in the Army, "created and perfected the jubilant Jeep." Bantam naturally resented these claims which seemed to add insult to injury. Soon the Federal Trade Commission entered a formal complaint against Willys. After extensive investigation the FTC eventually—in 1948—ruled that the Willys advertisements constituted unfair methods of competition, and issued a "cease and desist" order. Willys had indeed designed and built the model of jeep used in World War II, but Bantam and the Army had laid the groundwork for Willys' success.[56]

As to the proper division of credit within the Army there was no dispute between the Quartermaster Corps and Ordnance. After transfer of motor transport to Ordnance, General Campbell sent to General Gregory the following forthright statement about the jeep:

All of us in the Ordnance Department fully realize that this vehicle was developed and put into production by the Quartermaster Corps prior to the time when Motor Transport was transferred to the Ordnance Department on August 1, 1942. None of the credit for this achievement belongs to the Ordnance Department and it would be presumptuous on our part ever to allow a shadow of doubt on this point. . . . It is a very remarkable achievement for which the Quartermaster Corps, and those who worked for or with it, are entitled to credit. We of Ordnance join with all your other friends in giving this credit completely and gladly.[57]

A few months after this letter was written, one of the original Bantam jeeps took its place beside other historical properties in the halls of the Smithsonian Institution in Washington, and the word "jeep" appeared in the newer dictionaries as a war-born addition to the English language.[58]

Production Lag

All during the defense period truck production in one category or another lagged behind requirements. As early as October 1940 nearly a third of all vehicles due for delivery were behind schedule.[59] They continue to lag behind during the winter, and in March 1941 the Office of the Under Secretary of War called the matter to the attention of The Quartermaster Gen-

Jeep (New York: Harper & Brothers, 1946); (6) Additional Rpt of the Mead Comm., S. *Report* No. 110, pt. 7, 79th Cong., 2d sess., p. 7, 1946.

[56] (1) FTC Docket No. 4959, 6 May 43; (2) *FTC Decisions*, vol. 44 (Jul 47–Jun 48) p. 590. For the claim of Lt Col Homer G. Hamilton, see H.R. *Report* No. 1045, 82d Cong., 1st sess., and H.R. *Report* No. 290, 83d Cong., 1st sess. For a journalistic account giving chief credit to the Army for development of the jeep, see "Jeep at Any Price," *Time*, June 28, 1943, pp. 84–86.

[57] Quoted by Maj. Eugene P. Hogan, "The Jeep in Action," *Army Ordnance*, XXVII, No. 146 (September–October 1944), 271.

[58] An amphibian jeep was developed but not widely used, and some effort was devoted to an extra-light airborne model. For the amphibian, see extensive correspondence in OO 451.2/1301–1420; OCM 20771, 17 Jun 43; Progress Report, QMC MTS, 2 July 1942, Pages 10–12; and Rifkind's notes. Both types are discussed in PP 47; History, Detroit Ordnance District, Volume 114; Report on Design, Development, Engineering, and Manufacturing. . . , 14 October 1944, OCO-D, OHF; and Baxter, *Scientists Against Time*, Chapter XVI.

[59] Memo, Lt Col William C. Young for Spalding, OASW, 31 Oct 40, in ASF Prod Div file 451–2 Motor and Auto Trucks. This memo itemizes all vehicles on contract to each manufacturer and shows quantity due and quantity delivered to date.

eral, urging action to bring deliveries more nearly into line with the Time Objective.[60] In July 1941 Patterson complained that the automotive industry had "hardly been touched by the rearmament effort" and urged that steps be taken to put munitions ahead of pleasure cars.[61]

Of the many reasons for the lag in production, most were beyond control of the QMC. Requirements kept rising with every new estimate of Army needs; priorities for trucks remained low; steel and rubber were scarce; productive capacity for certain items was limited; and labor unrest slowed production in some plants.[62] The program lacked momentum because the Quartermaster Corps had not pushed forward toward big procurement in 1940. Manufacturers of bottleneck items—chiefly axles, transmissions, and transfer cases—were induced to enlarge their capacity and help meet the demand, but the QMC could not do much about the remaining problems, for they were fundamental to nearly every phase of war production. As this condition dragged on through 1941, dissatisfaction accumulated both in the QMC and the Office of the Under Secretary. "For the past two years," wrote the chief of the Procurement Control Branch to General Gregory three days after Pearl Harbor, "it has been known that there were important bottlenecks limiting the procurement of tactical motor vehicles. This problem has been attacked in a piecemeal fashion from time to time with only limited success. . . . It is felt that an overall approach to a solution is long overdue. . . ." [63]

The First Year of War

Pearl Harbor put an end to piecemeal attacks on the whole problem of industrial mobilization. Beginning in January 1942, the nation took drastic measures on all fronts to convert to all-out war production. And the automotive industry in Detroit dramatically symbolized the whole process. The newly created War Production Board moved promptly and decisively in January to issue orders banning further production of motor cars and trucks for civilian use.[64] The cars and trucks already on the road or in the stockpile would have to last until the Army's needs were met.[65]

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[60] Memo, USW for QMG, 6 Mar 41, sub: Proc of Motor Vehicles, ASF Prod Div file 451.2 Motor & Auto Trucks.

[61] Memo, USW for Brig Gen Rutherford, 10 Jul 41, ASF Contl Div file 400 Time Objective, dr 47. See also Ltr, President to SW, 9 Jul 41, same file.

[62] (1) Memo, Maj Charles Norman for Director Prod Br, OUSW, 18 Jul 41, sub: Proc of Motor Vehicles, ASF Prod Div Job 19 B; (2) Memo, QMG for USW, 20 Aug 41, sub: Prod Rates and Time Objective, ASF Prod Div, Job 19 B. The QMG Daily Activity Reports in 1941 contain countless references to strikes and threats of strikes, and the annual Report of the QMG for FY 1942 reviewed the difficulties encountered.

[63] Memo, Chief Proc Contl Br for Gregory, 10 Dec 41, sub: Critical Order Situation of Constant Velocity Joint Suppliers, QM 451.01 PC-Proc. For expression of the USW's dissatisfaction, see Memo, USW for QMG, 19 November 1941, sub: Production of Motor Vehicles, ASF Prod Div file 451.2 Motor and Auto Trucks, Job 19 B. See also the lengthy discussion in 1942 Motor Transport Procurement Program—Anticipated Production Difficulties, 25 January 1942, MTS files P4228. For a summary of the situation as of November 1941, see Memo, Col. Doriot for John D. Hertz, 14 November 1941, copy in Roberts file.

[64] Auxier, Truck Prod and Distribution Policies of the WPB and Predecessor Agencies, Jul 40–Dec 44, p. 17 citing General Limitation Order L–I–C and L–3–a, both dated 1 Jan 42. See also Operations Rpt of WPB Automotive Div, 26 Dec 42, WPB 053.108 NA. Trucks in the hands of manufacturers and dealers were frozen temporarily and then rationed to war industries. Production of special types of civilian trucks was permitted later.

[65] For a critical analysis of the results of this policy, see *Report,* Truman Comm., 78th Cong., 1st sess., S. *Report* No. 10, pt. 13, 15 Dec 43, pp. 18–25.

"America's major industry died in Detroit last week," one news magazine commented.[66] But the industry did not really die. It merely shifted from peace to war production—the greatest model changeover in its history. When the War Production Board ruling freed the entire industry for conversion to munitions making, confidence ran high in its capacity to meet the challenge of war. "When Hitler put his war on wheels," General Somervell observed after a tour of Detroit industries, "he ran it straight down our alley." [67]

Production Problems

But behind the scenes the stubborn, hard problems of production were still there.[68] No magic wand or government decree could banish materials shortages or rearrange production lines overnight. Rubber, aluminum, steel, and canvas duck were still in short supply, and production of constant velocity joints and various types of bearings was far below the required level. To deal with these bottlenecks and speed the conversion process, leaders of the industry early in 1942 formed the Automotive Council for War Production, headed by Alvan Macauley of Packard.[69] In March, when the Army was reorganized at the top, the newly formed Army Service Forces set to work drafting an Army Supply Program (ASP) that called for production of more than three million vehicles of all types by July 1944—nearly one million in 1942, over one million in 1943, and over one million in the first six months of 1944. Quantities of light trucks in this program, although much greater than the mid-1941 requirements, were not beyond the industry's capacity, judging by its 1939 production. The hitch lay in ASP emphasis on heavy trucks, those that carried two tons or more. In 1939 heavy trucks constituted only 7 percent of the year's annual production, light trucks 93 percent. But ASP required roughly 50 percent heavy and 50 percent light.[70]

In May 1942 the Quartermaster Corps submitted a detailed report showing that industrial capacity for light trucks was more than adequate to meet the ASP, but that capacity for heavy trucks, although already expanded 600 percent since 1940, was far below the required level.[71] It further reported that the shortage of rubber might force a one-third cut in the Army Supply Program and that lack of strategic metals was a constant drag on the produc-

[66] *Newsweek,* February 9, 1942, p. 42. For a reflection of industry views, see articles in *Business Week* with titles such as "Car Dealers Weep," "Detroit's War Load," and "Autos—No. 1 Conversion Job."

[67] Quoted in *Freedom's Arsenal. The Story of the Automotive Council for War Production,* p. v. For a pictorial story of the changeover in a typical plant, see the yearbook of the automotive industry, *Automobile Facts and Figures 1942* (Detroit, Mich.: Automobile Manufacturers Association, 1943), pp. 32–33.

[68] For discussion of the outlook early in 1942, see 1942 Motor Transport Procurement Program —Anticipated Production Difficulties, and Van Deusen, Speech, 19 February 1942, before SAE. An informative article written from the industry viewpoint is E. L. Warner, Jr., "What Uncle Sam Expects of the Automobile Industry," *Automotive Industries,* vol. 36, No. 2 (January 15, 1942), p. 17.

[69] *Freedom's Arsenal* describes the history of this council in detail. See also *Automobile Facts and Figures, 1942;* Hist, Detroit Ord Dist, vol. 116; and Harold Titus, "Goodby, Bottlenecks," *Saturday Evening Post,* November 21, 1942, p. 16.

[70] (1) Ann Rpt QMG, FY 1942, p. 69; (2) Auxier, *op. cit.,* p. 4; (3) Survey of ASP by QM MTS, 8 May 42.

[71] Survey of ASP by QM MTS. 8 May 42. See also the earlier report titled Anticipated Production Difficulties—QM Motor Vehicles for Delivery in 1942, 24 Jan 42, and the later report, Progress Rpt QMC MTS, 2 Jul 42.

tion machine. "Motor Transport Service production schedules are almost daily being drastically interrupted by the uneven and insufficient flow of almost every type of metal product," wrote The Quartermaster General. With scarce metal going into high priority Navy and Air Force items, Motor Transport Service[72] had had to get along as best it could with an A-1-i or A-1-f rating throughout 1941. It did not get up even to an A-1-c until after Pearl Harbor, and on several occasions automotive plants had to shut down temporarily for lack of materials.[73]

What was needed to correct the situation? Nearly everything, it seemed. Further expansion of facilities to make axles, transfer cases, constant velocity joints, transmissions, and other parts was high on the list. This meant collateral expansion of forging and machining capacity and depended entirely on a better supply of both steel and machine tools. Machine tools formed a narrow bottleneck because QMC requests for them went into a miscellaneous classification to which only 8 percent of all machine tools were allotted.[74] Speedy production of synthetic rubber was also called for, along with strict economy in the use of existing tires and other rubber products. Deliveries of needed steel had to be assured; and, to reduce consumption, cargo bodies had to be made of wood instead of steel. Finally, the QMC recommended that, in view of the difficulties ahead, the whole ASP should be restudied with a view toward reducing requirements for heavy trucks.[75]

The Transfer to Ordnance

While the QMG was recommending restudy of truck production goals, and industry was building new plants for producing bottleneck items, General Somervell's staff was considering a drastic realignment of motor transport responsibilities. The impetus for change came originally in the area of maintenance, not procurement. As early as November 1941 the Hertz report had revealed glaring abuses in maintenance of Army trucks by the using arms and had recommended that Motor Transport Service be given independent status and full authority to enforce maintenance discipline.[76] The movement for creation of an independent automotive corps to handle maintenance for both combat and transport vehicles gained considerable support during the winter of 1941-42 but was strongly opposed by both The Quartermaster General and the Chief of Ordnance. As the discussion continued, an alternative idea gained ground, to concentrate all responsibility, including

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[72] The Motor Transport Division was renamed Motor Transport Service in April 1942.

[73] (1) Survey of ASP, 8 May 42; (2) Ann Rpt QMG FY 42, p. 70; (3) Desk Book of Statistics, Maj S. B. Robinson. In June the MTS requested the War Production Board to study the problem of expanding production facilities and come up with recommendations. Ltr, QM MTS to WPB, 12 Jun 42, sub: Expansion of Prod Facilities, MTS file, P4229. For examples of plant shutdowns, see Incl to Memo, QMG for ACofS Matériel, SOS, 27 Jul 42, sub: Efforts Made by MTS to Maintain Truck Production. . . , SPQMC 411.5 (Steel).

[74] Progress Rpt QMC MTS, 2 Jul 42, p. 30.

[75] (1) Survey of ASP by QMC Motor Transport Serv, 8 May 42; (2) Ann Rpt QMG FY 1942, pp. 65-80; (3) Progress Rpt QMC MTS, 2 Jul 42. As early as mid-May the requirements for Defense Aid vehicles were cut. See OQMG Daily Activity Rpt, XI, No. 15.

[76] Summary of Motor Maintenance Activities in the U.S. Army, Incl to Ltr, Hertz to USW, 18 Nov 41, copy in OHF. See also comments on this report by Brig. Gen. Brehon B. Somervell (then G-4, WDGS) in Memo for CofS, 7 Jan 42, Somervell files, folder ASF Automotive Serv 1941-42.

research, procurement, and maintenance, for both tanks and trucks either in the Quartermaster Corps or Ordnance. This would achieve the desired unification without creating a new command in the middle of the war. With manufacture of both tanks and trucks depending on the automotive industry for many components—engines, transmissions, axles, and so on—ASF decided to put an end to the unnatural division of responsibility by making Ordnance the sole channel for dealing with the industry. General Somervell issued orders to this effect in mid-July with the first of August 1942 as the effective date. No adequate explanation for the choice of Ordnance over the Quartermaster Corps has ever been given.[77]

Along with the shift of construction from the Quartermaster Corps to the Corps of Engineers, this was one of the two largest transfers of functions among the technical services during World War II. It caused the shift to Ordnance of thousands of civilians, officers, and enlisted men, along with the motor bases, motor supply depots, and automotive schools they operated. The chief of the Motor Transport Service, Brig. Gen. James L. Frink, did not make the transfer, preferring to remain with the Quartermaster Corps, but most of the others joined forces with Ordnance. General Campbell, who had opposed the move originally, made it clear that he welcomed the MTS personnel and would tolerate no discrimination against them.[78] But it was inevitable that they should feel for a long time like strangers in a strange land.

On the procurement side the transfer brought to Ordnance some 4,000 contracts with a total value of nearly $3 billion. And it led to a far-reaching organizational change within Ordnance—establishment of the Tank-Automotive Center in Detroit. The T-AC, as it was called, was formed by moving the QM Motor Transport Service and the Ordnance Tank and Combat Vehicle Division from their offices in the Washington-Baltimore area to the Union Guardian Building in Detroit where they joined up with small Quartermaster and Ordnance units already there.[79]

By the time Ordnance took over motor transport the worst of the production crisis was past.[80] Many difficulties remained, and new problems were to come up later, but the sky-high requirements of the original ASP had dropped considerably, and were soon to drop more.[81] Production of bottleneck items was steadily increasing, and the trend toward procurement of more and more different types of vehicles had been halted.[82] The War Production

[77] (1) Ltr, CG SOS to CofOrd, 17 Jul 42, sub: Transfer of Motor Transportation. . . , OO 020/47; (2) WD Cir 245, 25 Jul 42, sub: Transfer of Motor Transport Activities, par 10, as amended by WD Cir 267, 8 Aug 42; (3) ODO 315, 28 Jul 42, sub: Transfer of Motor Transport. . . , copy in OHF. The QMC version of the transfer is to be found in Risch, *The Quartermaster Corps,* Volume I, pp. 19–22, and in Carstensen, Motor Transport Under Quartermaster General, 1903–42, pp. 167–81; the ASF version is found in Millett, *Organization and Role of the Army Service Forces,* p. 302. The Carstensen version is the most detailed and comprehensive account extant. Lt. Gen. Levin H. Campbell's views are expressed in a personal letter to Thomson, 31 August 1955, OHF.

[78] Ltr, Campbell to Thomson, 31 Aug 55, OHF.

[79] Intervs with Generals Glancy, Christmas, and Armstrong, and Col E. S. Van Deusen, summer 1949. See ch. XI, above. For further details on the T-AC organization, see Green, Thomson, and Roots, *Planning Munitions for War,* Chapter IV, and references therein cited.

[80] Prod Analysis Notes for Oct 42, by Plng Sec, Mfg Br, T-AC.

[81] See Progress Rpt QMC MTS, 2 Jul 42.

[82] (1) Ltr, TAG to CG SOS and others, 6 Apr 42, sub: Standardization of Wheeled Motor Vehicles. . . , AG 451 (4-4-42) MO-SP-M; (2) Ltr, TAG to CG SOS and others, 8 Jun 42,

Board and the Army and Navy Munitions Board had clarified the priority ratings on steel, and the automotive industry had made rapid progress in converting from steel to wooden cargo bodies.[83] Steel, rubber, copper, and machine tools were still in short supply, but a production report prepared by Ordnance in October showed most vehicles to be on schedule or just a little behind schedule. The very heavy trucks, four tons and over, were running well ahead of requirements.[84]

Development work was also nearly complete by the time motor transport came to Ordnance, and definite steps had been taken to freeze existing models. In June 1942, after the 1/4-ton jeep had been adopted and the 1/2-ton truck had been eliminated in favor of the 3/4-ton, the Secretary of War had issued orders standardizing the following eight chassis, all then in production:

1/4-ton, 4x4	Willys and Ford
3/4-ton, 4x4	Dodge
1-1/2-ton, 4x4	General Motors
2-1/2-ton, 6x6	General Motors
4-ton, 6x6	Diamond T
4–5-ton, 4x4	Diamond T
5–6-ton, 4x4	Diamond T
6-ton, 6x6	White, Corbitt, and Brockway

The Secretary of War had further declared that all development, procurement, and standardization of wheeled vehicles would be co-ordinated by the QM Technical Committee in accordance with AR 850–25. Existing contracts for nonstandard equipment were to be completed but not renewed or extended.[85]

The Dukw

The most important new vehicle to come into production during the period of Ordnance control—though ordered by the QMC—was the 2-1/2-ton amphibian. In the spring of 1942 the QMC turned over to the National Defense Research Committee responsibility for developing a swimming truck to carry supplies from ship to shore. Landing cargo quickly at overseas destinations, right on the beach without benefit of piers or heavy cranes, was a crucial problem for the Allies in 1942. But ASF was cool to the idea of taking on a new and possibly impractical type of special vehicle. Nevertheless NDRC, working

sub: Standardization of Wheeled Vehicles. . . , AG 451 (6–5–42) MO–SPOP–M; (3) PSP Prod Plng, OCO–D, 16 Jun 45.

[83] (1) Memo, CG, SOS, for QMG, 7 Aug 42, sub: Efforts Made by MTS to Maintain Truck Prod . . . , SPQMP 411.5 (Steel); (2) Survey of ASP by QMC MTS, 8 May 42; (3) Progress Rpt by MTS, 2 Jul 42; (4) Ann Rpt QMG FY 42, pp. 65ff; (5) Ltr, CG ASF to CofOrd, 4 Aug 42, sub: Wood Bodies for Cargo Trucks; (6) WD Press Release, Army Saves 275,000 Tons of Steel Annually . . . , 18 Jun 42, copy in OHF; (7) SOS Ann Rpt FY 1942, p. 49; (8) History, Ordnance Industry Integration Committee for Wood Cargo Bodies, OHF.

[84] Production Planning Report based on ASP, 15 Oct 42, vol. 8, copy in Roberts file. Compare with Status of Procurement–Transportation, Volume XXXVIII, 8 December 1941, QM Statistics Br, P4236, showing 12 out of 23 items behind schedule, and the Survey of ASP, by MTS, 8 May 42, which recommended deep cuts in the ASP. The improved situation as of mid-1942 is outlined in Progress Report—QMC MTS, 2 Jul 42, pp. 2–8. Detailed requirements for 1943 are to be found in Truck Requirements 1943, October 1942, prepared by Automotive Branch, WPB, and in Master Schedule, 25 November 1942, prepared by Ordnance Industrial Division, both in OCO–D file.

[85] Ltr, TAG to CG, AGF and others, 8 Jun 42, sub: Standardization of Wheeled Motor Vehicle Chassis and Trailers, AG 451 (6–5–42), MO–SPOP–M. This letter rescinded an earlier letter on the subject, dated 6 April 1942, AG 451 (4–4–42), MO–SP–M. See also Ann Rpt QMG, FY 42, pp. 65ff.



DUKW, 2½-TON AMPHIBIAN TRUCK, *leaving the water with cargo, Noumea, New Caledonia, April 1943.*

closely with the New York firm of naval architects, Sparkman and Stephens, Inc., and the Yellow Truck and Coach Manufacturing Company, soon produced a pilot model that performed so well in tests that several hundred were ordered.[86]

The new swimming truck took its nickname, Dukw or Duck, from its amphibious qualities and from its manufacturer's code —D for 1942, U for utility, K for front-wheel drive, and W for two rear driving axles. It consisted of a watertight body on a 2-1/2-ton truck chassis. Thirty-six feet long and eight feet wide, it could accommodate fifty men or an equivalent load of supplies. While on land it used its six driving wheels and conventional steering gear; in the water it used a marine propeller and a rudder. To avoid getting stuck while entering or leaving water the driver could shift controls to provide both wheel and propeller drive. Standardized by Ordnance in October 1942, the Dukw was used successfully at Noumea in March 1943, and by General Patton's Seventh Army in its attack on Sicily a few months later. General Eisenhower reported the Dukw to be "invaluable." [87]

[86] The NDRC phase of the development, as well as the Army's—and Navy's—lack of interest in the Dukw, are presented briefly in Baxter, *Scientists Against Time,* Chapter XVI, and in far greater detail in *Summary Technical Report of NDRC, Division 12, Transportation Equipment and Related Problems* (Washington, 1946), Chapters 3 and 4. See also Milton Silverman, "Three Men in a Dukw," *Saturday Evening Post,* Volume 218, Number 42 (April 20, 1946) and An Account of the War-Time Activities of GMC Truck and Coach Division of General Motors Corporation, 1945, OHF. An 11-page account of the Dukw's history written in February 1944 may be found in RCS 19, Transportation Corps Historical Program file, Amphibian Vehicles in World War II.

[87] (1) OCM 18950, 1 Oct 42; (2) OCM 19059, 22 Oct 42; (3) Col. Edwin S. Van Deusen, "Trucks That Go Down to the Sea," *Army Ord-*

The success of the Dukw in its first combat test soon led to an increase in requirements. In November 1943 the War Production Board wired Yellow Truck and Coach Manufacturing Company that Dukw production was "of utmost urgency in the war program." [88] Ordnance was authorized to request overriding priorities to help any manufacturer meet his schedules. From 4,508 in 1943, production rose to 11,316 in 1944 before tapering off. All told, 21,147 Dukw's were purchased before the end of the war. They were all produced by the Yellow Truck and Coach Division of General Motors.[89]

Lack of experience with this type of vehicle and the haste with which it was put into production led to a long series of design changes. So many engineering changes, including substitutions to save critical material, were made during the production period that some engineers remarked that no two Dukw's were ever built exactly alike. The Dukw was not a particularly complicated vehicle, but it did present some unusual manufacturing problems such as fabrication of the sealed tubes through which axles and propeller shafts pierced the hulls. The worst problem with the Dukw was maintenance in the field.[90]

Crisis in Heavy-Heavy Trucks, 1943–45

During the first six months of 1943 truck production moved along at a fairly steady pace. Then in July the lightning struck. ASF suddenly directed Ordnance to double its procurement of heavy-heavy trucks (4 tons and up) in 1944—to produce 67,000 instead of something under 35,000. Fighting in North Africa had demonstrated the need for thousands of heavy trucks to tow big guns and to haul food, ammunition, and other supplies for fast-moving armies in the field. At the same time Ordnance understood that the War Production Board was planning a program to replace worn commercial trucks in the United States and that the Navy would require several thousand vehicles in 1944. It was a staggering, if not impossible, job. As General Christmas observed, "It's going to be Subject No. 1, 24 hours a day." [91]

Ordnance officers, not fully briefed by their superiors on the justification for the huge new requirements, were at first skeptical.[92] They knew that manufacture

nance, XXV, No. 141 (November–December 1943), 557; (4) Paraphrase of secret Msg from Algiers, Eisenhower to Marshall, No. 86, CM-IN -9804 (14 Jul 43); (5) Ltr, Gen Marshall to Bush, OSRD, 22 Jul 43, copy in OHF; (6) *Summary Technical Report of NDRC* . . . , ch. 4. See also Colonel Van Deusen's folder marked Amphibian Research in Roberts file. A report on the Sicilian campaign by Lucas is quoted in Memo, CG ASF for Deputy CofOrd, 10 September 1943, sub: Report on Motor Vehicles in Sicilian Campaign, OO 451/2038.

[88] Telg, WPB to Yellow Truck and Coach Mfg Co., 27 Nov 43, ASF Prod Div, Job 19B, G-1996, 451.2 Trucks. See also Memo, ASF Director of Matériel for CofOrd, 1 Sep 43, sub: Expediting Prod of 2-1/2-ton, 6x6, Amphibian Trucks, ASF Prod Div files, 19B, G-1996, 451.2 Trucks.

[89] Summary Report of Acceptances Tank-Automotive Matériel 1940–45, by OCO-D, p. 86.

[90] (1) PP 47, p. 37; (2) Van Deusen, "Trucks That Go Down to the Sea," *Army Ordnance,* XXV, No. 141 (November–December 1943), 557; (3) Hist, Detroit Ord Dist, vol. 100, pt. 14, Contractor History—Chevrolet; (4) Summary Technical Report of NDRC . . . , ch. 4.

[91] (1) Rpt, Conf Ord Dist Chiefs, Springfield, Mass., 28 Jul 43, p. 5, OHF; (2) Memo, Brig Gen Christmas, T-AC, for CofOrd, 2 Jul 43, sub: 1944 Prod of Heavy Duty Trucks, with 2 Incls and 2 Indorsements, OO 451.2/636 (c); (3) Memo, Rqmts Div, ASF for CofOrd, 26 Jul 43, sub: Proc of Motor Vehicles, Incl to OO 400.12/9285 (c); (4) Memo, Brig Gen Christmas, T-AC, for CofOrd, 25 Jun 43, sub: Status of Proc for . . . 1944, OO 451/1692-1/2; (5) The Automotive Industry in War Prod.

[92] The Truman Committee was also skeptical. See S. *Report* No. 10, pt. 13, 15 Dec 43, 78th Cong., 1st sess., pp. 18–25.

of more than 67,000 heavy-heavy military trucks in 1944, plus thousands more for civilian needs, would require Herculean efforts by the heavy truck builders and their suppliers. In a lengthy memo on the matter, General Campbell estimated that the new 1944 schedule would cost about three quarters of a billion dollars and would require the labor of 200,000 men for one year. In terms of weight of finished material it was equivalent to manufacture of 14,000 medium tanks. General Campbell pointed out that in July 1943 only about 3,000 heavy-heavy trucks had been produced and that the average peacetime rate was only 600 per month. The new program would require approximately 6,000 per month all during 1944. "It is necessary that we be realistic. . . ," he observed. "It is my considered opinion that . . . [only] 75 percent of the 1944 heavy truck program will be obtainable practically." [93]

One of the worst fears of the Ordnance Department was that the truck program, in addition to all its other problems, would have to take a back seat because of its low priority. When there was a scarcity of labor, materials, or facilities, trucks "sit in the last place following the Navy, Maritime Commission, Air Corps, and combat vehicles." [94] These fears, first aroused by War Production Board approval of limited civilian truck production in May, were heightened early in August when WPB approved a large, high-priority farm implement program. District offices reported that in plant after plant farm implements were elbowing truck orders out of their regular places in the line.[95] But when all these facts were presented to General Clay he merely advised General Campbell that the 1944 requirements were not based on "wishful thinking" and directed that every effort be made to meet them. He assured General Campbell that action would be taken promptly on Ordnance recommendations regarding specific bottleneck items.[96] A few weeks later General Hayes expressed the following attitude toward the matter at a conference of district chiefs:

> Our job is to meet the Army Supply Program. We are not responsible for the figures in the Program. We are responsible that production meets those requirements—not whether it is adequate or inadequate, whether too great or too little. . . . Our job is just to meet the program.[97]

With the new requirements in hand, Ordnance turned at once to the established makers of heavy equipment. These were not the Big Three of the automotive industry but firms that normally built heavy specialized vehicles. Some, like International Harvester, were industrial giants while others were small firms that built only a few hundred vehicles a year. Among their numbers were Autocar, Brockway, Corbitt, Diamond T, Federal, Four Wheel Drive, Kenworth, Mack, Marmon-Herrington, Pacific Car and

[93] Memo, CofOrd for CG, ASF, 12 Aug 43, sub: 1944 Heavy Truck Program, OO 400.12/9218. The same estimate was made by W. B. Murphy, WPB Deputy Vice Chairman for Prod, in Memo. to Krug, 29 Sep 43, WPB PD 631.241.

[94] Maj Gen Hayes, Min Conf Ord Dist Chiefs, Springfield, Mass., 28 Jul 43, p. 5, OHF.

[95] Memo, Lt Col George W. White, T-AC for McInerney, OCO, 6 Aug 43, sub: Accomplishment of 1943-44 Truck Program, OO 451.2/10321. The Truman Committee in December 1943 criticized the lack of civilian truck production.

[96] Memo, Maj Gen Clay, ASF, for CofOrd, 31 Aug 43, sub: 1944 Heavy Truck Program, filed as Incl to OO 451.2/805, copy in OHF. For an analysis of the problem by the Automotive Div of WPB, see booklet, Production . . . 1944 Truck Program, 11 Oct 43.

[97] Rpt Conf Ord Dist Chiefs, Philadelphia, 8 Oct 43, p. 1, OHF.

Foundry, Ward La France, and White.[98] Most of these concerns were essentially assembly plants, not highly integrated like the Big Three. With the exception of Mack, they did not make their own engines, axles, and transmissions but purchased them from other companies such as Timken-Detroit, Fuller, Clark, Spicer, Eaton, Continental, Waukesha, and Hercules. The key to expanding production lay in obtaining an increased flow of components, chiefly axles, engines, and transmissions, but producers of these items were already working at full capacity. Axles were the tightest item at the start, closely followed by transmissions and engines. The shortage of heavy-duty engines was so great that General Christmas actually suggested powering heavy trucks with two or three small engines hitched in tandem.[99]

As time was at a premium, Ordnance had to take shortcuts. Plants that had never before made working automotive parts were converted to meet the emergency. A notable example was Standard Steel Spring of Gary, Indiana, peacetime producer of springs and bumpers for passenger cars, which became a fabricator of driving axles. Under a subcontract with Timken-Detroit, it took over an idle armor plant, retooled it completely, lined up scores of sub-subcontractors, and, after many delays, finally got into production. National Slug Rejectors, Inc., of St. Louis switched from slot machines to nondriving axles for big trucks, and Kearney and Trecker, a machine-tool firm in Milwaukee, took on the unfamiliar job of making transmissions.[100] Meanwhile the Ordnance Industry Integration Committee for Heavy Trucks, formed in March 1943, promoted co-operative effort among all producers.[101] It was closely tied in with the WPB Production Consultants Committee for heavy trucks with which it held joint meetings every month.

In the fall of 1943 WPB appointed an Automotive Production Committee to coordinate military and civilian truck production, screen proposals for building new plants, and allocate scarce components.[102] Truck production was officially labeled a "must program" and was placed near the top of the production urgency list for manpower. Recognizing that the production job assigned to Ordnance was a tremendous undertaking, Army and WPB representatives arranged for close working relations all around and assigned production follow-up to the Tank-Automotive

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[98] For a brief report on truck manufacturers and component manufacturers, see Memo, Lt. Col. Maurice R. Scharff, Production Division, for Director Production Division, ASF, 28 September 1943, sub: 1944 Heavy Truck Program, ASF Production Division, 19B, G–1996, 451.2 Trucks, 1943. More detailed data appear in folder, The 1944 Truck Program, no date, same file for 1944.

[99] (1) Rpt Conf Ord Dist Chiefs, Springfield, Mass., 28 Jul 43, p. 7; (2) Auxier, *op. cit.*, p. 52, showing percentage expansion required in 1944 for axles, transmissions, and engines; (3) Reports on Critical Programs made by Batcheller to WPB, 1944–45, WPB 210.3 R NA; (4) Memo, Col Edward L. Cummings, T–AC, for CofOrd, 14 Aug 43, sub: Survey Report of Heavy Duty Truck Requirements. . . . , ASF Prod Div Job 19B G–1996 451.2 Trucks; (5) *War Production in 1944, Report of Chairman of the War Production Board* (Washington, 1945), pp. 10–11.

[100] (1) Hist, St. Louis Ord Dist, VI, pp. 23–25; (2) History, Report, Ordnance Industry Integration Committee for Axles and Transmissions, 1943–45, OHF; (3) PSP on Prod Plng, 16 Jun 45.

[101] History of Industry Integration Committee for Heavy Trucks, 1 Mar 43–31 May 45, OHF.

[102] (1) Automotive Prod Comm. files, 631.-04095, NA; (2) Min of Mtg at T–AC, 29 Oct 43, sub: 1944 Truck Program ASF Prod Div file 19–B, 451.2 Trucks 1943; (3) Auxier, *op. cit.*, pp. 56–60. The latter account stresses the lack during the first two years of war of an over-all program for civilian and military truck production. See also *War Production in 1944, Report of Chairman of WPB*, Page 21.

Center and the Ordnance district offices.[103] At the end of October General Campbell took the unusual step of writing a memo for General Somervell's personal attention, pointing to the failure to meet required schedules of production and declaring that the reasons for the failure—shortage of manpower and components—were "beyond the power of the Ordnance Department and of the automotive industry to correct." [104] At the end of the year General Hayes again warned that the goals for 1944 would not be met unless ASF and WPB took vigorous efforts to relieve the shortage of manpower, increase the supply of critical components, and push completion of new plants. In fact, wrote General Hayes, "unless manpower and component shortages can be solved, vehicular production in 1944 may not equal the rate attained in the last quarter of 1943. . . ."[105]

In spite of everything that could be done, the new year got off to a poor start. Only 2,788 heavy-heavy trucks were produced in January 1944, compared to 4,353 in December 1943. (*Table 22*) February and March were not much better than January, and in May the Automotive Production Committee (APC) reported: "The Heavy-Heavy Program continues to run materially behind. . . . All companies in the Heavy-Heavy Program have fallen behind." [106] The reasons for this discouraging performance were traced back to shortages of forgings and castings for heavy duty axles, engines, and transmissions, and to the time required to bring new producers into the picture. The results were not good, and, what was even worse, there was no immediate relief in sight. Col. Emerson L. Cummings bluntly declared at a Detroit conference in April 1944: "The second quarter is going to be tough, and as for the third quarter we can see no way of meeting it at present." [107]

In June 1944, as Allied invasion forces consolidated their Normandy beachheads, WPB took drastic action to speed heavy truck production. It authorized use of the "special directives treatment" that had been adopted earlier for landing craft and heavy artillery. This action was taken a few days after E. J. Bush, Chairman of

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[103] (1) Memo, Minton, ASF, for CofOrd, 10 Nov 43, sub: Critical Situation with Respect to Prod of Automotive Equipment, OO 400.12/10898; (2) Memo, CofOrd for CG, ASF, 30 Oct 43, sub: Critical Situation . . . Automotive Equipment, ASF Prod Div, 19–B, 451.2 (1943); (3) Rpt of Conf on 1944 Truck Program, 2 Nov 43, by Brig Gen Walter P. Boatwright, OCO–D, WPB PD 631.241 C, NA; (4) Memo, Director WPB Auto Div for Deputy Vice Chairman for Prod, 18 Nov 43, sub: Manpower Situation. . . , WPB PD 631.241 C, NA.

[104] Memo, CofOrd for CG ASF, 30 Oct 43, sub: Critical Situation with Respect to Prod of Automotive Equipment, ASP Prod Div 19–B, 451.2 Trucks 1943.

[105] (1) Memo, Maj Gen Thomas J. Hayes, OCO, for CG, ASF, 16 Dec 43, sub: Motor Truck Proc Program 1944, OO 400.12/11332; (2) Memo, Brig Gen John K. Christmas for CofOrd, 4 Dec 43, sub: Motor Truck Proc Program 1944, OO 400.12/11198; (3) Statement by Minton, ASF, in Rpt, Conf Ord Dist Chiefs, New York, 18 Jan 44, pp. 8–9. OHF; (4) Rpt on the 1944 Prod Program, Motor Trucks, by Progress Div, WPB, 20 Nov 43, copy in ASF Prod Div, 19B, G–1996, 451.2 Trucks 1944; (5) S. *Report* No. 10, pt. 13, 15 Dec 43, Truman Comm., 78th Cong., 1st sess., pp. 18–25.

[106] Rpt of Mtg Automotive Prod Comm., 11 May 44, Washington, D.C., APC file 631.02095, NA. See also Memo, Murphy, Deputy Vice Chairman for Prod, WPB, for L. R. Boulware, 9 Jun 44, WPB PD 641.243C, NA. For the February cut in requirements, see Memo, Fletcher E. Nyce to Murphy, 4 Feb 44, sub: Mtg February 3, 1944. . . , WPB 631.2412, NA.

[107] Rpt Conf Ord Dist Chiefs, Detroit, 22 Apr 44, p. 26, OHF. See also Ann Rpt ASF FY 1944, p. 148; Ann Rpt WPB Automotive Div 1944, p. 14, WPB 053.108, NA; and Memo, Minton, ASF, for CofOrd, 5 Feb 44, sub: Possibilities of Increasing Prod . . . , with 1st Indorsement, 14 Feb 44, CofOrd to CG, ASF, OO 400.12/11689.

TABLE 22—PRODUCTION OF HEAVY-HEAVY TRUCKS BY MONTH, 1943–1944–1945

Month	1943	1944	1945 (to August)
Total	38,314	50,862	[a]32,014
January	2,183	2,788	4,918
February	2,221	2,976	4,189
March	2,927	3,038	5,245
April	3,505	3,404	4,783
May	2,719	4,002	4,574
June	3,974	3,800	4,222
July	3,570	3,980	2,538
August	3,592	4,518	1,545
September	3,154	4,888	0
October	2,856	5,566	0
November	3,260	5,555	0
December	4,353	6,347	0

[a] Includes 1,460 that were remanufactured, converted, or modified.

Source: Summary Report of Acceptances Tank-Automotive Matériel 1940–45, by OCO-D, pp. III–IV OHF. This source also gives acceptances by truck types from each manufacturer. The two models with highest volume were the 6-ton, 6x6, and the 10-ton 6x4.

the WPB Production Consultants Committee, wired WPB Chairman Donald M. Nelson that, since truck production was "sadly behind schedule," someone in authority had to decide what was wanted most and then had to enforce that decision. "Someone must recognize bottlenecks which are choking our program," Bush declared, "and issue directives that will insure preference and priority being given to castings."[108] Under the "special directives treatment," manufacturers unable to obtain supplies needed to meet production schedules could appeal through channels for a special and immediate WPB directive to cope with the problem.[109] This procedure, one of the most potent weapons in the WPB arsenal, had psychological as well as legal effect. It proclaimed to all industry that component parts for heavy trucks were to be

[108] Telg, Bush to Nelson, 12 Jun 44, WPB, PD 631.241 C, NA. For discussion of the problem of identifying orders for castings with end products, see *War Production in 1944, Report of the Chairman of the War Production Board,* Page 92.

[109] Ltr, Murphy, Deputy Vice Chairman for Prod, WPB, to Manufacturers of Heavy Trucks, Truck Trailers, and Components for Such Vehicles, 8 Nov 43, copy in PSP on Prod Plng, 16 Jun 45.

given the right of way over all other traffic, except artillery and landing craft. But it was not widely used and did not work miracles. It had to be followed up by periodic conferences and visits to the plants by WPB and Ordnance representatives to deal with specific problems at the source.[110]

As June gave way to July, the Allied armies overcame initial enemy resistance and began to move inland. After winning the battle for Normandy they drove into Brittany and swung around to outflank Paris from the south. Hard-driving armored units led the advance that soon brought about the liberation of Paris and of all France. To keep pace, the supporting forces called for more and more trucks of all kinds. Because French railroads had been systematically bombed by Allied air forces to hamper German resistance, and had been further destroyed by retreating Germans, many supplies and reinforcements had to move forward during the early months of the campaign in truck convoys over ever-lengthening supply routes. To meet this emergency the famous Red Ball Express, employing 5,958 vehicles at one point, was organized in August to provide a fast and uninterrupted flow of supplies to the advancing front-line troops. It was for such long-distance hauling that heavy-heavy trucks were needed in large numbers. But there were never enough to meet the demand.[111] Lighter trucks, forced to carry emergency overloads and run for long distances at high speeds, soon wore out.[112] Theater transportation officers were convinced that the lack of heavy-duty trucks "contributed materially to the bogging down of [combat] operations in the first days of September." [113]

The supply line to France was not the only one that called for heavy trucks. The Italian campaign also had its truck requirements, and in the Far East there was a constant demand for heavy trucks to haul supplies over the Stilwell Road to China. In the spring of 1945 there were actually more 4-ton 6x6's in the Pacific Area than in the European Theater of Operations.[114] Every theater had its own peculiar needs, and the supply had often to be spread dangerously thin.

Throughout the summer of 1944 heavy truck production slowly gained momentum. From 3,800 in June and 3,980 in July it rose to 4,518 in August and to 6,347 in December. (*See Table 22.*) The work of WPB and Ordnance committees, plus all the other measures taken to speed output, helped boost production totals,

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[110] (1) Ltr, Murphy, Deputy Vice Chairman for Prod, WPB, to Manufacturers of Heavy Trucks, 22 Jun 44; (2) Joint Operating Instructions No. 4, 19 Jun 44, sub: Heavy Truck Program. Both in WPB file PD 631.241 C. NA. See also telg, Wilson, WPB Executive Vice Chairman, to Selected List of Foundries and Forge Shops, 20 Jun 44, quoted in Auxier, *op. cit.*, p. 86; PSP on Prod Plng, and Batcheller, Critical Programs, a Rpt to WPB, 14 Nov 44, p. 13, WPB 210.3 R NA.

[111] Memo, Chief of Transportation for CG ASF, 23 Jun 44, sub: Cargo Hauling Vehicles for ETO, copy in ASF Prod Div 451.2 Trailers. See also Wardlow, *Transportation Corps: Reponsibilities, Organization, and Operations,* pp. 91–92, and Roland G. Ruppenthal, *Logistical Support,* vol. I, ch. XIV.

[112] Incl 3 to Memo, CG ASF for Dir, Office of War Mobilization and Reconversion, 7 Dec 44; Gen Clay's reading file, G1595.

[113] Ruppenthal, *Logistical Support,* vol. I, p. 555. Chapter XIV of this volume, with the title "Transportation in the Pursuit," describes the Red Ball Express and the condition of railroads in some detail. See also Cole, *The Lorraine Campaign,* Pages 23–25 and 595, and an urgent appeal by the Chief of Transportation in Memo, to CG ASF, 23 Jun 44, sub: Cargo Hauling Vehicles for ETO, ASF Prod Div files 451.2 Trucks 1944, 19B, G1996.

[114] Transport Vehicle Mission to Europe, Apr 45, R&D file, OHF.

but the chief reason for increased output was simply the passage of time. No matter what else was done, it took time to bring in new producers of essential components. In the case of Standard Steel Spring, to cite one important example, it took twelve months—from November 1943 to November 1944—to convert an armor plate plant to production of truck axles.[115] As Ordnance officers frequently remarked, "You can't turn production on and off like a spigot." Even with the rise in the production curve during the latter half of the year, the 1944 total fell short of requirements—only 50,862 against initial demand for 67,000.

Early in 1945 requirements for the year ahead were set at approximately 60,000 heavy-heavy trucks on the assumption that fighting would continue for some time in Europe and then the final attack on Japan would be launched. Somewhat less than the original 1944 requirement, the figure was nevertheless challenging, for it exceeded actual 1944 production. Ordnance drew up plans to expand capacity for major components such as Hercules engines and Clark transmissions and to keep Standard Steel Spring producing axles.[116] But, with the surrender of Germany in early May, the pressure was relieved and schedules were cut back.

Special Vehicle Types

In addition to the standard types and sizes of trucks, Ordnance procured a bewildering array of special vehicles, ranging from light pickup and dump trucks to heavy wreckers and giant diesel-powered tank transporters. A mere cataloging of truck types in the fall of 1943 required 178 pages in TM9-2800. Among the better known types were ambulances, carryalls, panel delivery trucks, weapons carriers, bomb service trucks, buses, repair vehicles, fire trucks, huge tank trucks for hauling gasoline or water, and tractors for towing big guns. Four broad categories—half-tracks, tractors, tank transporters and wreckers, and truck-trailer combinations—illustrate the procurement problems in this area.

Half-Track Cars and Personnel Carriers

These hybrid vehicles, standing midway between trucks and tanks, were closer to the former than to the latter. They consisted of lightly armored truck chassis with standard front wheels for steering and track-laying rear drives to give them greater cross-country mobility. When designed primarily as mobile mounts for machine gun or light artillery pieces they were known as gun motor carriages, but, when built primarily for transporting troops or cargo in combat zones, they were called either cars or carriers.[117] The latter were normally armed with one or more machine guns and other small arms and, unlike gun motor carriages, were procured in comparatively large quantities. The Autocar Company and the White Motor

[115] Hist, St. Louis Ord Dist, V, p. 13, pp. 72-73, pp. 93-94, pp. 101-102; VI, pp. 90-100, VII, pp. 55-64; VIII, p. 73-80, IX, pp. 90-103. See also Hist Rpt, Ord Industry Integration Comm. for Axles and Transmissions, 1943-45; Rpt Meeting, APC, 28 Dec 44 (dated 3 Jan 45), in APC file PD 631.04095, WPB files, NA; and monthly reports to WPB on Critical Programs by Hiland G. Batcheller, 1944-45, WPB 210.3 R, NA.

[116] (1) Memo, Director Auto Div WPB for Lt Col H. P. Valentine, ASF, 8 Feb 45, sub: Program Determination No. 713. . . , ASF Prod Div, 19-B, 451.2 Trucks 1945; (2) Memo, Actg Director of Matériel ASF for Chairman WPB, 6 Jan 45, sub: ASF Truck Program for 1945, same file.

[117] Gun motor carriages are discussed in Chapters V and X.

Company turned out some 16,400 half-track cars of various models. These two concerns, along with the Diamond T Motor Company and the International Harvester Company, produced 22,837 half-track carriers of various models. Ordnance formed a Half-Track Integrating Committee in September 1942 to coordinate the efforts of the four producers. There were many design changes in half-track vehicles, and frequent changes in requirements, but otherwise half-track production posed no unusual problems for manufacturers or for Ordnance.[118]

Tractors

Before the war, only trucks and commercial-type tractors were available for towing heavy artillery weapons, and it was widely believed that special tractors for this purpose were not needed. But experience soon showed that battlefield conditions demanded specially designed vehicles, and in 1941 Ordnance undertook development of full-tracked, high-speed prime movers for cross-country towing of big guns. Four high-speed types eventually went into production, the 7-ton for towing light equipment, the 13-ton for towing 155-mm. howitzers, the 18-ton for towing 155-mm. guns and 8-inch howitzers, and the powerful 38-ton that could pull 240-mm. and 8-inch guns over rough terrain and maneuver them into firing position.[119] Caterpillar Tractor, International Harvester, Cleveland Tractor, and Allis-Chalmers started production in 1940 and 1941 on the 7-ton model but did not begin producing the 13-ton and 18-ton types until 1943, or the 38-ton until 1944. Roughly 21,000 of all four types combined were produced before V-J Day.[120] As low-speed tractors for construction work were used chiefly by the Corps of Engineers, ASF directed Ordnance in 1943 to turn over to the Engineers full responsibility for their procurement and supply.[121]

Tank Transporters and Heavy Wreckers

During World War I, trucks were employed to save wear and tear on light tanks by hauling them up to the forward areas. But as tanks grew heavier and better able to travel long distances under their own power this practice was abandoned. The earliest tank transporters in World War II were designed for a different purpose—removing disabled tanks from points along lines of evacuation or supply. They were not standard cargo trucks but combinations of truck-tractors and low-bed trailers such as one occasionally sees on the highway loaded with heavy construction machinery. Because of the laws governing over-all dimensions of vehicles, maximum loads on axles, and tire sizes, the early models did not give good off-the-road performance and could not be used

[118] (1) The Design, Development, Engineering and Production of Half-Track Vehicles, 1940–1944, OHF; (2) Catalog of Standard Ord Items; (3) A History of Half-Track Vehicles, Jun 46, OHF; (4) Ltr, Col Gerald B. Devore, president of Armored Force Bd, to CG, Armored Force, 22 July 1942, sub: Half-Track Personnel Carrier, M5, and 7 Indorsements, OO 451/756 (c); (5) Memo, 1st Lt Eldon M. Messersmith for M. B. F. Jones and others, 7 Oct 42, sub: Organization of the Half-Track Prod Comm., copy in OHF.

[119] (1) Barnes, *Weapons of World War II*, pp. 271–81; (2) TM 9–2800, sec. X.

[120] Whiting, Statistics, p. 42.

[121] (1) OCM 22535, 30 Dec 43; (2) OCM 21873, 16 Oct 43; (3) Memo, CofOrd for CG ASF, 27 Oct 43, sub: Commercial Low Speed Tractors—Transfer . . . to . . . Engineers, OO 451.3/194. See also correspondence on this subject during October 1942 in Gen Glancy's file, OCO–D, D 56–347.



HALF-TRACK CARS M2, *built primarily to transport cargo and personnel in combat areas, nearing completion at the White Motor Company, June 1941.*

for battlefield recovery. But, as the war progressed, new and improved types came into service along with tank retrievers, i.e., medium tanks fitted with winches, cranes, and other wrecking equipment. The huge 40–45-ton tank transporters had an armor-protected cab for their crews and mounted a .50-caliber machine gun on the roof. Equipped with three powerful winches, they could pull a mired tank out of the mud or haul a disabled tank behind the lines for repair. Fruehauf Trailer Company, holder of the prime contract for these vehicles, subcontracted the work first to Knuckey Truck and later to Pacific Car and Foundry, which had greater capacity.[122]

Along with tank transporters went other trouble-shooting vehicles known as heavy wreckers. These were big trucks that carried all sorts of equipment for administering first aid to disabled vehicles, including an oxyacetylene cutting and welding outfit. The best known heavy wrecker was the 10-ton M1A1, an outgrowth of the M1's built by Corbitt in 1939. Ward LaFrance made the first M1A1 version in 1942, and Kenworth was later brought into the picture to boost production. Basically a heavy-duty 6x6 truck, the M1A1 carried a single-boom crane mounted behind the cab as well as winches front and rear and a small arsenal of wrecking tools. Of the smaller wreckers, the 6-ton model was

[122] (1) Barnes, *Weapons of World War II*, pp. 269–70; (2) *Army Ordnance*, XXX, No. 154 (January–February 1946), 76; (3) Report on Design, Development, Engineering, and Manufacturing, 14 Oct 44, OCO–D, OHF; (4) Wheeled Vehicle Project, Oct 44–May 45, OCO–D, OHF.

built by Mack and the 4-ton by Diamond T.[123]

Truck-trailer Combinations

For hauling cargo long distances over improved roads the most efficient vehicle was the big truck-trailer combination. It consisted of a so-called truck tractor, ranging in size from a 1-1/2-ton 4x2 up to an 8-ton 6x4, and a trailer of proportionate size. The standard van-type trailer or semitrailer for general cargo had a box-shaped body with either one or two axles.[124] This type of trailer could be put to an infinite variety of uses other than hauling general cargo. It could be fitted to carry anything from pigeons to horses, and was suitable for use as a refrigerator car, map reproduction unit, or shop for repair of shoes, clothing, or delicate instruments. Some models served as mobile laundries, photographic laboratories, or bathing and sterilizing units. Still others were specially designed for hauling telephone poles, chemical containers, bombs, radio antennae, gasoline, or ponton bridge material.[125]

Production of the truck tractor portion of the combination was essentially the same as building standard trucks and was handled by established truck makers. In the manufacture of trailers and semitrailers, a comparatively simple process, a host of firms participated, some producing only a few hundred and others turning out tens of thousands. The biggest volume came in the smaller sizes, (up to one ton) with American Bantam, Ben Hur, Checker Cab, Gerstenslager, Nash - Kelvinator, and Willys-Overland among the leading producers. In the larger sizes, Fruehauf, Gramm, Highway, Trailmobile, and Winter-Weiss led the list.[126]

Total production of military transport vehicles from 1939 to 1945 amounted to more than 3 million vehicles, counting passenger cars, motorcycles, and bicycles. (*Table 23*) Ranging from 1/4-ton jeeps to giant tank transporters, the list included about forty different vehicle types. Roughly one-third of the total was procured by the Quartermaster Corps before the transfer to Ordnance in August 1942. In terms of number of units delivered, peak procurement came in June 1942 when 62,258 trucks of all kinds were accepted. Total cost of World War II transport vehicles, including spare parts and tools, was something over $7 billion, with prices ranging from about $1,000 for a jeep to nearly $6,000 for a Dukw and $14,000 for a heavy wrecker.[127]

Although more than two dozen firms held major truck contracts, the bulk of the Army's cars and trucks came from the Big Three of the industry. The number of trailer manufacturers ran into scores, and the number of subcontractors making parts and assemblies of all kinds ran into hundreds. As most contractors turned out

[123] (1) Summary Rpt of Acceptances, Tank-Automotive Matériel 1940–45, pp. 113–25; (2) TM 9-2800, pp. 286–313; (3) PP 47, pp. 54–56.

[124] A trailer had two axles and could "stand on its own feet." A semitrailer had only one axle and had to rest on a dolly when not on the move, or on the truck tractor which pulled it.

[125] TM 9-2800, sec. XV.

[126] For a tabulation of types, companies, quantities, and contract numbers, see Summary Rpt of Acceptances, Tank-Automotive Matériel 1940–45. Numerous documents on trailer procurement are in ASF Prod Div 19B, 451.3 Trailers.

[127] (1) Summary Rpt of Acceptances, Tank-Automotive Matériel 1940–45; (2) Whiting, Statistics; (3) Summary Hist Engineering-Manufacturing Division, OCO-D, copy in OHF; (4) Ord Supply Catalog, ORD 5-3-1, Hq ASF, 9 Aug 45; (5) Ordnance Wheeled Vehicle Program 1939–45, prepared by Rqmts and Progress Br, Prod Div, OCO-D, 28 Mar 46, copy in OHF.

TABLE 23—PRODUCTION OF MOTOR TRANSPORT VEHICLES, 1939–1945

Item	Total (1939-45)	1939–1940	1941	1942	1943	1944	1945
Total	3,200,436	46,384	232,545	791,432	983,359	738,643	408,073
Light (1-ton and under)	988,167	8,058	74,514	273,997	256,488	245,201	129,909
Medium (1 ½-ton)	428,196	14,153	37,139	140,375	133,523	80,888	22,118
Light-heavy (2 ½-ton)	812,262	9,589	62,123	182,049	193,177	220,012	145,312
Heavy-heavy (over 2 ½-tons)	153,686	804	9,838	23,314	38,314	50,862	30,554
Semitrailers	59,731	236	1,603	8,661	9,436	26,765	13,030
Trailers	499,827	6,494	33,311	81,881	241,450	79,188	57,503
Tractors [a]	34,295	993	1,675	7,433	12,674	8,106	3,414
Other vehicles (such as bicycles, motorcycles, and passenger cars)	224,272	6,057	12,342	73,722	98,297	27,621	6,233

[a] Excludes 82,099 commercial type tractors procured by the Corps of Engineers.

Source: Whiting, Statistics, and Summary Report of Acceptances Tank-Automotive Matériel 1940–45, by OCO–D, copy in OHF.

vehicles closely allied to their peacetime products they were able to use existing plants with little change and to turn out products that had already been tested and proved by years of experience. There was no Standard Fleet such as Motor Transport officers had fought for during the interwar years, but neither was there a repetition of World War I experience. Although the number of different types was high, there were only about thirty different makes in World War II, and of this number only five were high volume items.[128]

The jeep was the outstanding example of standardization, with Willys and Ford turning out more than six hundred thousand nearly identical models. The 2-1/2-ton, 6x6, was another, with General Motors producing those issued to the U.S. Army, and Studebaker those needed for lend-lease. But not all the trucks produced by either firm were identical. Some GMC 2-1/2-ton trucks used the Timken axle while others used the General Motors axle, and there were other variations. Even with the jeep there were a few noninterchangeable parts, and with the Dukw the variations were so numerous that, as noted above, engineers joked that no two Dukw's were really identical. Yet the Dukw was built on the 2-1/2-ton chassis, and between the two vehicles there were more than one thousand interchangeable parts. The greatest diversity of types came in the heavy-heavy category where nearly a score of producers took part and the

[128] See list titled Types of Vehicles, OHF, and Summary Rpt of Acceptances, Tank-Automotive Matériel 1940–45.

number of noninterchangeable components quickly multiplied.

Many different models of engines were used but nearly all were of the liquid-cooled gasoline type. A few air-cooled models were tested during the 1930's but none saw service in the war. Diesel engines were produced only for some lend-lease trucks and for a limited number of heavy duty vehicles. The policy of procuring commercial vehicles for Army use precluded adoption of new devices such as automatic transmissions which had not yet been put into production for commercial vehicles.

It is sometimes asserted that truck production in World War II was unduly delayed by the Army's search for perfection. Prolonged testing and retesting of vehicles by the technical services and by the combat arms have been blamed for loss of precious time in getting volume production under way. But the facts do not bear out this criticism. There was rigorous testing of pilot models, to be sure, followed by numerous design changes, but the testing and redesigning were not carried to extremes. In most cases standard commercial trucks were put into production with very few basic design changes. Minor modifications were always being made to meet specific military needs, but major modifications were rare. Two completely new vehicles—the jeep and the Dukw—were designed, tested, and adopted in record time. Both went into volume production quickly and both were highly successful in the field. The using arms were cool toward the idea of an amphibian truck at the start but they lost no time in adopting it after they saw the Dukw in action.

After production got under way the basic design of vehicles was frozen unless some really serious weakness developed. But minor changes were frequently approved under the title of Engineering Change Orders (ECO's). This, it should be noted, is standard practice in private industry and is unavoidable when new models are introduced, whether one is producing trucks, washing machines, or airplanes. With the exception of the Dukw, the flow of ECO's on military trucks was not out of line with commercial practice or with experience in other areas of war production. Perhaps the chief difficulty in this area was the lack of adequate liaison between the armies in the field and the Office Chief of Ordnance in Detroit. Engineering changes that originated with experienced automotive engineers, whether in Detroit or overseas, were usually based on sound principles, but in many instances requests for modifications came from officers in the field with no explanation as to their purpose or necessity, and without review by competent automotive specialists. The Engineering Division in Detroit complained that, as a result, the Army was in the position of having its right hand ignorant of what its left hand was doing, and of making design modifications without adequate engineering study.[129]

One of the incredible features of World War II truck production was that it lagged behind schedule year after year. With all its vaunted capacity to lead the world in automotive production, the United States turned in a poorer score on trucks than on most other items of military equipment. Light and medium trucks, closely akin to normal production of the automotive industry, generally met their schedules, but

[129] (1) Interv with Lt Col John H. Davis, Ord R&D Div, 2 Jun 55; (2) Draft MS entitled The Lessons of World War II in Roberts file.



"I'll be derned. Here's one what wuz wrecked in combat."

light-heavy (2-1/2-ton) models fell short of requirements both in 1942 and 1943. This was partly the Army's fault. After underestimating its needs for heavy-heavy trucks early in the war the Army in mid-1943 set impossible goals for their production in 1944, and the goals were not met. A great deal of time and effort was devoted to studying the bottlenecks, but no really effective action was taken to deal with them. All things considered, the automotive industry did a magnificent job, but it could not work miracles.

Another discouraging facet of the situation was the inexcusable abuse meted out to military trucks by some of their drivers, young and irresponsible enlisted men not adequately trained or properly indoctrinated with the need for treating their vehicles with the same care that cavalrymen gave to their horses in years gone by. The average American soldier was regarded as possessing more mechanical aptitude and experience than the soldiers of any other army in the world, but he often gave a poor account of himself in handling military trucks. There were many exceptions, of course. Countless examples of mechanical ingenuity in keeping vehicles running might be cited, but the toll from neglect and abuse was terrific. Overloaded vehicles were driven recklessly at excessive speeds over good roads and bad with the result that tires, brakes, motors, clutches, and transmissions wore out at an alarming rate. In spite of efforts to enforce maintenance discipline, many soldier drivers appeared to consider their position behind the wheel as an opportunity to demonstrate both their courage and their powers of destruction. Bill Mauldin, the Army's satirical cartoonist, once drew a soldier mechanic, possibly from Ordnance, standing atop a pile of wrecked vehicles and calling to his buddy, "I'll be derned. Here's one what wuz wrecked in combat." Much of the hard usage meted out to trucks was, of course, unavoidable, but all of it, avoidable or not, added to the Ordnance problem of maintenance. The casualty rate among vehicles was so high, and the load on maintenance units so heavy, that a separate chapter is required to deal with the problem of spare parts.

CHAPTER XIII

Spare Parts for Vehicles

The term "spare parts" has an unfortunate connotation. It suggests something unimportant, dull, and uninteresting. It also brings to mind the thought of a fifth wheel on a cart, something not wholly necessary that under normal conditions can be done without or "spared."

But all these connotations are completely misleading when we examine closely the role of spare parts in World War II. As far as Ordnance history is concerned, it is no exaggeration to say that spare parts, particularly for trucks and tanks, posed one of the most important and persistent problems of the whole war. In Africa, General Rommel's success in recovering from defeats was often ascribed to the fact that he was well supplied with parts and had a competent maintenance organization while the British were less well off. "When I die," a high-ranking British Ordnance officer once remarked, " 'spare parts' will be written across my heart." [1]

The basic reason for the spare parts problem lies in the fact that an Army tank or truck does not last for one hundred years, as did the Deacon's wonderful one-hoss shay. Nor does it all fall apart at once —"like a bubble when it bursts"—unless blasted by an enemy mine or shell. It usually breaks down one part at a time. And the whole vehicle may be immobilized for lack of that one part, whether it be a simple item like a cracked spark plug or something more intricate like a burned-out bearing. "This is not a war of ammunition, tanks, guns, and trucks alone," wrote Ernie Pyle, the famed correspondent.

> It is as much a war of replenishing spare parts to keep them in combat as it is a war of major equipment. . . . The gasket that leaks, the fan belt that breaks, the nut that is lost . . . will delay GI Joe on the road to Berlin just as much as if he didn't have a vehicle in which to start.[2]

In World War II the role of the proverbial horseshoe nail in battles of the distant past was assumed by a host of mechanical items—spark plugs, distributor points, condensers, generators, carburetors, gaskets, fuel pumps, tires, tank tracks, and so on and on. Their types were numbered in the hundreds of thousands, and the quantities of some, like spark plugs and tires, ran into the millions. They formed several different categories, including small individual pieces such as spark plugs

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[1] Maj Gen L. H. Williams, Controller of Ord and Director of Warlike Supplies, British War Office, at a conf on 27 Sep 43, quoted in Hines, History of the General Purpose Vehicle in ETO, vol. I, OHF. For evidence that the Germans also had tank maintenance problems, see DA Pamphlet No. 20-202, Jun 54, German Tank Maintenance in World War II.

[2] Quoted in Wheels of Victory, the Story of Industry-Ordnance Accomplishment in the Tank and Automotive Field, OCO-D, Nov 45, p. 12, OHF.

and points; larger subassemblies such as carburetors or generators; and big assemblies such as complete engines or rear axles. They ranged in size from delicate springs weighing a fraction of an ounce to tank engines weighing more than half a ton. They had to be produced in huge quantities and also had to be named, numbered, packed, and shipped to all corners of the globe. "Almost anywhere in the world you can get spare parts for the family car when it breaks down," Colonel Van Deusen once observed. "Not so with an Army truck; it has to take its mechanic civilization with it. If it travels light it may not travel far." [3] In the middle of the war the rate of Ordnance shipment of spare parts to the using arms and lend-lease countries amounted to more than one hundred million pieces per month.[4]

Categories of Parts

When cars and trucks were placed beside tanks and heavy guns, the contrast between commercial design and military design made itself clear. Except for a few components, tanks and big guns were designed entirely by Ordnance, or under its direct supervision. The drawings and specifications for every part were kept on file in Ordnance and could not be changed without its consent. Further, tanks and guns were produced only for military use, not for ordinary commercial sale, and the same was true of their spare parts. Trucks, on the other hand, were designed by industry primarily for commercial sale, and, before the war, only incidentally for sale to the government. As wholesale and retail outlets all over the country carried supplies of spare parts for cars and trucks, Army repair shops were able to purchase locally whatever parts they needed to keep their motor fleets in operation.

Another distinction of importance was that between the old and the new. Ordnance experience with rifles and artillery weapons ran back for over one hundred years, and with machine guns for about half that time. Decades of development work, combined with long experience in field maintenance, had built up a solid backlog of maintenance data, including fairly exact knowledge of what replacement parts would be needed. Throughout World War II there were, as a consequence, few complaints of parts shortages for shooting ordnance. "It is the rarest thing I ever hear that there is a shortage of machine gun parts or artillery parts," General Campbell commented early in 1944. "On the other hand, there is hardly a day, hardly an hour, that I don't hear about a shortage of automotive parts." [5] Because tanks and trucks were comparatively new items of military supply they had not been through a century of development, test, and field maintenance. Further, they were complex mechanisms whose proper functioning depended upon precise integration of countless moving parts. In addition to all this, trucks were called upon to perform

[3] Quotations from speech by Col Edwin S. Van Deusen before SAE, New York, 19 Feb 42.

[4] For discussion of spare parts supply, numbering, and distribution within the Field Service area, see Chapter XIX, below. For a brief summary of the spare parts story, see draft of booklet, Ordnance Spare Parts in Mechanized Warfare, August 1944, copy in P4341, OHF. A much more detailed account is Clifford and Alspaugh, Record of U.S. Army Ordnance Combat and Motor Transport Vehicle Spare Parts Policies and Operations. Brief historical reports and scores of documents are to be found in OCO–D History of Spare Parts, Project No. 54, Volumes 43–44, P4336. See also section on spare parts in Annual Report Requirements Division ASF, ASF file.

[5] Rpt Conf Ord Dist Chiefs, 18 Jan 44, New York, N.Y., p. 4, OHF.

their strenuous missions day after day, often working around the clock, over rough terrain, and in all kinds of weather. While rifles, guns, and howitzers were fired only for short periods in training or in combat, motor vehicles were always in demand and were in actual use a great deal of the time.[6]

These distinctions gave rise in Ordnance and the Quartermaster Corps to sharply differing spare parts policies. With supplies available from commercial outlets, the QMC did not carry warehouse stocks of parts for peacetime maintenance of the Army's cars and trucks. As a result, it had no real spare parts problem in peacetime, except insofar as the great variety of vehicles made it a problem. For tanks and other combat vehicles, on the other hand, there were no local garages carrying periscopes, tank tracks, or spare gun tubes. Ordnance had to maintain its own supply of such parts. It is true that the burden was not very heavy, for the few tanks in service saw little if any use during the average peace year and big guns were seldom fired. But the principle of keeping on hand a full stock of maintenance parts for weapons and combat vehicles was firmly rooted in Ordnance long before 1940.

Spare Parts in Ordnance, 1939–42

The Ordnance contract for 329 light tanks placed with American Car and Foundry in November 1939 is historically important as the first U.S. Army tank order awarded industry since World War I. It is also significant in the World War II history of vehicular spare parts because, following standard Ordnance policy, it included a provision for replacement parts as well as for complete vehicles.[7] Before the order was placed engineers of the Industrial Service, with the concurrence of Field Service maintenance specialists, had compiled a list of "essential extra parts" needed to keep the tanks in repair for one year of war. Lacking data from combat experience, the engineers could make only estimates, taking into account the number of miles the tanks would probably run, estimated hours of operation, results of proving ground tests, and other factors. The parts on this list were known as "first year parts" or, because they were delivered concurrently with the vehicles, "concurrent parts." Standard shop supplies such as solder, welding rod, cotton waste, gaskets, and nuts and bolts were procured in bulk by Field Service along with such standard commercial items as spark plugs, batteries, oil seals, radiator hose, and tires.[8] Also procured concurrently with the vehicles, these items were described as Field Service supplies to distinguish them from first year spares procured by the Industrial Service.

When Ordnance depots occasionally ran short of parts to repair deadlined vehicles they bought directly from automotive dealers or requested procurement through Rock Island or the district offices. The parts thus obtained went under the name of "deficiency parts" as they were used to make up unexpected deficiencies in

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[6] For a discussion of this theme, see Brig. Gen. Julian S. Hatcher, "Automotive Spare Parts," *Army Ordnance*, XXVII, No. 146 (September–October 1944) 257ff.

[7] In 1939 the governing regulation was OO Memo No. 467, 2 March 1935. It was later replaced by OO Memo No. 510, 21 January 1941. Copies in folder marked Spare Parts, ORDIR-T640-A.

[8] For tires and other rubber products, see Green, Thomson, and Roots, *Planning Munitions for War*, Chapter XVIII.

depot stocks. This practice served well during peacetime, but after Pearl Harbor the mounting flow of requests for small quantities of many deficiency parts led to confusion and had to be discontinued.[9] A new system was then introduced to procure second-year parts for all equipment. The quantities on the second-year lists amounted to 60 percent of the first year lists and were to be delivered within six months of delivery of the original item.[10]

In 1940, when defense production rapidly gained momentum, estimates of Ordnance parts requirements reached what then appeared to be staggering totals. During fiscal year 1940 the Department had spent on spare parts over $15 million —more than the entire Ordnance appropriation in earlier years—and plans called for spending ten times as much in fiscal 1941. A survey in the fall of 1940 by an industrial consultant, Lawrence S. Barroll, showed that roughly 20 percent of all funds apportioned for new matériel went into spare parts.[11] In view of the magnitude and complexity of parts procurement after Pearl Harbor, Ordnance decided to give its parts policies and practices a careful re-examination. Barroll was again called in late in 1942 to study the situation. Many conferences were held to discuss proposed new procedures.[12]

One of the underlying difficulties at the start was the need for closer co-ordination between Field Service and Industrial Service. Because of the nature of their functions these two services did not always see eye to eye on spare parts.[13] Alert to its duty to keep depots and field units always well supplied, and mindful of its long experience with the knotty problems of maintenance, Field Service gave high priority to spare parts. The Industrial Service recognized the needs for parts but was more directly influenced by pressure to procure complete items. Production of a carload of extra carburetors or spare tires did not make news; nor did it satisfy the demands of the Assistant Secretary of War half as well as did production of an additional tank or carload of complete machine guns. The essence of the difficulty was the calculation of requirements. When General Harris questioned the need for the huge quantities of parts that Field Service wanted for spares, and asked to see the records of parts consumption on which they were based, General Crain replied that the records were fragmentary or nonexistent. He contended that troops in the field should not be burdened with demands for consumption data but should

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[9] Roy W. Stosch, Spare Parts and Supplies Replenishment, sec. 6 of PSP 63, Stock Control and Supply Control Policy and Practice, by OCO, Jun 45, OHF.

[10] For a brief summary by an ASF officer, see Memo, Col Phillips W. Smith for Brig Gen Albert J. Browning, Director ASF Purchases Div, 5 Apr 44, sub: Proc of Standard Motor Vehicle Spare Parts, copy in folder Whom Do We Buy From?, P4340. See also Memo, Duffy, OCO for ASF, 27 Mar 44, sub: Spare Parts Proc Policy, OO 451.01/8190, and Memo, Howard, OCO-D for Col Phillips Smith, ASF, 8 Mar 44, sub: Spare Parts Proc Policy, T617.

[11] Study of U.S.A. Ordnance Department Spare Parts Procedure, 8 Oct 40, by Lawrence S. Barroll, Technical Consultant of the office of W. K. Norton, Washington, D.C. (hereafter cited as Barroll Rpt, 1940), in PSP 63, ex. 1. An earlier version dated 13 Sep 40 may be found in ORDIR T640 -A, folder on spare parts.

[12] Lawrence S. Barroll, Survey of Ordnance Spare Parts Supply, 26 Dec 42 (hereafter cited as Barroll Rpt, 1942), in PSP 63, ex. 2. This survey reviews the situation as it existed in 1940 and describes development during 1941 and 1942. The stock control aspect of the Barroll report is discussed below in Chapter XIX.

[13] For an example of disagreement between Field Service and Industrial Service on parts lists, see Report, Wesson Conference, 31 October 1940.

be supplied automatically, at least in the early stages of war. "I did not believe in blind automatic supply of spare parts," wrote General Harris years later. "I believed rather in selective supply based on consumption experience." [14] Lacking experience data, Field Service tended to set requirements high to be sure of having enough, and Industrial Service tended to set them low to allow more production of complete items.

Another difficulty cited by Barroll in his 1940 report was that the division of spare parts responsibility between the two services was too vague. He recommended that Field Service be given full responsibility for determining parts requirements and that the Industrial Service be responsible only for placing the orders with industry or the arsenals.[15] Meanwhile a conference of Field Service and Industrial Service representatives came to the opposite conclusion —that the Industrial Service should be responsible for preparing parts lists.[16] General Wesson, apparently not agreeing fully with either proposal, in early November 1940 appointed a permanent Spare Parts Board, headed by the chief of Field Service, to review and approve all parts lists before the Industrial Service placed orders with industry.[17]

Appointment of this board was a step in the right direction but it did not solve the whole problem by any means. In mid-January 1941 when General Wesson inquired at an 11 o'clock conference how spare parts were coming along, the answer of General Crain, chief of Field Service, was, "Not so well." For one thing, he reported, Rock Island Arsenal, because of the pressure to meet production goals, was giving priority to complete items and was neglecting parts. He complained that some parts orders placed with the arsenal in 1939 were still unfilled. This was contrary to standing instructions, replied the Industrial Service representatives. But that was of little help to General Crain.[18] A year later the problem apparently still existed. General Harris found it necessary at that time to call the policy on spare parts orders to the attention of his division chiefs and direct them in forceful language to give top priority to Field Service requisitions for parts and to expedite their production "in every way possible." [19]

Another troublesome problem was the delay in compiling parts lists for new items and getting them into the hands of contractors. With the ACF light tank order in 1939, parts lists had been provided promptly. But with the medium tank, which went into production in 1940 while design work was still in progress, the story was different. By the end of February 1941 the medium tank contracts with American Locomotive, Baldwin Locomotive, and

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[14] Ltr, Maj Gen Charles T. Harris, Jr. (Ret.) to Thomson, 25 Aug 55, OHF.

[15] Barroll Rpt, 1940. See also Memo, Chief of FS for Chief of Ind Serv, 23 Aug 40, sub: Proc of Spare Parts . . . and Memo, Lt Col William A. Borden, for Col Gladeon M. Barnes, 23 Aug 40, sub: Spare Parts, both in folder marked Spare Parts ORDIR T640-A. For a critical review of the Barroll report, see Memo, Borden for Lt. Col. Walter W. Warner, 21 September 1940, sub: Spare Parts, in folder marked Spare Parts, ORDIR T640-A.

[16] Memo, Chief FS for ACofInd Serv, Engr, 13 Sep 40, sub: Preparation of Essential Extra Parts Lists, OO 451.01/98.

[17] (1) Ord SO No. 263, 7 Nov 40; (2) Min, Wesson Confs, 31 Oct 40. The other members of the board were representatives of the Industrial Service, Fiscal Division, and General Office. The minutes of the board are in OHF.

[18] Min, Wesson Confs, 15 Jan 41. See also same source 28 Jan 42 and OOM 510, 21 Jan 41.

[19] Memo, Maj Gen Charles Harris, for Chiefs of Divs, 30 Jan 42, sub: Placing Orders for and Prod of Spare Parts, copy in Min, Spare Parts Board, OHF.

Chrysler still did not provide for production of spare parts lists because the parts lists had not yet been completed.[20] As late as December 1942, Barroll declared that preparation of parts lists was still "in bad shape." [21] Compilation of parts lists was no easy chore, for a single list might include thousands of items, and every item posed its own peculiar problems.

When reports reached Ordnance from Fort Benning early in the spring of 1941 that large numbers of tanks were deadlined for lack of parts, General Wesson sent a teletype to Rock Island authorizing immediate procurement of parts without advertising.[22] "It is absolutely essential," he added, "that every spare parts order be given the highest priority." [23] But the backlog of unfilled parts orders remained for months, particularly hard-to-manufacture items like engines and transmissions. Meanwhile both General Harris, chief of Industrial Service and General Crain, chief of Field Service, opposed cutting parts production to boost output of complete items. Although not always achieved, their objective was to keep parts production synchronized with complete item production even at the cost of reduced totals for complete items.[24] The wisdom of this policy was confirmed by British combat experience. "Striking figures of tanks produced per day look very well in the papers," a British report stated, "but we cannot fight this war with statistics. . . . Tanks without spares are very little more use than no tanks at all." [25]

After Pearl Harbor, and particularly after announcement of the Presidential Objectives early in January 1942, the pressure for procurement of complete items became intense and the task of bringing parts production abreast of vehicle production became even more difficult. In the early weeks of 1942 the Under Secretary of War and other high-ranking officials kept almost daily tab on the output of tanks, guns, and ammunition, and constantly exhorted Ordnance to speed production. "The demand for completed pieces of equipment . . . was so great," wrote General Campbell, "that the fundamental urge of all concerned, both in Industry and Ordnance, was to produce as many finished articles as possible." [26] With many industrialists asserting that Ordnance parts requirements were excessive, and complaining of delays in receipt of approved parts lists, the District offices had constantly to combat a tendency in industry to neglect parts production. The Chief of Ordnance in April 1942 specifically directed the District offices to include in every contract a list of spare parts, with time of delivery clearly stated and synchronized with delivery of major items.[27]

Ordnance also gave close attention to

[20] Memo, Maj William F. Sadtler for file, sub: Spare Parts for Tanks, 26 Feb 41, ORDIR T640–A.

[21] Barroll Rpt, 1942, p. 19, in PSP 63, ex. 2.

[22] Min, Wesson Confs, 15 Apr 41.

[23] Teletype, CofOrd to CO Rock Island Arsenal, 7 May 41, OO 451.25/5199.

[24] Min, Wesson Confs, 15 Jul 41. For similar comments, see same source 19 Nov 41, and Min of Spare Parts Board, OHF.

[25] Importance of Provision of Spare Parts for Tanks, April 1942, British Army Staff. See also Rpt of Conf, 3 Jul 42, British and U.S. officers on spare parts. Both in Tank-Automotive Spare Parts Policy docs., OHF.

[26] (1) Campbell, *The Industry-Ordnance Team*, p. 349; (2) Intervs, summer 1949, with Maj Gen Charles Harris and Brig Gen Burton Lewis.

[27] Clifford and Alspaugh, *op. cit.*, p. 73. See also OO Memo No. 618, 30 Apr 42, copy in folder marked Spare Parts, ORDIR, T640–A. On the contract between military and commercial parts requirements, see Memo, Col Raaen for Amberg, 25 Jul 44, sub: . . . Truman Comm. Ltr. . . , OHF.



MAJ. GEN. LEVIN H. CAMPBELL, JR., *Chief of Ordnance, May 1942.*

the organizational side of the problem in the spring of 1942. When the newly formed ASF Control Division looked into the matter it observed that Ordnance's parts troubles stemmed from the fact that "ten separate offices deal with various aspects of Spare Parts, and no one person is effectively co-ordinating the entire operation." [28] The Spare Parts Board was the final authority on parts lists, but its authority did not extend to procurement and distribution. A survey of Ordnance in May 1942 by a team from General Motors also came to the conclusion that responsibility was too widely scattered. The General Motors people went on to recommend creation of a Spare Parts Service, to be on the same level as Industrial Service and Field Service.[29]

The General Motors report came at an opportune time for action. When General Wesson retired at the end of May 1942 his successor, General Campbell, was prepared to take drastic measures to deal with the parts problem. Early in June, in line with the General Motors report, he created a Parts Control Division headed by Brig. Gen. Rolland W. Case and staffed in part by General Motors men who had made the survey.[30] Its mission was to formulate spare parts policies for Ordnance and see that they were carried out by Field Service and the Industrial Service. But it never achieved its objectives. After spending some time in discussing plans and procedures, General Case became convinced that the new division was administratively unsound because it overlapped existing organizations and did not have sharply defined lines of control. Another factor that entered the picture was the coming merger of the Motor Transport Service with Ordnance, and the absence of a Parts Control Division in the MTS. In view of these facts, General Case recommended that the new division be abolished. General Campbell reluctantly agreed and on 28 July 1942 issued orders abolishing the division and assigning its duties to

[28] Notes on Organization and Operation of the Tank and Combat Vehicle Division of the Ordnance Department by ASF Contl Div, Rpt No. 26, no date but probably March 1942, dr 2172 ASF Contl Div files.

[29] General Motors Overseas Operations, May 1942, General Survey of the Organization, Functions and Operations of the Ordnance Department, 3 vols., OHF. For criticism of the GM proposal on parts as functionally unsound, see Memo, Gordon M. Bain, Bur of Budget, for Col Clarence E. Davies, Ord Contl Div, 22 Jul 42, sub: Recent Ord Reorganization. . . , ASF Contl Div file 321 (Ord).

[30] (1) ODO 285, 26 Jun 42; (2) Interv with Brig Gen Rolland W. Case, 22 Nov 49; (3) Key Pers Rpt, 2 Nov 45, Col Lawrence J. Meyns, ExecO Parts Contl Div, OHF.

Field Service.[31] This marked the end of more than two years of persistently unsuccessful efforts to "solve" the parts problem and ushered in a new phase with absorption into Ordnance of transport vehicles.[32]

Spare Parts in the QMC, 1939–42

All during the years before World War II the QMC made no provision for purchasing spare parts along with vehicles. Not only were its financial resources too slender to purchase stock of about half a million different parts, but there was no real need to keep large supplies of parts on hand, for Army cars and trucks were of the same design as commercial vehicles. When they broke down, the QMC purchased repair parts from local distributors on an "off the shelf" basis.[33] For Army transport vehicles there were no lists of first year spares, nor any concurrent procurement of parts as there was for combat vehicles.

In the summer of 1940, as the Army's truck fleet expanded, the motor depots were authorized to build up small reserve stocks of parts by direct purchase from vehicle manufacturers. Drawing upon the experience of industry and the Motor Transport Division staff, depot commanders endeavored to build up stocks that would give "a good general coverage." [34] This step marked the first departure from the policy of relying solely on local purchase, but local purchase continued as a major source of parts supply for the next two years.[35]

The depot stocks of parts procured in this manner were not strictly analogous to Ordnance first year or concurrent spares. They were not geared in directly with scheduled vehicle procurement but were more closely akin to Ordnance replenishment parts purchased to fill deficiencies in depot stocks. The QMC did not undertake systematic procurement of first year spares concurrently with procurement of vehicles until the Lend-Lease Act came into the picture in 1941 and did not get the new system into good working order until after Pearl Harbor.[36] To keep lend-lease vehicles supplied with repair parts after they were shipped overseas the QMC decided to compile voluminous parts lists to be incorporated in lend-lease contracts. The same lists were later made a part of all domestic contracts as well. Based at the outset on

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[31] (1) Change 1, ODO 285, 28 Jul 42; (2) Interv with Case, 22 Nov 49; (3) Key Pers Rpt, 2 Nov 45, Meyns; (4) Memo, Deputy Chief FS Suboffice for Chief FS Suboffice, Rock Island, 6 Jun 45, sub: Stock Contl Activities 1941–45, copy in OHF.

[32] See Barroll Rpt, 1940, for a critical review of the 1940–42 period.

[33] (1) Ann Rpt QMG 1942; (2) Memo, QMG for ASW, 13 Dec 37, sub: Contracts for Purchase of Repair Parts. . . , QM 451.01 T–M. See also draft MS by Harry Roberts on Spare Parts, OHF, and Memo, Col Roland P. Shugg, ASF Opns Div, for Generals Somervell and Lutes, 17 Mar 42, sub: Automotive Parts, OHF.

[34] (1) Clifford and Alspaugh, *op. cit.*, p. 40; (2) Memo, Barzynski to CO, Holabird QM Depot, 30 Oct 40, sub: Purchase of Assemblies and Parts for Motor Vehicles, and 1st Indorsement CO Holabird QM Depot to QMG, 8 Nov 40, QM 451.01 M–FO (Holabird), copy in OHF; (3) Ann Rpt QMG 1942.

[35] For restrictions on local purchase in the summer of 1941, see: (1) MTS Ltr No. 8, 28 Aug 41, quoted in Clifford and Alspaugh, *op. cit.*, p. 111; (2) Ann Rpt QMG 1942; (3) Press Release, OQMG, 4 Sep 41, sub: Quartermaster Corps Establishes Spare Parts System, copy in OHF.

[36] (1) Ann Rpt QMG 1942; (2) Stosch, Spare Parts and Supplies Replenishment, PSP 63, sec. 6; (3) Press Release, OQMG, 4 Sep 41, sub: Quartermaster Corps Establishes Spare Parts System.

commercial experience,[37] they had to be revised as time went on to bring them into line with combat experience of the Allied nations. They were known variously as first-year lists, concurrent lists, and United Nations lists. For export shipment, and also for a time for domestic use, they were put up in 100-unit packs, that is, packs with enough parts in each to maintain one hundred vehicles for a year of wartime service.[38]

Preparation of United Nations lists took months of painstaking work and was not completed until the end of 1941. Meanwhile the Motor Transport Service had procured some three hundred thousand vehicles without spares, except for small depot stocks, and friendly nations had procured for their own use another three hundred thousand—also without first-year spares.[39] After Pearl Harbor it became obvious that further reliance on local purchase to supply a wartime truck fleet was out of the question, for commercial production of parts had been stopped and distributors' shelves were nearly bare. In the spring of 1942 the Director of the Motor Transport Service therefore took the bull by the horns and authorized purchase of $20 million worth of parts for the cars and trucks already in service.[40] The Munitions Assignment Board approved similar procurement of parts for cars and trucks in the hands of the British and other friendly nations.[41] To avoid disrupting production schedules of vehicle manufacturers, and in the hope of saving both time and money, these parts were purchased whenever possible directly from parts manufacturers. This was a departure from existing practice and was apparently initiated by Jack Creamer, formerly with a New York firm known as Wheels, Inc., who had been placed in authority over MTS purchase policy.[42] As established parts suppliers were immediately flooded with orders, the Motor Transport Service departed from its stated policy of buying only from concerns that supplied original equipment and turned to the so-called "independents" who did not normally supply parts to vehicle manufacturers but sold to the public cut-rate parts that were claimed to be just as good as original parts.[43]

While orders were being placed against this huge backlog, General Somervell urged General Frink to stop buying parts "in driblets of from 5 to 6 percent of the gross value of the vehicles" and adopt the British practice of ordering parts worth 35 percent of the vehicle cost. General Frink

[37] For detailed comment on the differences between commercial experience and military experience, see Memo, Raaen for Amberg, Spec Asst to SW, 25 Jul 44, sub: . . . Truman Comm. Ltr. . . , copy in OHF.

[38] (1) Ann Rpt QMG 1942; (2) Stosch, Spare Parts and Supplies Replenishment, PSP 63, sec. 6; (3) Clifford and Alspaugh, *op. cit.*, pp. 76–81.

[39] Statement by Brig Gen Walter P. Boatwright, 29 Nov 44, *Hearings,* Mead Comm., pt. 26, pp. 11927–28.

[40] Ltr, John H. Creamer, OQMG, to Maj Paul G. Tossy, QM Motor Supply Depot, Fort Wayne, Mich., 15 May 42, sub: Misc. Spare Parts Purchases, 1940–41 Vehicles, copy in OHF. See also unsigned typescript, Hist of Spare Parts Procurement Policy, 1942, p. 6, in folder Purchase Policy IV, photostat copy in OHF.

[41] Clifford and Alspaugh, *op. cit.*, pp. 141–46.

[42] (1) Ann Rpt QMG FY 1942, copy in MTS files, P 4233; (2) Memo, Raaen, OCO, for Amberg, Spec Asst to SW, 4 Jan 44, sub: Senate Investigation. . . , in Maj John F. Lane, Spare Parts Notebook, T618; (3) Memo, sub: Conf with Maj G. W. Pillers, Jr., 8 Mar 44, no signature or addressee, OHF; (4) Hist, Spare Parts Proc Policy, 1942, p. 3.

[43] (1) Statement by Boatwright, 29 Nov 44, *Hearings,* Mead Comm., pt. 26, pp. 11927–28; (2) Ltr, Creamer, OQMG, to Tossy, QM Motor Supply Depot, Fort Wayne, Ind., 15 May 42, sub: Misc. Spare Parts Purchases, 1940–41 Vehicles; (3) Hist, Spare Parts Proc Policy, 1942.

was happy to be released from the existing ceiling of 10 percent on parts. He soon established for motor transport the same basic procedure for parts procurement that Ordnance had for combat vehicles—to contract for a two-year supply of parts at the time vehicles were ordered, first-year parts to be delivered with the vehicles and second-year parts six months later.[44] In addition, so-called deficiency spares were ordered as needed to make up for incorrect calculations in the first-year list, and replenishment spares were ordered as needed to keep depot stocks up to par. The weakest link in this chain of supply was the second-year list. Calculated as a percentage—usually 60—of the first-year list, it tended to perpetuate whatever deficiencies appeared in the first-year list and placed an added burden on deficiency procurement. It was abolished in July 1943, after the merger with Ordnance, in favor of a system of quarterly replenishment whereby actual records of consumption and stocks on hand during a given quarter set the pace for procurement during the next quarter.[45]

It should be noted that neither the Quartermaster Corps nor Ordnance attempted to supply spares for all parts of a given vehicle. In fact, the percentage of truck parts supplied as spares was rather low in most cases. In one vehicle, the 3/4-ton weapons carrier made by Dodge, less than one thousand out of some eight thousand separate parts were supplied as spares. The many bits and pieces that went into small assemblies such as generators or carburetors were not issued separately. Nonfunctional parts such as fenders and hub caps were seldom issued at all, for vehicles would still run even if these parts were missing, and replacements could usually be obtained from other vehicles shot up or otherwise damaged beyond repair. Nevertheless, the number of different spare parts was great—some 260,000 for automotive equipment—and posed baffling problems of identification, storage, and distribution.[46]

After the Merger, 1942–45

After the merger of Motor Transport Service with Ordnance in September 1942, the spare parts problem went through several different phases. At the outset, from late 1942 to the end of 1943, the

[44] (1) Memo, Brig Gen Brehon Somervell, ACofS, G–4, for QMG, 5 Feb 42, sub: Automotive Parts, G–4/22528–153, and 1st Indorsement, Frink to Somervell, 26 Feb 42; (2) Memo, Frink for Gregory, 13 May 42, sub: Spare Parts, copy in OHF. See also Admin Order No. 51, MTS, 4 Jul 42, in folder marked Whom Do We Buy From?; Ann Rpt QMG 1942; AG Memo No. W850–5–42, 24 Aug 42, sub: Automotive Parts Policy; and Spare Parts and Supplies Replenishment, in PSP 63, sec. 6, OHF.

[45] The new procedure was authorized by AG Memo No. W–700–32–43, 6 July 1943. It is described in detail in booklet entitled Spare Parts Requirements Policy, Procedure and Practice for Ordnance Vehicles, September 1943, T–AC, copy in OHF. See also Memo, Duffy, OCO, for CG ASF, 27 Mar 44, sub: Spare Parts Proc Policy, OO 451.01/8190; Memo, Howard, OCD–D, for Col Phillips Smith, ASF, 8 Mar 44, sub: Spare Parts Proc Policy, T617; Memo, Col Emerson Cummings for Howard, 21 Mar 44, sub: Spare Parts Policy and Procedure, in folder marked Purchase Policy II, P4337; and Memo, Boatwright for CofOrd, 15 Mar 44, sub: Spare Parts Proc Policy, in folder Whom Do We Buy From?, P4340.

[46] For a discussion of Ordnance parts requirement methods, see Memo, Raaen for Amberg, 25 Jul 44, sub: Further Inquiries in Truman Comm. Ltr. . . , OO 032/416. See also booklet entitled Spare Parts Procurement Policy, Procedure and Practice for Ordnance Vehicles, Sep 43, T–AC, and Clifford and Norman, Proposed Statement on Proc of Spare Parts for Combat and Wheeled (Tank-Automotive) Vehicles prepared by Lt Col Daniel Clifford and Maj J. A. Norman for Possible Use in Testifying Before S. Investigating Comm., Aug 44.

main problem was to meet the insistent demand for production. How the parts were procured was a secondary consideration: the main thing was to get them as soon as possible. After that job was taken care of, attention was turned to the methods used. The Mead Committee in 1944 focused its spotlight on Ordnance spare parts procurement policies and asked a number of searching questions. At about the same time more and more effort was devoted to improving overseas parts supply while ASF attempted to regulate with great care the flow of production and distribution.

Getting Out Production

In spite of everything that was done to speed production, spare parts for both tanks and trucks lagged behind schedule throughout 1942. One reason was that spare parts carried a lower priority rating —in the minds of industrial leaders as well as in government decrees—than did parts for vehicle assembly. Another reason was that requirements for complete vehicles had shot upward in 1942 leaving spare parts to catch up later. Near the end of July, on the day before the Ordnance Parts Division was abolished, General Campbell had written to all District chiefs that shortages of parts had become "so acute that drastic and immediate action is necessary." [47] After setting up four priority ratings for parts orders and directing that assembly of complete vehicles be halted when necessary to make spare parts available, he added that after 1 October 1942 Ordnance would not accept any more major items unless delivery of the corresponding spare parts was up to date. At the same time he wrote directly to K. T. Keller, president of Chrysler, to request his help in dealing with this "nationally serious matter." [48]

But when October rolled around parts deliveries were still behind schedule. General Campbell then sent a teletype to all Districts advising them that henceforth, unless a waiver were granted for a specific contractor, no major item would be accepted or paid for if the corresponding parts were not on schedule.[49] Many contractors protested that this policy was unfair because the fault lay as much with Ordnance as with industry. In cases where parts lists were not available at the time of contract signing the manufacturer had to hold off placing his orders for materials and then later on found himself unable to get prompt delivery. Frequent engineering changes also upset original production schedules and made it extremely difficult to match spare parts with the proper vehicles.[50] Changes in priority ratings added further complications. As a result, rigid enforcement of the October directive proved impossible. After lagging behind throughout the winter of 1942–43, parts

[47] Memo, CofOrd to District Chiefs, 27 Jul 42, sub: Spare Parts for Tanks and Combat Vehicles, ASF Maint Div 451.9 Spare parts policy. See also Teletype, Christmas to Col Alfred B. Quinton, Jr., Chief, Detroit Ord Dist, 16 Jul 42, copy in OHF.

[48] Ltr, Maj Gen Levin Campbell to K. T. Keller, president, Chrysler Corp., 27 Jul 42, OO 451.25/383331.

[49] Teletype, Campbell to District Chiefs, 5 Oct 42, quoted in Clifford and Alspaugh, *op. cit.*, p. 84. See also Ord Fiscal Cir 162, 17 Oct 42, par. 3. For General Campbell's comments on this the following spring, see Rpt Conf Ord Dist Chiefs, Detroit, 22 Apr 44, pp. 23–25, OHF. For copies of Ordnance Procurement Circulars setting forth the new policy, see Spare Parts, Procurement-Contractual Provisions by Capt M. C. O'Neal, Legal Div, OCO, 1 May 45, OHF.

[50] Memo, David J. Long, Chief Spare Parts Mfg Br, T–AC, for Col Milton E. Wilson, 14 Oct 42, sub: Spare Parts Sec Rpt. . . , copy in OHF.

production gradually improved as requirements for complete items were scaled down, parts lists were revised downward, and steady pressure for parts production was maintained. But, in the words of one Ordnance officer, "the results [were] none too good." [51] All during 1943 and into 1944 shortages of spare parts continued.[52]

A major change occurred in the summer of 1944 when the War Department eliminated procurement of first-year or concurrent spare parts, except for new types of equipment. With the Army well supplied, the War Department reasoned that future procurement would be needed chiefly to replace initial issue matériel for which stocks of spare parts had already been created.[53] All the technical services were enjoined to keep a close watch on parts procurement schedules to avoid either overprocurement or short supply. The practice of ordering parts in sets was abandoned in favor of ordering by individual items. Each service was permitted to order specific replenishment parts only as the need for them was shown by stock records and issue experience.[54] As procurement of second-year spares had been stopped in 1943, elimination of first-year spares in 1944 put an end to the complicated pattern of parts procurement in force early in the war period.

Senate Committee Investigation

In the summer of 1943 the Truman Committee turned its attention to the Ordnance Department's handling of spare parts and devoted a good deal of time to exploring all the complexities of the problem. Hearings were held, reports were submitted, and numerous exhibits were introduced into the record. It is probably safe to say that on no other phase of Ordnance wartime procurement was so much effort spent in collecting documentary material.

Intent upon ferreting out examples of waste or mismanagement in the national defense program, the Truman Committee found Ordnance parts procurement an inviting field for investigation on several counts. With roughly half a billion dollars being spent annually for motor vehicle parts, the opportunities for either waste or economy were obviously substantial. Furthermore, in an industry as highly competitive as the automotive, the government had to be constantly on the alert to safeguard its own interests and to avoid charges of favoritism toward any manufacturer or industrial group. Complaints had in fact been made that Ordnance was favoring the Big Three of the automotive industry by purchasing parts for Chrysler, Ford, and General Motors vehicles directly from those concerns instead of from parts manufac-

[51] Memo, Wells for Chief, Ind Div, 2 May 44, sub: Spare Parts Policy and Procedures, in folder Spare Parts, ORDIR, T640–A. On revision of parts lists, see Memo of Col Graeme K. Howard, Director Parts and Supplies, for Chief, T–AC, 3 Jul 43, sub: Rpt for Week Ending 2 Jul 43, in folder D–1 Wheeled Vehicles. See also O'Neal, Spare Parts, Procurement-Contractual Provisions.

[52] (1) Remarks by Maj Gen Thomas Hayes, Rpt Conf Ord Dist Chiefs, New York, 18 Jan 44, pp. 2–5, OHF; (2) Notes for Spare Parts Mtg, 22 Feb 44, by Wells, in notebook marked Spare Parts, ORDIR, T640–A; (3) Memo, Asst TIG to Deputy CofS 12 May 44, sub: Memo, 1 Jan 44. . . , WD Spec Comm. 334, G–4.

[53] WD Cir 227, 7 Jun 44. See also WD Cir 434, 9 Nov 44, and O'Neal, Spare Parts, Proc-Contractual Provisions.

[54] For discussion of the new policy, see Memo, CofOrd for CG ASF, 12 Dec 44, sub: Proc of Spare Parts, and 1st Indorsement CG ASF to CofOrd, 16 Dec 44, copy in OHF, and Memo, CofOrd for Hayes and Hatcher, 16 Dec 44, same sub, copy in OHF. The legal consequences of the new method are treated in Spare Parts Procurement-Contractual Provisions.

turers who were willing to quote lower prices on identical items. Ordnance was charged with refusing to buy directly from the concerns that manufactured certain parts while willingly purchasing the same parts from vehicle manufacturers who bought the parts from the original producers—adding their handling charges to the price paid by the government.[55] It was also alleged that Ordnance was wasting millions of dollars by procuring too many parts of one kind and not enough of another. In particular, critics charged that the supply of small, fast-moving parts like spark plugs and distributor points was below actual requirements while the stock on hand of heavy, bulky replacements like axles and transmissions was too great. All told, the Truman investigation touched upon nearly every facet of the complex problem of spare parts procurement and distribution.

The committee questioned most intensively whether Ordnance should buy parts from the vehicle manufacturer or the parts manufacturer. The chief complaint was that purchase of parts from vehicle manufacturers was not the most direct or most economical method of procurement. Ordnance had always bought most of its spare parts from vehicle manufacturers and stoutly defended that policy. There were exceptions, of course. With track-laying vehicles Ordnance had arranged for a number of facilities before the war to produce specially designed components such as armor plate, transmissions, and track rollers, and when war came Ordnance naturally purchased spare parts directly from these facilities rather than from the tank assemblers.[56] With general purpose vehicles, whose components were of commercial design, the most natural method was to procure parts from the vehicle manufacturer, for he carried a complete line of parts and guaranteed their quality. That was the practice of the QMC until the summer of 1942 when the policy of procuring replenishment parts directly from parts makers was tried for a short time.[57]

Precise definition of certain terms is essential to an understanding of the controversy. Spare parts fell naturally into three classes. Parts peculiar were those that fitted only one make of vehicle and could not be used in any other. Parts interchangeable could be used successfully in two or more makes but would not necessarily fit other types. Parts common, sometimes called standard parts, were such items as batteries, tires, tubes, brake lining, or spark plugs that came in various sizes to fit a wide range of vehicles regardless of their make or model.[58] On parts peculiar there was no argument: they could be purchased only from the vehicle manufacturer. Nor

[55] As an illustration, see remarks by Senator Homer K. Ferguson, *Congressional Record,* vol. 89, pt. 8, 15 Dec 43, pp. 10685–86. These remarks should be read in the light of Memo, Amberg for USW, 17 Dec 43, sub: Senator Ferguson's Statement. . . , copy in Lane, Spare Parts Notebook.

[56] (1) Memo, Duffy, OCO, for CG ASF, 27 Mar 44, sub: Spare Parts Proc Policy, OO 451.01/8190; (2) Memo, Raaen for Chief, Purchase Div ASF, 27 Dec 43, sub: Request for Info. . . , Truman Comm., OO 451.01/7853.

[57] Memo, Raaen for Amberg, 4 Jan 44, sub: Senate Investigation, OO 032/383. For an earlier discussion of QMC policy, see Memo, Barzynski, OQMG, for CO Holabird QM Depot, 30 Oct 40, sub: Purchase of Assemblies and Parts for Motor Vehicles QM 451.01 M–FO (Holabird) directing purchase from parts makers, and 1st Indorsement by Lt Col Van Ness Ingram opposing the move. On 7 March 1941 Colonel Ingram wrote a lengthy memo to The Commanding Officer (apparently of Holabird) on the same subject, copy in OHF.

[58] For a detailed explanation of these terms, see Clifford's Memo for file, 12 Sep 44, sub: Explanation of Variations from Proc Policy. . . , P4337, copy in OHF.

was there much disagreement on parts common, for Ordnance usually purchased such parts from parts manufacturers. It was on parts interchangeable that the argument turned, with the Senate committee favoring purchase directly from parts makers and Ordnance defending its practice of buying from vehicle manufacturers.[59] But the situation was never static for long and by the winter of 1943-44 Ordnance was moving toward procurement of replenishment spares from the parts makers, meanwhile continuing to buy first-year spares from the vehicle manufacturers.[60]

One of the most telling arguments used by Ordnance officers in defending the policy of buying from vehicle producers was that purchase from hundreds of parts manufacturers would demand a large staff to negotiate and administer contracts. Vehicle manufacturers such as General Motors had experienced specialists to handle the job of placing orders for parts with hundreds of subcontractors, scheduling and expediting production, and finally inspecting the finished product, but Ordnance did not.[61] Had Ordnance attempted to bypass these firms and purchase directly from several thousand parts producers, it would have been faced with the virtually insuperable task of recruiting, in the midst of the wartime shortage of manpower, a staff of parts experts. "A government procurement colossus composed largely of inexperienced personnel," one official dubbed it.[62] In addition, the administrative cost of placing and following up thousands of parts contracts with many small concerns would have been great, as would the task of co-ordinating countless engineering changes between the vehicle makers and the parts makers. Employment of hundreds of additional inspectors would have been required at a time when Ordnance was barely able to recruit enough inspectors for its established needs. The result might well have been higher cost to the government, and perhaps slower procurement of critically needed items, or failure to keep up with engineering changes made by the vehicle manufacturer.[63] This

[59] (1) Memo, CofOrd for Chief, Purchase Div ASF, 27 Dec 43, sub: Request for Info. . . , Truman Comm., OO 451.01/7853, copy in Lane, Spare Parts Notebook; (2) Memo, Raaen for Amberg, 4 Jan 44, sub: Senate Investigation, OO 032/383, copy in Lane, Spare Parts Notebook; (3) OQMG Admin Order No. 51, 4 Jul 42, copy in OHF; (4) Draft of statement prepared for use of Maj Gen Lucius D. Clay at proposed Mead Comm., *Hearings on Automotive Spare Parts* in September 1944, folder 334 in D56-347, OCO-D, Field Serv Opns.

[60] Memo, Raaen, OCO, for CG ASF, 21 Jan 44, sub: Purchase of Replacement Parts. . . , OO 451.01/7977.

[61] See Brief for Processing and Development of Concurrent and Replacement Spare Parts Orders Received from Government Procurement Agencies by Chevrolet Motor Div, GMC, Incl to Ltr, E. W. Ivey, Chevrolet, to Maj Robert Bruce, OCO-D, 16 Jun 44, copy in OHF.

[62] Unsigned, incomplete draft of Memo from OCO-D to CofOrd, 28 Mar 44, sub: Specific Info . . . for the Truman Comm. . . , in folder marked Purchase Policy, V, P4337. Similar views appear in Memo, Brig Gen Gordon Wells for Amberg, 25 Apr 44, sub: Specific Info . . . , in Lane, Spare Parts Notebook.

[63] (1) Statement by Boatwright, 29 Nov 44, *Hearings*, Mead Comm., pt. 26, pp. 11,927-28; (2) Memo, Col Phillips Smith, Deputy Director ASF Purchases Div for Browning, Director ASF Purchases Div, 5 Apr 44, sub: Proc of Standard Motor Vehicle Spare Parts, copy in folder Whom Do We Buy From?; (3) Memo, CofOrd for Amberg, Spec Asst to SW, 25 Apr 44, sub: Specific Info Requested by . . . Truman Comm., in Lane, Spare Parts Notebook; (4) Clifford and Alspaugh, *op. cit.*, pp. 69-70; (5) Ltr, Brig Gen Alfred Quinton, Chief Detroit Ord Dist, to CofOrd, 16 Nov 44, sub: Practicability of Purchasing. . . , P4337. See also Memo, Duffy, OCO for CG ASF, 27 Mar 44, sub: Spare Parts Proc Policy, OO 451.01/8190, Memo, Maj Rex Howard, OCO-D for Col Phillips Smith, ASF, 8 Mar 44, sub: Spare Parts Proc Policy, T617; Memo, Col Emerson Cummings for Maj Rex

was the conclusion of all Army representatives who studied the matter, and also of a leading industrialist, Arthur G. Drefs, president of McQuay-Norris Manufacturing Company, who reviewed the whole parts procurement process in Ordnance at General Campbell's request. Although offering certain specific criticisms, and urging more direct purchase from parts manufacturers, Mr. Drefs' report in July 1944 stated that the parts industry as a whole endorsed existing Ordnance procedures and concluded that, in the time available to it in 1942–43, Ordnance "could not have recruited an organization which could have handled the job with the same effectiveness and at the same cost." [64]

But the picture was neither all black nor all white. On some parts interchangeable it was entirely feasible for Ordnance to purchase directly from the parts manufacturer. A leading example was the carburetor. Three companies dominated the field —Bendix, Carter, and Zenith—and the Senate committee counsel, Mr. Meader, successfully argued that Ordnance could purchase replenishment carburetors directly from these concerns with no more trouble, perhaps with less, that it could buy the same items from about twenty truck manufacturers. Direct purchase from the parts manufacturer whenever feasible became the established Ordnance policy during the last year of the war.[65] But in many cases direct procurement was not feasible because the parts manufacturers lacked staffs for handling government business, had no facilities for overseas packaging, preferred to deal with vehicle manufacturers, or positively refused to do business directly with the government.[66]

The Senate committee correctly maintained that, in principle, direct purchasing was better than indirect. It reduced handling and transportation costs, eliminated the middleman's mark-up, and simplified the procurement process. Purchasing of an interchangeable part from the vehicle manufacturer instead of from the parts manufacturer constituted what the committee termed "a kink in the pipe line of supply." [67] But it was a kink that could not be avoided at the start of the war and could be untangled only very slowly as time went on. The war ended long before the policy of purchasing directly from parts makers was put fully into effect.

Overseas Supply

As U.S. Army units moved into overseas bases, reports trickled back to Ordnance that supplies of spare parts were inade-

Howard, 2 Mar 44, sub: Spare Parts. . . , copy in OHF; and Memo, Clifford for Col Olaf P. Winningstad, OCO-D, 11 Sep 44, sub: Problems Involved in Direct Purchase of Parts. . . , copy in OHF.

[64] Ltr, Arthur G. Drefs to Maj Gen Levin Campbell, 27 Jul 44, in folder, Purchase Policy, V, P4337. See also Ltr, T. R. Lippard, president Federal Motor Truck Co., to Maj Robert Bruce. OCO-D, 21 Jun 44, copy in OHF. General Campbell's defense of the Ordnance policy appears in Campbell, *The Industry–Ordnance Team*, Chapter 22. Memos commenting on the Drefs report are in folder, Replenishment, P4338.

[65] (1) Mead Comm., *Hearings*, pt. 26, 20 Nov 44, pp. 11,924–67; (2) Memo, Duffy, OCO, to CG ASF, 27 Mar 44, sub: Spare Parts Proc Policy, OO 451.01/8190.

[66] (1) Memo, Col Phillips Smith for Browning, 5 Apr 44, sub: Proc of Standard Motor Vehicle Spare Parts, copy in folder Whom Do We Buy From?; (2) An Historical Brochure Presenting a Summary of the Activities of the Engineering-Manufacturing Division, OCO-D, 1 Nov 45, P4332; (3) *Hearing Before a Sub-committee . . .* , S., held at Detroit, Mich., 29 Dec 43, in OCO-D Spare Parts History, Project No. 54, vol. 43, P4336.

[67] *Hearings*, Mead Comm., 78th Cong., 2d sess., Rpt No. 10, pt. 20, p. 176, 19 Dec 44.

quate and that vehicles were deadlined for long periods awaiting repairs. Typical of the reports that came through is the following excerpt from a personal letter written by Col. Ward E. Becker:

> Our chief headache continues to be shortage of fast moving maintenance parts, especially those for wheeled vehicles. . . . Our vehicles have received torturous treatment. . . . In general, a 2-1/2-ton truck engine requires 4th echelon rebuild in 10,000 miles, due largely to the lack of parts with which to properly take care of 2nd and 3rd echelon maintenance. Another reason, however, is lack of maintenance discipline. . . . We have rear axles for GMC trucks "running out of our ears" but zero stocks of point sets, main bearing kits, carburetor repair kits, overhaul gasket sets, spark plugs, oil filters, etc. . . . In many units from 50–75% of the vehicles require . . . repairs which cannot be made due to lack of parts.
>
> Pardon my lengthy cry on your shoulder. If you could see our pathetic array of deadlined trucks, I really believe that you would feel that my official tears are justified.[68]

The reasons for these conditions were many. Faulty calculation of requirements, early neglect of spare parts, bottlenecks in the distribution system, ship sinkings, unforeseen conditions overseas—all these entered the picture. A spectacular example of the loss of spare parts occurred during the Italian campaign when the SS *William W. Gherard* sank off the coast near Salerno with more than two hundred long tons of spare parts aboard.[69] At the outset, parts requirements had been estimated hurriedly without benefit of extensive combat experience. Priority was given to complete vehicles, and the tendency, particularly with transport vehicles, was to neglect spare parts. Storage and distribution overseas under primitive conditions added further complications. Parts actually on hand at overseas bases were sometimes as good as lost because they were not properly identified by name or number.[70] Unusual conditions at overseas bases—whether fine sand or volcanic dust that got into oil filters and bearings, fungus that covered electrical equipment, or land mines that broke front axles—caused excessive damage to specific parts.[71] An amusing example was reported to Ordnance by a civilian field investigator who declared that French native troops in North Africa were so imbued with the thought that water was not fit to drink, and so indoctrinated with the importance of good care for their vehicles, that they poured wine into their batteries.[72] Under such circumstances, parts mortality tables were meaningless.

The problem was unpredictable and was never "solved" to the extent that it ceased to be a problem, but some improvement resulted from a new system of overseas packaging adopted in the spring of 1943. At the start of the war, first-year parts were boxed in quantities sufficient to supply one hundred trucks or twenty-five tanks. Each set or quarter set contained a complete line of parts and was suitable for initial supply of a depot or for lend-

[68] Ltr, Becker to Col William Borden, OCO, 1 Aug 43, copy in OHF. See also Memo, Maj Donald C. Pippel to CG, T-AC, 13 Oct 43, sub: Rpt of Travel to NATO. . . , copy in OHF.

[69] Lida Mayo, Ordnance Overseas.

[70] For discussion of "the numbers racket," see below, Chapter XIX.

[71] For other examples, see par. 10 of Memo, Raaen for Amberg, 25 Jul 44, sub: . . . Truman Comm. Ltr. . . , OHF.

[72] This story was told by W. E. Burnett of GMC to Maj Samuel C. Pace, OCO-D, 12 Jan 44. See 4-page report entitled Verification of Statements Made in Ordnance Spare Parts in Mechanized Warfare, and Ltr, Burnett to OCO-D, attn Maj A. E. Hadlock, 21 Sep 44. Both in folder marked Cost of Spare Parts, P4338.

lease shipments of hundreds of vehicles. But the system soon proved too inflexible for everyday use and had to be abandoned. As Colonel Becker's letter reveals, a depot might quickly use up all its fast-moving high-mortality parts like points and spark plugs, and have left over a surplus of little-used parts, like axles. When it ordered additional supplies they came in full sets, including duplicates of all the unneeded slow-moving parts.[73]

To correct this condition the so-called cycle pack was adopted. The essence of the new procedure was to pack parts in the smallest practical quantity that would meet the needs of the lowest echelon of supply. Each box contained only one type of part, was clearly labeled on the outside, and weighed no more than seventy pounds.[74] Under this system depots could requisition only those parts they actually needed, and could issue them in small, usable quantities.

After July 1943 all parts were preserved, packed, and boxed for export, generally at the point of manufacture. There was criticism of this policy by the Senate Committee on the ground that some of these elaborately packaged items were consumed in the United States. Ordnance answered this charge by reporting that the percentage of parts destined for overseas use was great, and rising all the time, and no one could tell in advance which parts would go overseas and which would stay at home. It was considered more economical to pack all parts for export, even if some never went overseas, than to attempt operation and scheduling of dual packaging lines.[75]

Compilation of a 20-volume index of interchangeability data brought some improvement in parts supply. During 1943, OCO-D devoted countless manhours to the tedious job of listing all types of automotive parts by number with cross references to all other parts that were interchangeable.[76] Much of the information on interchangeability came from parts manufacturers who sold to many different vehicle manufacturers, and from the Automotive Council for War Production. With this index, Ordnance depots could quickly determine which parts of different makes of cars or trucks were actually identical. This information increased the usefulness of each part in the supply system and improved service to maintenance companies in the field. But it was so cumbersome and complicated that in some instances it "reposed on the shelves of organizations throughout the war with very little use."[77] When coupled with constant engineering efforts to standardize parts, the interchangeability index, with all its defects, proved to be an effective means of attacking the parts supply problem and

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[73] This system was criticized by Phillip W. Copelin after his trip overseas. See Memo, Raaen for Amberg, 26 May 44, sub: Packaging . . . Spare Parts, copy in Lane, Spare Parts Notebook.

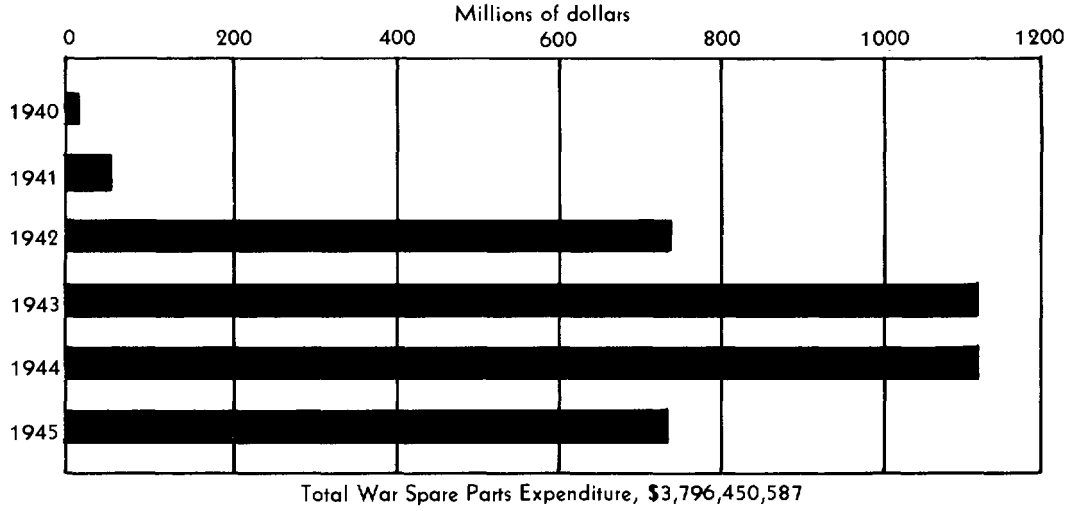
[74] (1) Memo, Col Graeme K. Howard, Director Parts and Supplies, for Chief, T-AC, 3 Jul 43, sub: Rpt of Director, Parts and Supplies . . . D-1 Wheeled Vehicles; (2) Clifford and Norman, Proposed Statement on Proc of Spare Parts, Aug 44, pp. 31-32; (3) Clifford and Alspaugh, *op. cit.*, pp. 20-24.

[75] (1) Ltr, Boatwright to Senator Ferguson, 6 Jul 44, sub: Visit by Senator Ferguson. . . , copy in Lane, Spare Parts Notebook; (2) Memo, Raaen for Amberg, 14 Jul 44, sub: Packaging of Automotive Spare Parts, Lane, Spare Parts Notebook; (3) Clifford and Alspaugh, *op. cit.*, pp. 20-24.

[76] Memo, Col Herbert White for CofOrd, 23 Aug 44, sub: Rpt . . . by Drefs, T617, ORDGL. The index was published in two 10-volume series designated ORD 15-1 and ORD 15-2.

[77] 1st Indorsement, CG Sixth Army to TAG, 8 Jun 48, on DA Ltr, 6 Apr 48, AGAM-PM 451.9 (30 Mar 48).

CHART 2—SPARE PARTS BUYING FOR TANK COMBAT AND MOTOR TRANSPORT VEHICLES, 1940–1945 [a]



[a] The transfer of the Motor Transport Service from Quartermaster Corps to the Ordnance Department in 1942 made an uneven break in certain accounts at a time when continued action was more important than accounting details. Records of expenditures were not kept separately for several of these years and accordingly the above annual allocations are strictly in the nature of estimates which we believe, however, are fairly accurate reflections of actual spare parts expenditures.

Source: Record of U.S. Army Ordnance Combat and Motor Vehicle Spare Parts Policies and Operations from 1940 to 1945, by OCO-D, Nov 45, copy in OHF. Compiled under direction of Lt. Col. Daniel J. Clifford and Maj. R. O. Alspaugh.

earned for Ordnance words of praise from the Mead Committee in December 1944.[78]

Ordnance officers derived some consolation from the fact that they were not alone in finding spare parts supply a persistent problem. When General Somervell attended an Ordnance conference in Detroit in 1944, he offered the following comments on spare parts:

I don't want you to think for a minute this is something that applies only to Ordnance. It is equally applicable to all the other services. We had a terrible time . . . with spare parts for kitchen ranges in QMC. We had a terrible time with spare parts in radio equipment. We are having perhaps the worst situation of all in the Engineers with respect to spare parts for construction equipment and tractors.[79]

Nevertheless, reports that parts were not available when needed made Ordnance officers feel they were failing in their mission to support combat troops. At first they found reports of parts shortages overseas incredible in view of the enormous quantities procured. In the single year of 1943 Ordnance spent $1,364,750,000 on vehicle parts procurement, both concurrent and replenishment, or more than $100 million worth of parts each month. (*Chart*

[78] S. *Report* No. 10, pt. 20, Mead Comm., 78th Cong., 2d sess., 19 Dec 44, p. 169. See also below, Ch. XIX, and Memo, Col Phillips Smith for Browning, 5 Apr 44, sub: Proc of Standard Motor Vehicle Spare Parts, copy in folder Whom Do We Buy From?

[79] Rpt Conf Ord Dist Chiefs, Detroit, 22 Apr 44, pp. 24–25.

2) This represented roughly 27 percent of the $5 billion spent that year on the whole combat and transport vehicles program.[80] Yet parts deliveries were frequently behind schedule, and vehicles were often delivered with some of their tools or spare parts missing. For trucks or tanks at bases in the United States, the problem was usually not serious. But for units in overseas theaters the lack of certain parts or tools could sometimes not be made good for months. Shipping space was at a premium, and supply routes, particularly in the Pacific area, were long and slow. Although reports from overseas struck a more optimistic note in 1944,[81] at the end of the war Ordnance officers were convinced that improved supply of parts to permit more effective field maintenance was one of the Army's most pressing needs.[82]

The spare parts problem is a striking example of the Army's failure to profit fully from its own experience. World War II saw a repetition, with variations and on a much grander scale, of the same type of maintenance failures that plagued the AEF in 1917–18. Indeed, as one historian has remarked, "Turn your field glasses on World War II and you will be looking at the Mexican Punitive Expedition insofar as vehicle maintenance is concerned." [83] There was the same multiplicity of makes and models, the same difficulty with parts supply and field maintenance, and the same encounter with rough terrain and severe climatic conditions.

Had the Army in the 1930's standardized its truck fleet along the lines suggested by World War I experience, the number of different makes and models in World War II would have been held to a minimum and interchangeability of parts greatly increased. But the fleet was not standardized, and in World War II there were actually more different types of vehicles in service than in World War I—about 330 as compared to 216. Standing alone, these figures are somewhat misleading. A few widely used types such as the jeep, the 1-1/2-ton, and the 2-1/2-ton cargo truck accounted for the bulk of all World War II transport vehicles, so the situation in 1945 represented a considerable advance over 1918. The number of different parts needed for tank-automotive maintenance was considerably less than in the earlier conflict—some 260,000 as compared to about 445,000 in 1917–18. Nevertheless, procurement and distribution of such a vast array of items to meet virtually unpredictable demands from all parts of the world imposed a heavy burden on both industry and Ordnance.

Some automobile manufacturers, observing the Army's struggle to supply spare parts to its troops overseas, recommended abandonment of all combat zone maintenance except organizational upkeep. They contended that it would be easier for industry and cheaper for the Army to supply

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[80] (1) Memo, Duffy, OCO, for CG ASF, 27 Mar 44, sub: Spare Parts Proc Policy, OO 451.-01/8190; (2) Memo, Col Emerson Cummings, OCO-D for Maj Rex Howard, 8 Mar 44, same sub, copy in OHF.

[81] (1) Ltr, Brig Gen John W. Coffey, Ord Officer, Hq SOS, NATOUSA, to CofOrd, 24 Jun 44; (2) Memo, Brig Gen Stewart E. Reimel for CofOrd, 30 Jun 44, sub: Automotive Spare Parts; (3) Memo, Raaen for Amberg, Spec Asst to SW, 10 Jul 44, sub: Overseas Rpts on Automotive Parts Supply. All in folder Automotive Parts Supply Situation in Combat Areas. . . , T615. Reference 3 summarizes findings and reports from many sources.

[82] See below, Chapter XXII, for further discussion of field maintenance and supply.

[83] Quoted by Wilfred G. Burgan in The Spare Parts Problem and a Plan, Incl to DA Ltr, 6 Apr 48, AGAM-PM 451.9 (30 Mar 48).

new vehicles instead of repairing those that were worn out or damaged.[84] After the war a modified version of this recommendation was developed by an Army civilian maintenance specialist with long experience with military vehicles. At a Supply Group Staff Conference in March 1948, Wilfred G. Burgan asserted that 15 percent of the different types of spare parts issued during World War II had met approximately 85 percent of all combat zone maintenance needs.[85] He therefore proposed that the Army cease its effort to repair all damaged or worn vehicles and concentrate on those that could be readily repaired in the field with a limited variety of parts. The others might never be repaired at all or might be torn down to yield special parts not normally issued.

Although superficially attractive as a means of quickly solving the parts problem, the Burgan plan met with little favor among Ordnance officers with overseas maintenance experience. They felt that its major premise—that modern warfare precludes higher echelon maintenance in combat zones—was contrary to their experience.[86] In World War II, they declared, the tendency was all the other way, toward requiring lower echelons to perform higher echelon repairs. They asserted that in both the European and Mediterranean theaters higher echelon maintenance was carried on in the field even under fluid tactical conditions. For the acknowledged difficulties encountered in the process they saw no simple or easy solution. Better tables of parts mortality, further standardization of designs, and more complete records of interchangeable parts were all recommended. Patient accumulation of experience data and constant pressure toward standardized components appeared to offer the best prospects for future attacks on this knotty problem.

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[84] *Ibid.*

[85] *Ibid.*

[86] 1st Indorsement, Hq Sixth Army to TAG, 8 Jun 48, on basic DA Ltr, 6 Apr 48, AGAM-PM 451.9 (30 Mar 48). This indorsement was based on the experience of the Sixth Army Ordnance officer, who had been chief of Ordnance maintenance in the ETO.

CHAPTER XIV

Inspection and Statistical Quality Control

Inspection of Ordnance matériel in World War II appears at first glance to have been a fairly cut-and-dried affair. Weapons, rounds of ammunition, and vehicles produced by industry were accepted if they conformed to drawings and specifications, and rejected if they failed to conform. The casual observer assumed that the inspector had merely to examine each item to discover obvious surface defects, make specific measurements, and perhaps check on the weight or other physical characteristics of the item. But Ordnance inspection in World War II was far more complicated than this description suggests. Though some inspection was routine in nature, much of it was complex, difficult, and troublesome. Few Ordnance functions raised as many problems as did inspection; few were as important to the safety and welfare of troops in the field.

Ordnance inspection differed from standard commercial inspection chiefly because of the use to which Ordnance matériel was put. Drawings and specifications for guns and ammunition called for closer tolerances than most commercial work, for a weapon that exploded or failed to fire in an emergency might cause loss of life among American troops, result in a tactical setback, and have a bad effect on the morale of troops. Yet all inspection standards had to be geared to industry's ability to manufacture matériel in quantity to close tolerances. Of necessity, they represented a compromise between the ideal and the practical.[1]

Each class of Ordnance matériel had its own inspection procedures and requirements. Rifles and machine guns were visually inspected, measured with a variety of instruments, and then given the test of actual firing at a small range near the plant. Spare parts for small arms were inspected 100 percent for conformance to specifications. Tanks, trucks, and artillery pieces could be visually inspected, measured, and put through their paces at a proving ground. Inspection of fire control instruments, particularly optical elements, called for special techniques because of the great precision required in their assembly. Ammunition, because of its explosive nature, was in a class by itself. There were many weighing and measuring tests for ammunition, but the only sure way to find out whether a round would function properly was to fire it and thus destroy it. Small arms ammunition required test firing of small samples from each lot, usually at a range near the plant; samples of artillery ammunition were test fired at one of the Ordnance proving grounds.

[1] For discussion of this theme, see Col. Chester Mueller, *The New York Ordnance District in World War II*, Chapter 12.

The broad heading of inspection embraced several different types of activity. "Surveillance" inspection was applied to matériel in storage, such as ammunition, that was subject to deterioration with the passage of time. "In-process" inspection was applied at various stages along the production line to check on processes; it was normally the function of the contractor, not of Ordnance. Another type, known as "screening" inspection, permitted acceptable items to go through and culled out the nonacceptable. Ordnance sometimes applied screening inspection to critical items but this type of inspection was normally the function of the contractor. Ordnance inspectors concerned themselves primarily with "acceptance" inspection, the final acceptance or rejection of matériel offered by the contractor in fulfillment of his contract. But acceptance inspection sometimes called for inspection of matériel during manufacture, before final assembly. Certain gears of a transmission, for example, had to be inspected before the transmission was assembled and placed in a vehicle. This type was really acceptance inspection but was occasionally referred to as "in-process" inspection.[2]

In theory, every piece of ordnance could easily be classed as acceptable or not acceptable by determining whether or not it conformed to drawings and specifications. But inspectors encountered all sorts of borderline cases that called for close study by engineers before final acceptance or rejection. Good judgment had to be mixed with engineering knowledge, familiarity with production processes, and an understanding of the functioning of the end item. No production line could turn out quantities of absolutely identical and acceptable items; there was always some variation, though it might amount to only one thousandth of an inch. Permissible variations shown on Ordnance drawings and specifications in the form of "tolerances" were usually on the conservative side. From experience and training, Ordnance inspectors knew that matériel that deviated from the tolerances set forth in the drawings and specifications might function perfectly—or might fail at a critical moment. Ordnance did not wish to reject serviceable matériel on the narrowly legalistic ground that it did not conform to the letter of the requirements; nor did it wish to take too liberal a view and run the risk of accepting matériel that might prove unserviceable, perhaps even dangerous, when issued to troops. Writing about this problem as it concerned artillery ammunition, one inspection specialist summed the matter up as follows:

> Conformance to a design implies that there exist arbitrary limits to variations in dimensions, in finishes, in materials, and so on. This is true, in a legal sense, since drawings and specifications prescribe such limits. From an engineering point of view, however, there generally do not exist sharp boundaries between good and bad. For most dimensions, and for most other prescribed properties, an increase in variation means either a decrease in effectiveness of the ammunition or an increase in probability of obtaining a malfunction. In most cases, the effect on functioning is very gradual, so that a very considerable variation may exist before the results become apparent in the small sample subjected to proving ground test.[3]

Once matériel passed inspection it was marked with the Ordnance escutcheon, commonly referred to as "the crossed cannon and bomb in circle," using a sten-

[2] Types of inspection are described in ASF M608 Inspection Manual.

[3] PSP 13, Jun 45, vol. I, ch. 6.

cil, stamp, seal, or tag. For some classes of items, identifying lot numbers or serial numbers served as evidence of inspection. When an inspector gave matériel only provisional acceptance he marked it with the Ordnance insigne, the flaming bomb. Artillery weapons that underwent proof testing were marked with the letters "P.A." (for small arms, "P" or a prick punch mark) followed by the initials of the proving ground. Matériel that failed to pass inspection was marked with a stamp, die, red rejection seal, or tag consisting of a large "X" in a circle with the words "Ordnance Rejected." All such matériel was carefully segregated to prevent its entering the production line until reworked to meet Ordnance standards, or until the Office Chief of Ordnance granted a waiver for it or decided to scrap it.

Ordnance did not inspect everything that it procured from industry. In some instances it accepted products on the strength of a contractor's certificate that they met the specifications. The contracting officer might accept such certificates in lieu of inspection when, for example, the product was a standard commercial item and past performance of the contractor had been particularly good. Certification not only helped to conserve inspection manpower but also promoted mutual respect and understanding between industry and the Ordnance Department.

Inspection Manuals

During the 1920's and early 1930's the Ordnance Department procured so little matériel that inspection was not a major problem. Practically every item that came off the production line was painstakingly examined, measured, and weighed. Each arsenal provided inspection service on matériel that fell within its domain; each had on its staff inspectors with long experience in their work. As early as 1922 the Chief of Ordnance, Maj. Gen. Clarence C. Williams, had recommended that the arsenals keep alive the art of inspection and be prepared to train inspectors in a future emergency when the districts would take over responsibility for inspection as part of their procurement function. As one of its preparedness activities, Ordnance in 1935 drafted a General Inspection Manual and circulated it to all the arsenals and district offices, followed three years later by a revised edition and by manuals on specific classes of matériel.

The 1938 manual continued to serve as the basic general guide for Ordnance inspection until 1945. One of the most important principles it set forth was that in-process inspection was the contractor's responsibility and that Ordnance inspectors should, wherever possible, be limited to inspection of end items. The manual set high standards of conduct for Ordnance inspectors because they were the personal representatives of the Ordnance Department in dealing with industry. In the eyes of workers in the plants, inspectors were "the government." "It is the desire of the Ordnance Department," the manual stated, "to have its inspectors . . . respected for their integrity, ability, impartiality, tact, thoroughness, and prompt and business-like methods of conducting inspections." Because they were usually the only government representatives in plants, inspectors were often called upon to perform many services not related to inspection, such as looking after government equipment in the plant or helping to solve production problems.

A few inspection manuals for specific items such as artillery shells and cartridge

cases were in use. They described the items, told how they were manufactured, and listed possible defects that the inspector was to look for. Defects were sometimes classed as critical, major, or minor, depending upon their importance to the proper functioning of the item. For some critical characteristics the manuals required 100 percent inspection; for others they stated that inspection of a certain percentage of items would be sufficient. As a rule, the manuals provided that the percentage of items inspected could be reduced if quality remained consistently high. Thus, during this early period, Ordnance was applying some of the basic principles of statistical quality control by using sampling techniques, classifying defects according to their importance, and gearing inspection to known quality level.

Recruiting and Training Inspectors

The Educational Orders Act of 1938 marked the revival of inspection activities in the district offices. Though the Chief of Ordnance retained in his hands close control over all educational orders, he delegated to the districts responsibility for inspecting the final product. The Boston district hired its first inspector in June 1938 and assigned him the task of bringing up-to-date the district's file of specifications and drawings. He also inspected whatever matériel was procured and, as time permitted, made plant surveys.[4] Other districts followed suit and most were able to recruit competent men to handle inspection of the small quantities of matériel procured under educational orders. Most districts, in fact, hired more inspectors than they needed at the start. The work called for a good deal of traveling, for inspectors usually went to contractors' plants to inspect matériel before it was packed for shipment. Stretching meager district funds to pay for travel of inspectors caused many headaches for district executive officers during the 1938–40 period. Later, when contractors achieved steady output on regular production orders, the districts assigned one or more inspectors to each plant on a full-time basis.

As the inspection work load mounted during 1938 and 1939 the districts appealed to the arsenals for help in supplying qualified inspectors. Nearly every district obtained one or two arsenal inspectors, but the arsenal commanders, faced with mounting work loads of their own, were reluctant to release more. The other source of supply, recruitment through Civil Service, gradually dried up as industry absorbed more and more workers at rates of pay higher than those offered inspectors under Civil Service.[5] At times the districts experienced exasperating delays, some stemming from pure red tape, in obtaining approval by the Civil Service Commission and the Chief of Ordnance of employees hired as inspectors.[6] To help meet such problems, the qualifications for inspectors were lowered, civilian schools were encouraged to offer courses in inspection techniques, and in June 1940 the Chief of Ordnance directed each district to send several of its most promising inspectors to one or another of the arsenals

[4] Hist, Boston Ord Dist, 1922–42, I, pp. 32–33. This history describes in some detail the gradual development of inspection activities in 1938–40.

[5] Inspection, a student comm. rpt, p. 25, 2 Apr 48, ICAF, SR 48–48, OHF.

[6] Hist, Pittsburgh Ord Dist. I, pt. 2, pp. 175–83. This is an excellent detailed account of the Pittsburgh experience in recruiting and training inspectors.

for a 6-weeks' training course.[7] Each arsenal instructed the trainees assigned to it on the items it normally produced, and repeated the courses as new groups of trainees arrived. Meanwhile each district assigned a few of its reserve officers to inspection work. Some took inactive duty training in inspection methods; others spent their terms of active duty in manufacturing plants observing the work of resident inspectors.

The districts were not altogether satisfied with the training their inspectors received at the arsenals. Some of the arsenals gave excellent instruction; others merely turned the students loose in the shops to learn what they could.[8] The main complaint was that the arsenals encouraged inspectors to use their own judgment in dealing with borderline cases. The districts felt that uniformity of inspection could never be achieved if inspectors were permitted to use their own judgment in accepting matériel that did not comply with specifications and drawings. District officials wished inspection standards to be as uniform as possible so that no contractor could complain that his products were rejected while similar products submitted by a competitor were accepted. The districts were keenly aware of the fact that most of their inspectors had too little experience to be counted on for exercise of good judgment on engineering problems.

During 1941 many of the Ordnance districts arranged with local schools or colleges to offer prospective inspectors training in elementary mathematics, physics, blueprint reading, mechanical drawing, machine shop practice, and the use of measuring instruments. During their time of study in these courses the trainees held the rank of Under Inspector, CAF–2, received a salary of $1440 per year, and upon graduation became Junior Inspectors, CAF–3, earning $1620 per year. Trainees received pay during their schooling, because experience had shown that most of those who attended courses without pay took jobs in industry instead of working for Ordnance.

In spite of low salaries and other problems, the districts managed to recruit inspectors rapidly during the defense period. In New York, for example, the number of civilian inspectors jumped from 5 at the end of 1939 to 492 in December 1941; in the latter month the district had 54 reserve officers on active duty and had under inspection roughly 800 prime contracts and 1,000 subcontracts.[9] At the end of 1941, inspectors accounted for about three-fourths of all civilians employed in each district. Most were in the lower Civil Service brackets; only a few were as high as CAF–9. Though they were technicians and should have been considered as Wage Board or subprofessional personnel, nearly all had CAF (clerical, administrative, and fiscal) ratings. As selective service took more men, women were hired to replace them. The turnover among inspectors was appalling. "If it were possible to secure higher grade inspectors," the Philadelphia Ordnance District reported, "it would be possible to handle the work with *less* personnel. This would lead to higher average standards and fewer rejections.

[7] Ltr, CofOrd to Ord districts, 24 Jun 40, sub: Training Courses, OO 381/38900 New York Ord Dist. See also pertinent chapters of histories of the districts in OHF, particularly History of New York Ordnance District, I, Part 2, Pages 41–55.

[8] For a detailed description and criticism of the arsenal courses, see Hist, Rochester Ord Dist, vol. 15, bk. I, pt. 1, pp. 314–28.

[9] Hist, New York Ord Dist, 1 (1939–41), pp. 41–55. See also Hist, Philadelphia Ord Dist, I, pt. 2, pp. 54–55.

. . ." [10] In most districts a commissioned officer directed the inspection staff and served as adviser on inspection to the district chief.[11]

General Somers' Role

Because of the growing importance of inspection, General Harris in July 1941 added Brig. Gen. Richard H. Somers to his staff in the Industrial Service as assistant chief for inspection. He assigned to General Somers responsibility for coordinating the inspection activities of the commodity branches, supervising acceptance testing at the proving grounds, and advising on inspection policies.[12] But responsibility for production, both quantity and quality, continued to rest with the commodity branches and the district offices. General Somers was to be consulted on proposed changes in specifications that had a bearing on inspection, but he had no overriding authority to enforce inspection standards. This basic arrangement continued throughout the war, though General Somers retired in 1942 and his duties were assigned to the Production Service Branch of the Industrial Division.

In spite of some brave talk about making the inspection staff the independent guardian of quality, it never achieved true independence either in the Office Chief of Ordnance or in the districts. General Campbell in the summer of 1942 delegated inspection responsibility to the matériel operating divisions on the theory that the same officials should be held accountable for both quantity and quality. Inspectors in the districts felt that, because commodity branch chiefs gained recognition by meeting production schedules, pressure to boost production sometimes contributed to deterioration in quality. Branch chiefs replied that quality was not absolute but relative. They contended that Ordnance had to deal with hard practical realities and that its objective was to procure the best matériel possible in the quantities required by the Army in the time available.[13]

There was, further, a diversity of practice among the district offices. Though all the districts procuring a given item used the same drawings and specifications there was no enforced uniformity among them on inspection procedures or organization. Early in the defense period the districts complained that some of the drawings and specifications issued by the arsenals were not up-to-date and did not show the latest changes in design. But, as time wore on, these discrepancies were corrected. When the ASF survey team headed by Dr. Luther Gulick visited Cincinnati in April 1942 it found that contractors were generally satisfied that government inspection was both fair and necessary.[14]

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[10] Hist, Philadelphia Ord Dist, I, pt. 2, p. 56.

[11] For an excellent detailed report on all phases of inspector recruitment and training, see Hist, Pittsburgh Ord Dist, I, pt. 2, ch. 3.

[12] (1) General Instruction 22, Ind Serv, 24 Jul 41, OHF; (2) ODO 183, 29 Jul 41; (3) PSP 13, vol. I, ch. 3; (4) Green, Thomson, and Roots, *Planning Munitions for War,* p. 88. For a contemporary statement by General Somers, see his article, "Ordnance Inspection," in *Industrial Standardization,* vol. 13 (June 1942), pp. 155–57.

[13] See comments on this theme in PSP 13, Chapter 6 and Chapter 9, and by Col. D. C. Seagrave in History, San Francisco Ordnance District, Volume I, pt. 2. Compare with Memo, Safford for Asst CofS for Matériel, SOS, 3 Feb 43, sub: Ordnance Inspection System and Memo of Safford for Production Division, ASF, 8 April 1943, sub: Inspection Manual. Both in OHF.

[14] Cincinnati Field Survey, Apr 42, p. 10, ASF Contl Div.

Inspection Gages

As mentioned in an earlier chapter, during the 1930's nine of the Ordnance districts set up gage laboratories, usually at universities, where acceptance gages could be checked for accuracy. In 1940 and 1941 the remaining districts and all the arsenals established similar laboratories, raising the total to nineteen.[15] As the Ordnance inspection force grew during the defense period, and as more and more items of equipment went into production, the need for gages and gage laboratories steadily rose. A single example illustrates the scope of the problem: one type of fuze for the 75-mm. shell consisted of some thirty-five metal parts and required over two hundred different gages for its inspection.

Ordnance met the early demands by using the half million old gages in storage. In 1938 and 1939 the Ordnance Gage Section vigorously pushed efforts to design gages for all items that were reasonably sure of going into production. In July 1940 approximately $2.5 million was made available to start production of new gages well ahead of the signing of major procurement contracts. In October 1940 President Roosevelt approved a $4 million program to enable gage manufacturers who had already expanded their plants with their own funds to increase their production capacity still further.[16] As the Ordnance Department was the agency with the greatest need for gages it was placed in charge of the expansion of gage capacity for all elements of the Army and Navy. In 1941 Ordnance gave another boost to gage production by purchasing machine tools and leasing them to gage manufacturers.[17]

These timely steps averted a critical shortage of gages that might otherwise have developed. But Ordnance occasionally had to resort to temporary expedients. By the end of the defense period, when production volume was rising fast, Ordnance inspectors sometimes had to borrow gages from contractors whose products they were inspecting. Whenever this was done the borrowed gages were first sent to a district gage laboratory to be checked for accuracy. Later, as Ordnance gage procurement caught up with demand, inspectors were required to submit their gages to a laboratory at intervals for checking. As an added safeguard, roving teams of gage checkers visited plants, examined Ordnance gages, and checked on their use.[18]

Proving Grounds

From its establishment in World War I, Aberdeen Proving Ground in Maryland had been the principal Ordnance center for proof firing of weapons and ammunition, but it was not capable of handling the heavy, diversified work load anticipated in 1940–41. Ordnance had established a second test center during World War I, Erie Proving Ground adjacent to

[15] Hist of the Gage Sec and Gage Facilities Section, Ind Serv, OCO, I, pt. 1, p. 5. This history contains copies of many pertinent documents.

[16] Ltr, President to SW, 15 Oct 40, copy in OHF.

[17] Ltr, CofOrd to Boston Ord Dist, 6 Jun 41, sub: Expansion of Gage Facilities. . . , copy in OHF.

[18] Hist of the Gage Sec and Gage Facilities Section, OCO, vol. I, pt. 1. See also Summary Report on Gages by Col William Borden in Min, Wesson Confs, 23 Jan 42, pp. 1, 292–93; collection of gage directives in Hist, Ind Serv, vol. 100; Mueller, *op. cit.*, ch. 12; and Hist, Chicago Ordnance Dist, vol. 107, ch. 5.

Camp Perry, Ohio, but had converted it in 1920 from a proving ground to a Field Service storage depot. Late in 1940 Ordnance decided to re-establish Erie as a proving ground for acceptance testing of guns, carriages, mounts, recoil mechanisms, and armor plate. At about the same time Ordnance selected a 50,000-acre site for a new proving ground near Madison, Indiana, in the heart of the ammunition-producing area. Named Jefferson, it was to proof fire all types of ammunition, ranging from small 20-mm. rounds up to heavy 240-mm. shells, from hand grenades to giant bombs. The first shot was fired at Jefferson on 10 May 1941, just a short time before construction began on another 50,000-acre proving ground near Hope, Arkansas. Named Southwestern, it had the mission of proof testing primers, fuzes, boosters, cartridge cases, propellants, bombs, pyrotechnics, and, late in the war, rockets. It fired its first shot on New Year's Day 1942. As these three new proving grounds came into service Aberdeen did less acceptance testing and devoted more time to research and development tests.[19]

Statistical Quality Control

One of the most significant developments in Ordnance inspection during World War II was the use of statistical sampling techniques under the name of "quality control." The origins of this practice in industry are usually traced back to the year 1924 when Dr. Walter A. Shewhart and his associates in the Bell Telephone System began to apply statistical analysis to the inspection of large numbers of production items. Seven years later Dr. Shewhart set forth the principles of what some writers called "a new science" in his book, *The Economic Control of Quality of Manufactured Product* (New York: D. Van Nostrand Company, 1931). But progress in the industrial application of the principles was slow.[20]

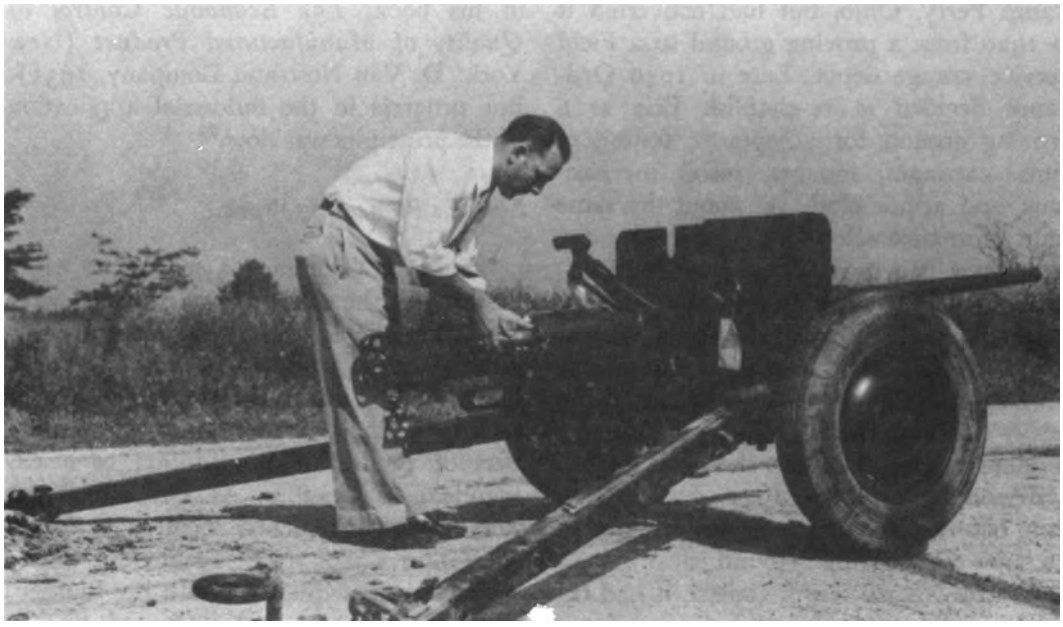
Simon's Pioneering Work

The first Ordnance Department experience with the subject came in 1934 when 1st Lt. Leslie E. Simon at Picatinny Arsenal began to study and apply Dr. Shewhart's work. Picatinny was a logical choice because it endeavored to make large numbers of rounds of ammunition as nearly identical as possible. As Dr. Shewhart's home was conveniently located in nearby Mountain Lakes, N.J., Lieutenant Simon soon became acquainted with the "father" of quality control and interested him in becoming a consultant to the arsenal. Under Simon's direction the arsenal drew up and published a practical pamphlet for shop use called Instructions for Control of Quality Thru Percentage Inspection.[21] In spite of the gains registered in the early tests, Picatinny's interest in the subject waned after Simon's transfer in 1937, and was not aroused again until the danger of war brought the need for mass production of munitions. In 1941, Simon, now a major and assistant director of the Ballistic Research Laboratory at Aberdeen Proving

[19] See PP 68, Proving Grounds, Aug 45, and histories of Aberdeen, Erie, Jefferson, and Southwestern, OHF.

[20] For an excellent brief summary of the prewar developments, and evaluation of the contributions of Shewhart and 1st Lt. Leslie E. Simon, see S. B. Littauer, "The Development of Statistical Quality Control in the United States," *American Statistician*, vol. 4 (October 1950), pp. 14–20.

[21] Reprinted in app. C of *An Engineers' Manual of Statistical Methods* by Maj. Leslie E. Simon (New York: J. Wiley and Sons, 1941).



LABORATORY FOREMAN LOADING 37-MM. ANTITANK GUN *for test shot at Erie Proving Ground, July 1941.*

Ground, published some of his thoughts on the matter in book form under the title, *An Engineer's Manual of Statistical Methods,* which soon found its way into college classrooms as well as into industrial plants.

Simon illustrated the nature of the problem faced by inspectors dealing with mass production items by pointing out that small samples taken at random from a moderately defective lot of items would not accurately reflect the quality of the lot; they would consistently show a lower proportion of defectives than the average for the entire lot. If, for example, Ordnance set up a requirement that each lot of one hundred items would be accepted when a sample of ten items selected at random from the lot contained not more than one defective item, it would in fact be accepting lots that averaged a good deal more than 10 percent defective. A commonly applied remedy for this condition was to require that the inspection sample contain no defectives at all. But Simon found this remedy far from satisfactory. "It is true," he wrote, "that it somewhat reduces the chances of acceptance of poor quality; but its penalties fall both on the just and the unjust, and it results in rather high rejections of relatively good quality." [22]

Simon's answer to the problem was not to reject the sampling technique but to buttress it with other evidence by keeping records that would tell the history of a given production run, would indicate its expected quality level, would sound the alarm when any variation in quality occurred, and would tell the producer when

[22] Simon, *op. cit.,* p. 11.

and where to look for trouble. The practical man, Simon noted, does not confine himself to the evidence of the sample, but instinctively considers everything he knows about the production process. This was essentially the line of thought earlier developed by Dr. Shewhart; it became the basis for the application of statistical sampling or "quality control" in Ordnance World War II inspection.[23]

The Edwards Survey

Soon after the Japanese attack on Pearl Harbor, General Somers decided to explore the possibility of making further use of statistical sampling techniques in Ordnance acceptance inspection. Their use was growing in industry and they were being applied for special purposes in the Ammunition Division, at the arsenals, and at Aberdeen Proving Ground. According to their proponents, these techniques yielded better control of quality, required fewer inspectors, and reduced the amount of matériel destroyed in testing. The importance of this latter item is suggested by the fact that in 1942 Ordnance was shooting up enough armor plate in ballistic tests to make approximately thirty medium tanks a month.[24] One of the first steps taken by General Somers was to enlist the services of George D. Edwards, director of quality assurance of the Bell Telephone Laboratories, as consultant to the Ordnance Department. Edwards was asked to survey existing Ordnance inspection methods and recommend ways of increasing their effectiveness by using the newest techniques of statistical quality control.[25]

The Edwards survey revealed that there was much room for the use of quality control methods in the acceptance inspection of matériel produced for Ordnance by industry. Lieutenant Simon's work at Picatinny had dealt mainly with in-process inspection of matériel being manufactured at the arsenal, and the bulk of all Ordnance inspection during the interwar years had been of this type. But by 1942 the situation had changed. The arsenals were producing only a small percentage of the Army's munitions. Industry was the chief source of new matériel, and the Ordnance task was that of acceptance inspection of industry's products. The Edwards survey also revealed that few persons in Ordnance, whether military or civilian, knew anything about quality control, and many were opposed to its adoption in their fields of inspection.[26]

Edwards took an eminently practical approach to the inspection problem. He recognized that no feasible plan of inspection would guarantee rejection of every defective item. The best that any inspection system could hope for was reduction to a minimum of the risk of accepting defective items without unduly holding up production. "The hard facts are," he wrote, "that we must have ordnance and we must accept and get along with ord-

[23] For a detailed description of Ordnance practice, see lecture by Walter S. Oliver, Standard Sampling Procedures, at University of Michigan, 11 December 1944, copy in Inspection Br file, and H. F. Dodge, "A Sampling Plan for Continuous Production," *Annals of Mathematical Statistics,* vol. XIV, September 1943, pp. 264ff. *The Production Handbook* (New York: Ronald Press, 1947), edited by Leon P. Alford and John R. Bangs, contains, in Section 10, an extensive description of quality control methods.

[24] PSP 13, ch. 3. See description of sampling procedures in History, Birmingham Ordnance District, Volume I, Part 1, Chapter 5.

[25] Ltr, Somers to all dists, 21 Feb 42, sub: Statistical Methods of Quality Contl, copy in PSP 13, ch. 3.

[26] No copy of the Edwards report has been found but it is briefly summarized in PSP 13, Chapter 3.

nance of the highest quality which can be produced in the quantities which we must have under present conditions." [27] The problem was to determine a level of acceptable quality and then draw up a statistical sampling plan that would pass matériel of the desired quality and would immediately sound an alarm when quality fell below that level.

The Quality Control Campaign, 1942–43.

The plan of campaign that resulted from the Edwards report called for two distinct attacks on the problem. Ordnance was to select one or more suitable types of matériel and apply quality control principles to their inspection. This would provide working examples of the system. The other attack was to develop a training program within Ordnance to teach the basic principles of quality control.

Ballistic testing of armor plate was selected as one area for the application of quality control principles, beginning in July 1942. The method involved plotting on a control chart the results of tests on armor submitted by each manufacturer. If the chart for a given manufacturer indicated that he was consistently producing acceptable armor Ordnance reduced the number of tests made on his product by two-thirds. Testing continued at this reduced rate as long as the chart indicated that the manufacturer was properly controlling the quality of his production. But if the number of rejections exceeded a certain level the reduced inspection rate was discontinued, inspection went back to normal, and a search was made for the factor that had caused quality to decline. Ballistic testing was, of course, by no means the only way of assuring quality of armor. Laboratories at the contractors' plants performed metallurgical tests; the manufacturers' knowledge and past experience in steelmaking gave added assurance that their production methods were sound.

Beginning in September 1942 the Inspection Branch, under Edwards' direction, conducted a series of 3-day conferences on statistical quality control. Some 220 officers and civilians from the district offices, arsenals, plants, works, and proving grounds, attended and gained at least a rudimentary knowledge of the basic principles.[28] One of the main themes stressed at the training conferences was that in-process inspection was the contractor's responsibility. The conference leaders demonstrated that sampling inspection, by accepting or rejecting large lots on the basis of small samples, would force contractors to screen out defective items before presenting a lot to Ordnance for acceptance. If contractors did not do so they would run the risk of having large lots rejected and sent back for screening.[29] While the training conferences were being held the Industrial Division issued a directive to the effect that Ordnance inspectors should perform only acceptance inspection. It called for the elimination of all in-process inspection that had been provided to aid contractors in getting production

[27] George D. Edwards, "Quality Control of Munitions," *Army Ordnance,* XXIII, No. 135 (November–December 1942), 482–85.

[28] Ltr, CofOrd for Dist Offices, 2 Nov 42, sub: Quality Contl Program, copy in OHF; Ltr, Maj Gen Thomas Hayes, Chief of Ind Div, to all Ord Dists and Others, 22 Feb 43, sub: Quality Contl Program, OO 337/4515.

[29] As an example, see Summary of the Quality Contl Conf held at Birmingham Ord Dist, 23–25 Sep 42, copy in Hist, Birmingham Ord Dist, I, pt. 1, ch. 5.

under way.[30] By February 1943 the Industrial Division was able to report that over 400 inspection plans embodying quality control principles in the inspection of some 150 types of matériel were in effect. To push the program further, General Hayes in that same month directed the branches of the Industrial Division, the Tank-Automotive Center, and all the district offices to appoint an officer or civilian to be responsible for quality control.[31]

As a result of these and related efforts, the number of Ordnance inspectors per million dollars of accepted matériel dropped from forty in September 1942 to about nine in April 1943. While the value of accepted matériel rose from $500 million in September 1942 to $1400 million in April 1943, the total number of Ordnance inspectors dropped from twenty thousand to thirteen thousand. "Such a record," wrote one inspection specialist, "can be attributed entirely to Ordnance contractors accepting the responsibility of producing satisfactory material before presenting it to Ordnance for acceptance." [32] But there were other elements in the picture, too. The Army-wide drive to conserve manpower was in full swing during the winter of 1942–43; in some instances Ordnance reduced its inspection force at the cost of lowered quality. Some economies naturally resulted from volume production as well as from increased use of sampling methods. As manufacturers got into production and gained experience with Ordnance requirements the need for meticulous inspection of every item by Ordnance inspectors declined. The Boston district conserved inspection manpower by forming small teams of traveling inspectors to handle the work at plants that did not produce enough matériel to justify full-time resident inspectors.[33]

At no time did Ordnance tell its contractors exactly what inspection to perform. It gave advice when requested and made a practice of conferring with each contractor on inspection matters as soon as his contract was signed. But it did not give its contractors detailed instructions on how to inspect. Had it done so Ordnance would have been morally bound to accept what the contractors turned out in accord with those instructions. Instead, Ordnance kept its hands free to accept or reject the finished items presented to it.[34]

The Trundle Report

While Ordnance was thus feeling its way in the quality control area, Army Service Forces decided to prepare an Inspection Manual as a means of simplifying and co-ordinating the inspection procedures of all the technical services. To this end it enlisted the services of the Trundle Engineering Company of Cleveland, Ohio, to survey existing practices and later prepare the manual.[35] When they made their

[30] Ltr, Maj Gen Thomas Hayes, Chief of Ind Div, to Ord field installations, 3 Oct 42, sub: Clarification of Functions of Ord Dept Field Staff. . . , copy in OHF.

[31] (1) Ltr, Maj Gen Thomas Hayes to All Ordnance Dists and Others, 22 Feb 43; (2) Ltr, Safford to All Dists, 15 May 43, sub: Quality Contl Program, copy in OHF.

[32] G. Rupert Gause, PSP 13, ch. III.

[33] Boston Ord Dist, Mobile Group Plan of Inspection Control, n.d., copy in Inspection Br file. See also Hist, Boston Ord Dist, II, p. 5, and IV, pp. 6–8.

[34] For comparison of Ordnance and Army Air Forces inspection policies on this point, see Memo Report by 1st Lt D. F. Boyd, AAF Matériel Center, 30 Aug 44, copy in Inspection Br file.

[35] Memo of Brig Gen Hugh Minton, ASF Prod Div, for CofOrd and others, 30 Mar 43, sub: Inspection Manual, copy in OHF. See also Memo, Safford for Resources and Prod Div, ASF, 8 Apr 43, sub: Inspection Manual, copy in OHF.

report in the summer of 1943 the Trundle analysts observed that the inspection mission of the technical services had become "a stupendous and complex task." [36] This task had grown with bewildering speed from the peacetime year 1939, when the U.S. Army numbered about 188,000 men, to the second year of war when the strength of the Army exceeded 7,000,000 men and annual expenditures for munitions ran into the billions of dollars. "Haste inevitably contributes to confusion, friction and ineffectiveness," the report continued. As a result it found that there was urgent need for improving, simplifying, and standardizing the inspection work of all the technical services.

The section of the report dealing with Ordnance criticized the districts for placing incompetent persons in responsible positions, for maintaining only loose control over inspectors, and for tolerating—or being ignorant of—"inefficient handling and duplication of forms in the field offices of the resident inspectors." The report scored the lack of uniformity among the inspection practices of the Ordnance districts, pointing out that one district would accept such raw materials as steel, paint, grease, and oils without inspection or test while another district would go to great lengths to inspect and test the same material.

Considering all the technical services, and without special reference to Ordnance, the report concluded that government inspectors were doing too much in-process inspection. It did not cite examples of undesirable Ordnance in-process inspection, nor did it describe the history behind the situation that it criticized. As noted above, the demand for production had been so great during 1941–42 that Ordnance had tried to help speed output by placing inspectors in plants to perform inspection that the contractors would normally have performed themselves. But after October and November 1942, when the districts were ordered to stop this practice, the only type of so-called in-process inspection officially approved was the inspection of certain parts, such as gears in a crankcase, before they were assembled and became inaccessible.[37]

The report also concluded that none of the technical services was making enough use of statistical quality control, though the report did not spell out in detail how or where Ordnance was deficient. In view of the pioneering work the Ordnance Department had done in this area the Ordnance inspection staff felt that this criticism was not fully justified. Ordnance had pushed forward with the adoption of statistical quality control techniques during the preceding year at what was considered to be prudent speed. It had gone farther and faster than any of the other technical services and was steadily advancing at the time the Trundle survey was made. The Ordnance inspection staff felt that it deserved commendation for its achievements rather than censure for its shortcomings.

Commodity Groups

The real story of Ordnance inspection can be told only by dealing with individual groups of commodities handled by the matériel operating divisions of the In-

[36] Rpt of Inspection Survey for Inspection Sec, Facilities and Inspection Br, Prod Div, Hq ASF, by the Trundle Engr Co., 1 Jul 43, copy in Inspection Br, Ind Div, OCO.

[37] *Ibid.* See also Saunders, "Standardized Inspection," *Army Ordnance,* XXIV, No. 137 (March–April 1943), 290–92.

dustrial Service. Each group was different. Each had its own peculiar problems and each found its own solutions. The following accounts put the spotlight briefly on rifles, tank-automotive matériel, and fire control instruments as three fairly representative types.[38]

Rifles at Springfield Armory

The history of the inspection of rifles at Springfield Armory sheds a good deal of light on the difficulties Ordnance inspectors encountered during the war and the progress they made in improving quality. In peacetime, when Springfield turned out only small quantities of rifles and rifle parts, inspection was a slow and painstaking business. High quality craftsmanship was the order of the day. But with mounting requirements for M1 rifles in 1940 and 1941 the armory was called upon to expand its shops and turn out rifles by the million. Under these circumstances inspection had to take a back seat. Minor defects in parts were ignored if the rifle fired satisfactorily when tested. All rifles were test fired with one high-pressure proof round and twenty or more normal rounds. A small percentage from each lot underwent a 6,000-round endurance firing; and a few were disassembled and checked for interchangeability. But there was no insistence on rigid adherence of all parts to drawings. In 1944 Dr. Constance McLaughlin Green, armory historian, wrote as follows:

> The drive to meet schedules had increased month by month in intensity to a point where standards of work had been somewhat undermined, from machine operator up through top inspection ranks. Rifles shipped out had, to be sure, always met function tests. . . . But this was true in spite of the fact that separate components often failed to meet the gage requirements. Presumably the tolerances entered on the drawings were closer than functioning of the assembled parts demanded. Still it was far from an ideal situation for the plant that was to serve as the model for all small arms manufacturers.[39]

In January 1944, with pressure for production eased, Lt. Col. William Gallagher took charge of the Inspection Department and mapped a vigorous campaign to improve quality. Though no complaints of defective rifles had come in from the field, the armory determined to improve its product in every way possible. After thorough study of the problems involved, Colonel Gallagher outlined four major steps:

(1) *Housecleaning in the manufacturing department.* Tools, fixtures, and machines that had been continually in use during the months of heavy production were to be overhauled and put into the most perfect adjustment attainable.

(2) *Floor inspection at every machine.* Instead of inspection at the end of three or four operations, a system of floor inspection at every machine was to be inaugurated so that machines in need of resetting or new cutters would be promptly detected and serviced.

(3) *Education.* The need for raising quality and holding every part within prescribed tolerances was to be sold to everyone in the armory, from machine operators up to production engineers and chief

[38] Inspection of small arms ammunition has been given some attention above in Chapter IX.

[39] Hist, Springfield Armory, vol. II, bk. III, Jan–Jun 44, pp. 473–74. See criticism of inspection at Springfield Armory in Ltr, Lt Col Stanley H. Ellison to TIG, 14 Oct 43, sub: Spec Inspection of Springfield Armory.

inspectors. All employees were to be taught that quality was just as important as quantity.

(4) *Periodic checking of manufacturing gages.* The general practice earlier had been to send gages back for checking only when a foreman or an inspector had reason to believe that they were worn. By setting up a schedule for checking each gage periodically it was hoped that faulty gages would be eliminated as causes of manufacturing inaccuracies.

The arsenal commander promptly approved Colonel Gallagher's proposals. They went into effect during the first six months of 1944.[40]

At the same time the armory's inspectors were divided into two groups: manufacturing inspectors and acceptance inspectors. Complying with the ASF Inspection Manual issued in March 1944, the armory put its production division in the same position as an Ordnance contractor by divorcing in-process inspection from acceptance inspection. All manufacturing operations and in-process inspection were to be performed under authority of the Manufacturing Department; the finished products were then to be turned over to the final inspection staff for acceptance or rejection. At the same time the final inspection staff began placing all components of the M1 rifle on a statistical sampling basis.

The over-all results of these two steps were found to be good, but quality still did not rise to the level desired by the Chief of Ordnance. During the early months of 1945 the armory inspection staff held weekly meetings to get to the bottom of the problem. The experts went over every component, studied its methods of manufacture, and examined its gages. But progress was slow and piecemeal with no major improvement before the end of the war.

Tank-Automotive Matériel

Ordnance inspection officials realized early in World War II that they could not apply traditional inspection procedures to products of the automotive industry. The very magnitude of the task was appalling even when Ordnance had only combat vehicles to consider, for each tank and gun motor carriage consisted of thousands of individual parts. After the transfer to Ordnance of transport vehicles in September 1942 the inspection job reached staggering proportions. "The complexity of parts as well as automotive sub-assemblies," wrote one observer, "caused inspectors to throw up their hands at the practicability of any statistically and technically logical approach. . . ." [41] The Ordnance inspection staff recognized that the procedures developed over the years for inspection of "shooting ordnance" would, if applied to automotive products, result in too much inspection and the wrong kind of inspection. There was, for example, no danger of explosion in the normal operation of trucks or tanks such as there was with weapons and ammunition. Nor was the process of manufacture unfamiliar to industry. The manufacture of military trucks was to a large extent the same as manufacture of civilian trucks; even tanks were made up in part of components similar to standard commercial items. "We are dealing with the largest and most responsible industrial

[40] (1) Hist, Springfield Armory; (2) William H. Davis, PSP 37, U.S. Rifle Caliber .30, M1, History of Design, Development, Procurement and Production, 1936 to 1945 (Jul 46), pp. 42–43, OHF.

[41] PSP 13, ch. 3, p. 16.

units," wrote the chief of the Inspection Branch on OCO–Detroit, "where no one in his right mind would endeavor to furnish substandard matériel for any reason whatsoever." [42] Though Ordnance felt that the manufacturers of tank-automotive matériel could be depended upon to produce acceptable matériel, it also realized that occasional lapses were inevitable and that a certain degree of inspection was necessary to protect the government's interests. Inspection policies were kept broad and flexible to permit their application to a wide variety of manufacturers.

Standard Ordnance procedure called for a functional test of every complete vehicle before it was accepted. This test included operating the vehicle on the road and trying out major units such as winches, lift devices, and turret traversing mechanisms. The contractors conducted these tests, under the eyes of Ordnance inspectors, at small test areas adjacent to the plants. To supplement such tests the Ordnance inspection force selected a few vehicles from each assembly line for special testing at one of the Ordnance proving grounds. These "inspection control tests," as they were called, proved to be valuable as checks on the manufacturers, as a means of revealing weaknesses in design, and as a test of packing procedures.

Subcontractors who manufactured engines, transmissions, axles, and other major components ran each of these items on a test stand before delivering it to the assembly plant. As a rule, this functional testing was done on a 100 percent basis. Little use was made of statistical quality control procedures, except in ballistic testing of armor, inspection of tank track components, and acceptance of pneumatic tires and tubes. With combat vehicles the proof firing of gun mounts was an added means of assuring that vehicles would perform properly. Ordnance also conducted interchangeability tests at the manufacturers' plants or at the proving grounds on components selected at random from process lines. These tests were spot checks only, for Ordnance did not insist upon complete interchangeability of automotive equipment. In peacetime the automotive industry had never achieved 100 percent interchangeability; it was generally understood that in using spare parts some slight fitting was necessary. Ordnance realized that it was not feasible, in time of manpower shortages and high production goals, to insist upon a degree of interchangeability never attained by industry.

Ordnance inspection of tank-automotive matériel was marked by great diversity. The basic policy provided that Ordnance would conduct inspection upon end items and as far back in the production chain as necessary to assure quality products. Tank-automotive production was characterized by assembly in the prime contractor's plant of many complicated subassemblies such as engines, transmissions, and axles. No single type of inspection would fit all these components. With some, materials and heat-treating controls were the essence of quality. With others, dimensional characteristics were the keys to proper performance. With still others there were simple operating tests that gave adequate assurance of quality. Most of the Ordnance tank - automotive contractors had enviable records in industry for quality production, but some were newcomers to the business who had little previous experience in making the parts needed by

[42] Maj F. A. Gitzendanner, Hist of Ord Inspection of Tank-Automotive Matériel, Dec 41–Sep 45, p. 4, OHF.

Ordnance. Inspection requirements had to be tailored to fit the needs of each case.

Fire Control Instruments

Binoculars, telescopes, directors, and other fire control matériel ranked as perhaps the most difficult class of items for Ordnance inspection. They presented a wide variety of problems, for they included mechanical, electrical, optical, hydraulic, and electronic instruments. Production of good optical glass required careful control; machined parts of fire control instruments had to be held to close tolerances; and assembly of optical elements called for meticulous accuracy. Evaluation of the importance of scratches, pits, and stain on surfaces of optical elements was largely a matter of experienced judgment, as was the determination of allowable distortion in the glass. Dependence on human judgment led to innumerable difficulties. Added to these problems was the need to use inexperienced inspectors and to meet constant demands for speedy production. "I think no one would willingly sacrifice or adulterate the quality of Ordnance supplies going to the fighting forces," wrote the chief of the Fire Control Sub-Office, Col. Gordon B. Welch, in March 1945. "However, that has to be tempered with judgment when the attainment of high quality prevents the fighting forces from having anything at all. I . . . have never hesitated to lower the quality in particular cases when it was necessary to meet our objectives." [43] As a result of all these circumstances, Ordnance accepted far too much unsatisfactory matériel in the early war period. American and British troops in North Africa in 1942–43 sent back a stream of complaints about defective fire control instruments.[44]

Reports that defective matériel had been issued to troops shocked the Chief of Ordnance and his staff. To correct the situation the Artillery Division strengthened the Inspection Section of the Fire Control Sub-Office at Frankford and set up new procedures calling for prompt action on reports of defective matériel. The chief of the sub-office wrote official letters to all the district offices and followed them up with a personal appeal to each district chief to stop the acceptance of substandard matériel. The Inspection Section pursued a vigorous program of interchangeability tests coupled with investigation of all deficiencies. As measured by these tests and by the number of defective matériel reports that came in, the quality of fire control instruments rose steadily from August 1943 to the end of the war.[45]

Some reports of defective matériel, thought to be caused solely by inadequate inspection, proved to be due wholly or in part to engineering design. With binoculars, for example, Ordnance received many reports that moisture and dirt had got into the instruments. As inspection standards for binoculars were strict, the reports were puzzling. Even after Ordnance began packing the instruments in vaporproof barriers with silica gel the reports persisted. Finally, a study of a large number of defective binoculars at Augusta Arsenal revealed that the so-called dirt within the binoculars was the result of a chemical

[43] Ltr, Col Gordon B. Welch to Dr. H. S. Newcomer, Dioptric Instrument Corp., 20 Mar 45, copy in OHF.

[44] Ltr, Welch to Dist Chiefs, 9 Aug 43, sub: Inspection of Fire Control Instruments, copy in PSP 12, ch. V. See also Hist, Ind Serv, Arty Div, p. 321.

[45] For evidence on this score, see Reports of Defective Fire Control Matériel, ex. 21 in Hist, Ind Serv, Arty Div, ch. 10.

action on the reticle cell, which was made of secondary aluminum. Investigation also proved that after the binoculars underwent the rain test at the plant they contained minute quantities of water that escaped detection by the inspection measures then in use. Once these facts were brought to light, corrective measures were taken, and reports of defective binoculars dropped almost to zero.[46]

Most fire control instruments did not lend themselves to inspection by statistical sampling, chiefly because they were produced in small numbers and did not involve a high volume of repetitive operations. As a matter of policy the Fire Control Sub-Office made little use of quality control. Along with artillery weapons themselves, fire control instruments ranked lowest in the Ordnance list of items inspected by statistical quality control methods.[47]

All things considered, the Ordnance record on inspection was checkered. With some items there was always a gap between the quality prescribed by the drawings and specifications and the quality of the matériel actually accepted. Ammunition, for example, was produced in huge quantities and won an enviable reputation for quality and reliability. But it was not perfect. Even late in the war, after more than two years of steady production, one investigator who checked on the manufacture of metal parts for fuzes reported that, "the quality of matériel being accepted by Ordnance inspectors is nowhere near that which has been established as acceptable." [48] The same was true in greater or less degree of weapons, both small arms and artillery, and of trucks and combat vehicles. They functioned well, as a rule, but they did not always comply exactly with specifications and drawings. In many instances there was reason for excusing noncompliance on the ground that the Ordnance tolerances were too strict. But in other cases it may safely be assumed that, had the manufacturers (including the arsenals) kept within the limits set by Ordnance, the end product would have functioned better, lasted longer, or been more reliable.

The chief reason for failure to maintain the highest quality was pressure to get out production. Ordnance realized that in time of war the overriding requirement was for good munitions in huge quantities, not perfect munitions in small quantities. The highest standards of precision manufacture were impossible of attainment in a war economy where skilled workers were scarce, the demand for speedy production was intense, and machine tools ran every day with very little time out for maintenance. Production managers looked upon the rejection of material by inspectors as something on a par with throwing a monkey wrench into the machinery. It caused loss of time, labor, and materials, and it played havoc with scheduling. Coupled with this was the fact that contractors could sometimes prove that Ordnance tolerances were unnecessarily close, or that inspectors were rejecting matériel for trivial defects. All these elements conspired to make the maintenance of high standards of quality a very difficult task. The result was a compromise between the ideal and the practical.

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[46] PSP 13, ch. 5, pp. 41–42.

[47] Hist, Ind Serv, Arty Div, OCO, ch. 10.

[48] Rpt of Check Inspection on Metal Parts of Fuze, P.D., M52 and M53, Inspection Br, Ammo Div, OCO, 29 Jan 45, copy in Mr. Lorber's file. See also ch. IX, above. There are frequent criticisms of inspection in the annual general inspections of Ordnance installations made by officers of the Inspector General's Department.

The most notable new development in Ordnance inspection was the introduction of statistical quality control. Ordnance took pride in being a pioneer in the use of quality control techniques. How successful its efforts were is hard to measure, for the techniques were not applied equally to all types of matériel. But the following summary statement drafted early in 1943 by the wartime chief of the Quality Control Unit in the Ammunition Branch appears to be close to the truth:

Ordnance inspection is becoming more efficient, Government inspectors are beginning to accept and reject on a more rational and standardized basis, rule of thumb is being eliminated, quality of accepted material is improving, and Ordnance inspection personnel are, in general, being reduced. At the same time, the responsibility of manufacturers to submit only material of satisfactory quality for acceptance is being more definitely crystallized, and greater cooperation is being obtained.[49]

[49] Saunders, "Standardized Inspection," *Army Ordnance* XXIV, No. 137 (March–April 1943), 290. An evaluation along these lines was presented by Gause at the ASF Inspection Conference, Washington, D.C., 9–11 Aug 45, pp. 185–86, copy in ASF Distribution Div files, NA Box 663.

CHAPTER XV

Contract Termination and Settlement

For Ordnance, termination of contracts began as a mere trickle in December 1941, continued at a steadily mounting rate during the next three years, and then reached flood proportions at the end of the war. After the basic policy decisions were made, the number of terminated contracts rose steadily until some thirteen thousand had been closed out by the end of 1944. Valuable experience was thus gained long before the war ended, and staffs were trained to deal with the problem. When the Japanese surrendered in August 1945, Ordnance was able to settle its outstanding contracts quickly, and generally with satisfaction to all concerned.[1]

This record stood in sharp contrast to the debacle after World War I when thousands of war contracts remained unsettled for many months after the Armistice, leaving a legacy of ill will and suspicion for the next twenty years.[2] Conscious of its World War I history, the War Department during World War II resolved to avoid making the same mistake twice. "Let's leave a better taste in their mouths after this war" was the attitude frequently expressed at contract termination conferences.[3] Taking a broad look at the economy of the nation in the middle of the war, Army policymakers saw that about 60 percent of all business concerns were dependent, wholly or in part, on war production, and that most of these concerns needed prompt action on their contracts if they were to succeed in making the change back to peacetime production. Under Secretary Patterson testified before the House Military Affairs Committee on the magnitude and urgency of the problem, recalling that after 1918 the Ordnance Department alone had 10,000 employees working on terminations.[4] In 1943

[1] For a comprehensive survey, see Lt. Col. Harold Shepherd, History Contract Termination Branch, Legal Division, OCO, 4 volumes, 30 April 1945, OHF. A concise history by Colonel Shepherd was published as Settlement of Ordnance Contracts, Army Ordnance Report Number 2, 9 August 1943, by the Army Ordnance Association (now American Ordnance Association). For a broad Army-wide treatment of this subject, see Smith, *Army and Economic Mobilization,* chapters XXVII–XXIX.

[2] J. Donald Edwards, Termination of Ordnance Contracts, Jan 43, Historical Study No. 57, and William Hoyt Moore, Post-Armistice Industrial Developments, 1918–20, Jan 43, both prepared by Bur of Labor Statistics, U.S. Dept of Labor, ORDGL–CR files. See also I. J. Gromfine and J. Donald Edwards, Termination After World War I, *Law and Contemporary Problems* (Duke University School of Law) X, No. 4 (Spring, 1944), 563–93. *A History of War Contract Terminations and Settlements,* July 1947, by U.S. Office of Contract Settlement, contains a bibliography on terminations in World War II.

[3] Min of Termination Mtg, 12 Aug 44, Chicago, p. 59, in Hist, Chicago Ord Dist, vol. 102. Historical studies of World War I contract termination prepared by the U.S. Department of Labor were distributed to the Ordnance districts and to divisions of OCO.

[4] Statement, USW, before H.R. Mil Affairs Comm., 15 Oct 43, *Hearings,* on H.R. 3022, 78th Cong., 1st sess., pt. 2, pp. 145ff.

it was estimated that Ordnance had 148,000 contracts with industry totaling $47 billion in value, and giving employment to millions of workers.[5] "If terminations are not completed and money paid to the contractors with utmost expedition," wrote an Ordnance district official from Chicago, "we will inevitably have a wrecked and bankrupt business structure in the United States." [6] Ordnance was also keenly aware of the importance for future production of retaining the good will of industry by fair treatment at the time of contract termination.[7]

Ordnance had given little thought to contract termination during peacetime, for the problem seldom arose. Nor was much attention paid to the matter during the defense period when top priority was assigned to speedy placement of orders with industry. The contract forms standardized by the Army in 1939 contained termination clauses covering instances of default by contractors, but their use by the procuring services was optional.[8] In September 1941 Ordnance broke new ground by issuing a standard clause for contract termination at the convenience of the government, and a few weeks later the Under Secretary's office issued Supply Contract No. 1, including a clause for termination when the contractor was not in default, and settlement according to a formula. The essence of these clauses was their provision that the contractor be reimbursed for "all actual expenditures certified by the Contracting Officer as having been made. . . ." [9] The hitch to this arrangement was that the contracting officer could certify that expenditures had been made only after the auditors had gone over all the books and assured him that every penny was accounted for. This was a long and tedious process, and it was feared that firms without strong financial backing might go bankrupt while the auditors were at work; for employees the procedure might result in "unemployment by audit." [10] Further, cost accounting was not an exact science or a matter of simple arithmetic. It required exercise of good judgment in weighing a host of varied elements. As a leading industrialist testified, "If you take six cost accountants of equal competency and put them on the job to find out what one of our crankshafts cost you would get six different answers." [11] How Ordnance contributed

[5] Termination Notes and Data for use at the Rochester Mtg of Dist Chiefs, and Address by Lt Col Harold Shepherd before the Michigan State Bar Assn, Detroit, Mich., 16 Sep 43, both in folder marked Speeches Delivered by Col Shepherd, ORDGL–CR files.

[6] Ltr, H. P. Isham, Chief Purchasing, Termination and Renegotiation Policy Br, Chicago Ord Dist, to Lt Col A. R. Cutler, ASF Purchasing Sec, 14 Aug 43, OO 164/471. See also Remarks by Browning, in transcript of Proceedings of Joint Conf of Price Adjustment Bds, 15–17 Aug 43, New York, copy in OHF, and Statement by Automotive Council for War Prod, 7 Aug 43, OO 400.12/48943.

[7] Memo on Negotiated Settlement, 27 Aug 43, prepared by H. P. Isham of Chicago Ord Dist, copy in OUSW file, dr 14.

[8] Leon Malman, "Policies and Procedures for the Termination of War Contracts" *Law and Contemporary Problems* (Duke University School of Law), X, No. 3 (Winter, 1944), 449–517.

[9] (1) Ltr, CofOrd to all Contracting and Purchasing Officers of the Ord Dept, 3 Sep 41, sub: Provision for Termination. . . , copy in Shepherd, Hist, Contract Termination Br; (2) History of Readjustment Division, ASF, prepared by 1st Lt Reynold Bennett, 1946, pp. 20–21, copy in OCMH; (3) Hist, New York Ord Dist, I, pt 2, pp. 96–99.

[10] The phrase is from Bernard M. Baruch and John M. Hancock, *Report on War and Post-War Adjustment Policies,* (Washington: 15 Feb 44), p. 8.

[11] Testimony of J. H. Marks, vice president, Packard Motor Co., before H.R. Mil Affairs Comm., *Hearings,* on H.R. 3022, 70th Cong., 1st sess., pt. 2, p. 477. On the same point, see Statement by Secretary Patterson, *ibid.,* p. 148.

to solving this problem is illustrated by the following two case histories.

The Walter Scott Case

On 5 June 1940 Ordnance had placed an educational order with Walter Scott and Co. of Plainfield, N.J., for manufacture of fifteen recoil mechanisms for the 155-mm. gun, along with certain machine tools and manufacturing aids. Fifteen months later the company, not yet in production, had taken on a large Navy contract that threatened to leave no room for future Ordnance production orders. Under these circumstances Ordnance decided, two weeks before Pearl Harbor, to cancel the contract and move elsewhere the machine tools the company had purchased. This decision officially opened the contract termination phase of Ordnance World War II history.[12]

As there was no question of default on the part of the contractor this was clearly an example of contract termination "for the convenience of the government," as the lawyers expressed it. The paragraph of the contract that covered such cases provided that the government should reimburse the contractor for all expenses incurred by him in good faith in performance of the contract plus 10 percent of the total of such expenses. To avoid making a complete audit of the contractor's books, the Chief of Ordnance, on the day after Pearl Harbor, suggested that the company might be willing to terminate the contract by a supplemental agreement providing for payment of a lump sum determined by negotiation. Here was the origin of the negotiated settlement that did so much to speed reconversion at the end of the war. Satisfactory terms were soon worked out, and the contractor signed a termination agreement on 26 June 1942 releasing the government from all further obligation under the contract in return for payment of $18,155.89.[13]

The Guiberson Case

Before the Scott case was closed, another and much larger termination was in the works. In April 1942, when the Army decided to replace diesel tank engines with gasoline engines,[14] steps were taken to cancel two contracts, totaling $8 million, with the Guiberson Diesel Engine Co., and to turn over the Guiberson plant in Garland, Texas, to Continental Motors Co. for production of gasoline engines. Although the earlier of the two Guiberson contracts had no clause covering termination for convenience of the government, the later contract did, and the company agreed to let this clause apply to both. But the clause in the later contract called for reimbursement of the contractor according to a formula based on a complete audit of all expenditures. The accounting and auditing work on such a contract, Ordnance reported, would reach "gigantic proportions," requiring the full-time services of fifteen auditors for nine months, for the contract extended over a long period of time and involved large sums of money, complex inventories, work in process, and claims of many subcon-

[12] (1) Ltr, Col Alfred B. Quinton, Jr., to USW, 22 Oct 41, sub: Cancellation of Educational Order Contract. . . , OO 160/74713; (2) Shepherd, Hist, Contract Termination Br; (3) Mueller, *New York Ordnance District in World War II,* pp. 124–26; (4) Hist, New York Ord Dist, I, pt. 2, pp. 96–99.

[13] (1) Shepherd, *op. cit.;* (2) Hist, New York Ord Dist, I, pt. 2, pp. 96–99.

[14] See Green, Thomson, and Roots, *Planning Munitions for War,* ch. X.

tractors.[15] When he had signed the contract, the contractor had had no idea he would some day be called upon to produce a written record of every expenditure. In addition, Ordnance pointed out that the results of the audit would be subject to review by "another governmental agency," meaning the General Accounting Office, and expressed some concern lest the GAO take exception to minor irregularities and thus do, in the long run, more harm than good. Ordnance felt that any such review would involve the exercise of new judgment on complex problems and would, in effect, amount to a new negotiation. Ordnance argued that terminations should be kept within the control of the agency responsible for the original contract, for only in that agency was there intimate knowledge of the kinds of property involved, the avenues for its disposition, and knowledge of its value. Further, Ordnance contended that a detailed audit of all large contracts would delay contractors from shifting to other war work and would thus hamper the war effort, while the war continued, and would hold up reconversion in the postwar era.

In view of these facts the Ordnance legal branch proposed that the contract be terminated with a negotiated lump-sum settlement; there would be no complete audit or review by another governmental agency, but only sufficient spot checking and accounting analysis to satisfy both parties. This proposal was based on the ancient common law principle that private contracting parties may agree to settle a contract in any way they choose, regardless of contract provisions for some other method of settlement. The Ordnance view was that contracting officers who were empowered to enter into contracts and agree upon prices to be paid for war goods in the first place were assumed to have equal authority to agree upon final compensation when the contracts were canceled.[16] "The negotiated settlement in essence," wrote Lt. Col. Harold Shepherd in formal legal language,

> is the use of a contract device to convert unliquidated claims not susceptible of exact demonstration without 100 percent audit into a new liquidated obligation in the nature of an accord, merging and extinguishing all prior rights and claims not specifically reserved. It has all the sanctions and legal incidents of an original contract, and the contracting officer who negotiates it has all the discretion, authority, and responsibility that he has in making any original contract.[17]

Convinced of the wisdom of this approach, Ordnance laid the whole matter before the Judge Advocate General in August and asked for an opinion. Within three weeks that office and the U.S. Attorney General approved the Ordnance proposal on the basis of the First War Powers Act and Executive Order No. 9001, and Ordnance proceeded at once to settle the Guiberson case by negotiation. In the process it used the services of only five auditors for about four or five months. Thus another major step was taken toward developing a new Army policy on contract termination and settlement for conveni-

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[15] (1) Memo, Col Charles R. Baxter, Fiscal Br, for Duffy, Legal Br, 24 Aug 42, sub: Settlement of Guiberson Contract, copy in Shepherd, *op. cit.*, (2) Ltr, Maj Harold Shepherd to JAG, 28 Aug 42, sub: Termination of Contract. . . , OO 160/133. See also Malman, *op. cit.*

[16] This was the line of reasoning enunciated by the Supreme Court in the case of U.S. *vs.* Corliss Steam-Engine Co. (1876), 91 U.S. 321.

[17] Shepherd, Army Ord Rpt No. 2. For the legal background, see Malman, *op. cit.* For comments by Ordnance districts, see folder marked Terminations—Procedure (Districts), cabinet 2, dr 1.

ence of the government. Soon thereafter Ordnance drew up termination instructions for its field representatives and gave wide publicity to the negotiated settlement among Army personnel, lawyers, and industrial contractors.[18] Emphasis was placed on speeding war production by enabling contractors to shift quickly from one product to another, and assuring industry that, at war's end, their claims would be settled fairly and quickly. The goal was to achieve the 3 F's of contract termination, making them "fair, fast, and final." [19]

The International Harvester Case

In December 1941 Ordnance approached the International Harvester Company about making a new type of tank that then existed only on the drawing board. It was to weigh twenty tons, carry a 57-mm. gun, and be both fast and maneuverable. International Harvester accepted the proposal, contracts totaling $217 million were signed, and Ordnance immediately purchased and remodeled for Harvester's use an idle plant at Bettendorf, Iowa, naming it the Quad Cities Tank Arsenal.[20] Soon thereafter the proposed tank was redesigned in the light of British reports from North Africa of the need for more powerful guns and tougher armor to cope with German tank and antitank weapons. The 57-mm. gun became a 75-mm., and the weight of the tank went up to 28 tons. A steady flow of engineering change orders delayed the start of production until March 1943. Then on St. Patrick's Day, just as the first tanks were rolling off the line, the contract was canceled. It was a stunning blow for the company and its employees and caused a certain measure of resentment. Assurance that cancellation was dictated by the fortunes of war, and that no blame attached to the plant, was received in silence by the employees assembled to hear the news from Col. John Slezak of the Chicago district.[21] Explanation that the tank, originally meant to be light, had grown to be of medium weight and was thus too close to the existing Shermans did not prove very convincing.

Compared with the Harvester contract, the Scott and Guiberson cases had been small potatoes. Not only was there $217 million involved in the Harvester contract, but the company used 12 different plants located in as many cities. Its 438 subcontractors were to be found in 100 cities scattered over an area of 20 states, and there were, in addition, about 2,000 subsubcontractors. The company had on hand a huge stock of all the countless parts that go into a tank—generators, tracks, periscope assemblies, and even a few tank hulls—as well as machine tools, jigs, and fixtures. When everything was piled into an impromptu warehouse so the company

[18] (1) Ord Fisc Cir 153, 9 Oct 42, sub: Termination of Fixed Price Contracts, copy in Hist, Contract Termination Br; (2) Ord Fisc Cir 170, 29 Oct 42, sub: Termination of CPFF Contracts, copy in Hist, Contract Termination Br; (3) Leon Malman, *op. cit.;* (4) Campbell, *The Industry-Ordnance Team,* ch. 25; (5) U.S. Office of Contract Settlements *A History of War Contract Terminations and Settlements,* p. 7.

[19] Ann Rpt CofOrd, FY 1944, p. 7. See also Smith, *Army and Economic Mobilization,* and "Termination of War Contracts for the Government's Convenience," J. Harry LaBrum, *Temple University Law Quarterly,* vol. XVIII, No. 1, Dec 43.

[20] See p. 251.

[21] (1) Furnas, "Good-by Contract!" *Saturday Evening Post,* June 2, 1945, p. 77; (2) Hist, Chicago Ord Dist, vol. 102, Min Termination Mtg, 12 Aug 44, pp. 48ff; (3) Chicago *Tribune,* May 21, 1943, p. 25; (4) *Wall Street Journal,* August 8, 1944, p. 1.

could get on with a tractor order that was to replace the tank contract, the place looked like "an auditor's nightmare and a junkman's dream." [22] The whole stock, valued at over $10 million, had to be quickly inventoried and disposed of by public sale or transfer to other government agencies. Engines, tanks, and armor plate were promptly diverted to other tank manufacturers or to Field Service for use as spare parts.[23] Hundreds of subcontractors had to be given help in submitting their claims, and for that purpose the company organized a staff of fifteen traveling termination specialists. The Chicago Ordnance district sent representatives to Bettendorf to work with the company's termination team toward arranging advance payments for subcontractors and ironing out procedural details. Although the principle of the negotiated settlement was applied, so many aspects of the problem required careful checking that the whole process took about fifteen months. This was no speed record, to be sure, but the Chicago district felt that in the process it had gained experience that would enable it in the future to cut that time in half. The company settled for $25 million.[24]

Organization and Training

By mid-summer of 1943 Ordnance had completed about eight hundred negotiated settlements. The district offices reported that contract settlements could be reached by negotiation with a 75 percent saving of time and labor over settlements based on a complicated formula and complete audit. Immediate partial payments were made to both prime contractors and subcontractors to tide them over the conversion period. Contracting officers were permitted to use their own judgment in each case, and there was no need for review of the settlement by any other agency, except in case of suspected fraud. All this was to the good, but adequate preparation for the anticipated avalanche of terminations at the end of the war called also for creating and staffing strong termination units in all the district offices, and providing a firm statutory and regulatory base for the new procedures.[25]

Though keenly interested in speed, Ordnance did not intend that negotiated settlements would be reached haphazardly without scrutiny by lawyers, auditors, and production experts.[26] A set of rules was, in fact, soon developed and published in April 1943 as a section of the Ordnance Procurement Instructions. Ordnance assigned termination work to its district offices where each terminated contract was passed through the hands of district specialists in procurement negotiation, inspection, engineering, and accounting, and was finally reviewed by the district's Settle-

[22] J. C. Furnas, *op. cit.*, pp. 77.

[23] Ordnance policy on this score was described in detail by an Ordnance officer, Maj. Forton A. Christoffer, in "Disposal of Contractor-Owned Property on Termination," *Law and Contemporary Problems* (Duke University School of Law), X, No. 4 (Spring, 1944), 646–58.

[24] This subject is discussed at length in History, Chicago Ordnance District, Volume 102. For brief summaries of other cases, see Contract Termination in the Chicago Ordnance District, OUSW file.

[25] On the importance attached by the War Department to termination planning and organization, see Remarks by J. Browning, in transcript of Proceedings of Joint Conference on Price Adjustment Boards, 15–17 August 1943, New York.

[26] Termination Notes and Data for Use at the Rochester Mtg of Dist Chiefs, n.d., in file marked Speeches Delivered by Col Shepherd, ORDGL–CR files.

ment Review Board. It thus became "procurement in reverse." [27] In the Chicago district the basic philosophy was put into a memo by the chief of the termination policy unit, stressing speed rather than meticulous accuracy and "true negotiation vs. the rejection of each part of each claim that cannot be proven in detail by the contractor." [28]

In the summer of 1943 ASF helped to standardize procedures throughout the War Department by issuing a technical manual on termination accounting for fixed-price supply contracts, closely following the earlier Ordnance instructions.[29] Soon thereafter a new section on contract termination was added to the Procurement Regulations as PR 15.[30] This section described the main steps in termination procedure, beginning with the government's telegram to the contractor advising him to stop work on a specific contract, followed by a confirming registered letter and a copy of the War Department Termination Accounting Manual. The contractor then notified his subcontractors, began to look for other business, and put men to work drawing up his claim for payment by the government. Surplus material and government-owned equipment was promptly moved out of the plant, and representatives of the company sat around a conference table with government officials to work out a negotiated settlement. When possible, a pre-termination conference was held with the contractor to iron out problems of timing and procedure.[31] Reasonably explicit rules and regulations governed each major step in the process, and it was through these regulations, plus the detailed provisions of the termination accounting manual, that the interests of both contractor and government were protected and the whole process given a semblance of due process of law.[32]

A much simpler type of settlement was that in which the contractor made no claim for payment above what he had already received. In return for waiving any claim he might have against the government the contractor had the right to retain his termination inventory, which might include scarce raw materials or useful semifinished items, and dispose of it as he saw fit. He was immediately free to proceed with conversion to other work without need to take an inventory and prepare his claim against the government, thus saving time for himself and for the

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[27] Campbell, *op cit.*, p. 404. See also histories of all Ordnance districts in OHF, and Memo of Duffy, OCO, for CG ASF, 1 Jan 44, sub: Comments on Admin of Contract Termination, copy in OHF.

[28] Memo by H. P. Isham, Chicago Ord Dist. 27 Jul 43, sub: Negotiated Settlement, copy in OUSW file. See also Ltr, Lt Col George V. Rountree, Chicago Ord Dist, to Duffy, OCO, 1 Apr 43, sub: Termination. . . , copy in OHF.

[29] TM 14-320, Termination Accounting Manual for Fixed-Price Supply Contracts (1943), later issued as TM 14-1005 (1944). See also the recommendations supporting negotiated settlements in memo of William C. Foster, Chairman Purchase Policy Advisory Comm., for USW, 30 Sep 43, copy in OUSW file.

[30] Copy in Hist of Readjustment Div, ASF.

[31] On pretermination, see Memo, Shepherd, OCO, for Director Readjustment Div, ASF, 30 Dec 44, sub: Progress Rpt on Pre-termination Training, copy in OHF.

[32] Settlement procedures were described in general terms by Secretary Patterson in *Hearings*, Comm. on Mil Affairs, H.R., 78th Cong., 1st sess., on H.R. 3022, pt. 2, pp. 151ff, and by Leon Malman, *op. cit.* For a detailed case history, see "Settlement of a War Contract," *Mill and Factory*, May 1945, copy in History, Philadelphia Ordnance District, Volume XI, Part 3. See also manual entitled Termination Procedure for War Contracts issued by Cincinnati Ordnance District, and *Hearings*, Committee of Military Affairs, H.R., 78th Cong., 1st sess., on H.R. 3022, 24 June 1943, Pages 47-49.

government. This was especially attractive to contractors during the first two years of the war when they could easily shift to other war work. As it was the essence of administrative simplicity, its use was also attractive to the government and was given official encouragement. A further reason for the popularity of "no cost" settlements was the Renegotiation Act. When a contractor knew he had earned all allowable profit during a given period there was no point in trying to gain more in the final settlement.[33] By the end of December 1945, "no claims" cases accounted for roughly one-fourth the money value of all Ordnance settlements, and well over half the number of cases settled.[34]

In November 1943, when ASF created a Readjustment Division, headed by an Ordnance officer, Col. David N. Hauseman, and the Office of War Mobilization established the Joint Termination Board, Ordnance set up a contract termination section in the Legal Branch and called in Col. Dean Witter from the San Francisco district office to head it. Meanwhile, Ordnance called regional conferences in Chicago, Detroit, New York, and St. Louis to inform district officials of plans and policies being formulated in Washington. The Ordnance districts created their own termination sections and prepared to put their procurement machinery into reverse.

Each Ordnance district opened termination training courses for members of its staff and drew up manuals to prescribe practical operating procedures. When this work was well under way the districts turned to the task of introducing contractors to the mysteries of contract termination and settlement, and stimulating their interest in advance preparation for submitting termination claims. Specialists from Colonel Witter's staff and from district offices gave short talks on the subject to trade associations, chambers of commerce, and professional societies. In February and March 1944 the Boston district held a series of eight all-day conferences for contractors in the Boston area. The Springfield district conducted similar training conferences while the New York district arranged for New York University to give evening classes in contract termination. In the Philadelphia area, the Ordnance district co-operated with other government procurement offices to prepare a course in contract termination to be given by the University of Pennsylvania. The purpose of these courses was to speed contract termination and settlement by instructing contractors how to submit their claims to the proper government agency. The staff of the Chicago district wrote a comedy skit called "Negotiation for Termination, or You Can't Take It With You," presented it as after-dinner entertainment for many businessmen's groups, and gave one performance for a subcommittee of the House Military Affairs Committee.[35]

The Statutory Base

The principle of termination by negotiation was applied, on the basis of the

[33] (1) Smith, *Army and Economic Mobilization;* (2) War Contract Terminations and Settlements, Report by the Director of Contract Settlement to the Congress, 2d rpt, Jan 45, p. 20; (3) Hist, Readjustment Div, ASF, pp. 43–46.

[34] Graphic Analysis, Progress of Ord Program, sec 4, 23 Jan 46, OHF, p. 2.

[35] (1) Shepherd, *op. cit.;* (2) Mueller, *The New York Ordnance District in World War II*, ch. 9; (3) Robert T. Gebler, *Philadelphia Ordnance District in World War II* (Philadelphia; Westbrook Publishing Company, 1949); (4) Folder marked Termination-Training.

Judge Advocate General's decision, to cases that came up in 1942–43, but procurement officials and contractors both saw the need for putting such important matters on a firm statutory base. The War Department drafted proposed legislation for this purpose in 1943, and committees of Congress opened hearings on the subject. At this point, Lindsay Warren, the Comptroller General, vigorously objected to the Army's plan to put the negotiated settlement on a firm statutory base. Mr. Warren complained that the procedures proposed by the War Department contained no adequate means of safeguarding the public interest. They bypassed the General Accounting Office, and required no audit, no documentary evidence of the validity of contractors' claims, and only a spot check that was "an insult to proper audit of a matter of this magnitude." "When I read these regulations," he testified,

> I became so amazed and astounded that I have wondered if those officers or civilian employees of the War Department who prepared them ever gave a passing thought that they were in fact servants of the Government, whose interest they were sworn to protect. These regulations have all the appearance of being put forward by special pleaders for industry in disregard of the Government and those other citizens who are paying the Government's bills.[36]

Warren brought forth case after case to show that contractors in the past had claimed payment for goods or services in no way related to their government contracts, and had been stopped only by the GAO audit. He challenged the War Department's assertion that all its contracting officers were efficient and capable men working within a well established framework of regulations, and asserted that contract settlements without audit were open invitations to fraud. The War Department's answer to these charges was that the General Accounting Office had so far disallowed less than 10 cents per $1,000 of expenditures under War Department contracts, and had approved 99.95 percent of all procurement vouchers submitted for audit during the four months ending with August 1943.[37] Industry spokesmen termed Warren's proposal impractical.[38]

The House Committee on Military Affairs later reported out a bill to place the Comptroller General in charge of termination settlements, but the bill was defeated in favor of a modified version of the War Department's proposal. Strong support for the negotiated settlement came from industry representatives who testified before the House Committee in October 1943, and further support appeared in February 1944 when the Baruch-Hancock report on postwar adjustment policies was released. It recommended "quick, fair, and final settlement of terminated war contracts through negotiations by the contractors and the procurement agencies." The Comptroller General's insistence on detailed audit before payment would, the

[36] *Hearings*, H.R. Comm. on Mil Affairs, 78th Cong., 1st sess., on H.R. 3022, pt. 2, p. 191. See also Ltr, Comptroller General to Hon. Andrew J. May, 20 Sep 43, and to Hon. James E. Murray, 20 Sep 43, copies in OCMH file.

[37] Ltr, USW to May, 27 Oct 43, printed in *Hearings*, H.R., Comm. on Mil Affairs, 78th Cong., 1st sess., on H.R. 3022, pt. 2, pp. 626–27. See also Ltr, Patterson to Murray, 8 Oct 43, copy in OCMH file.

[38] The New York *Times*, October 24, 1943, p. 57. See also the later Report to the Office of Contract Settlement by Industry Comm. Selected to Investigate Direct Settlement and Related Problems, 12 Dec 44, OCMH file; and Termination of War Contracts, a study prepared by the Law Department of the National Association of Manufacturers, copy in OUSW file.

report contended, "quibble the nation into a panic." [39] The Contract Settlement Act of 1944, signed by the President on 1 July, created the Office of Contract Settlement headed by a director responsible for prescribing policies and procedures and enforcing their observance.[40] The act followed existing procedures in providing for quick negotiated settlements, prompt removal of inventories from contractors' plants, and interim financing to enable contractors to proceed with conversion to peacetime business.[41] Joint Termination Regulations (JTR) issued by the War and Navy Departments in November 1944 set forth detailed procedures to guide government officials in applying the law. JTR and the Contract Settlement Act laid a firm statutory and regulatory base for the procedures Ordnance had first tried out in the Scott and Guiberson cases more than two years earlier.

By the end of December 1944, Ordnance had authorized termination of nearly fourteen thousand contracts, and of that total some 93 percent had been finally settled. The time required to settle cases was steadily reduced during the year, dropping from ten months for settling a large claim in April to less than six months by the end of the year. The backlog of pending cases had dropped from its February peak of 2,265 involving over $4 billion to less than one thousand totaling about $1-1/2 billion.[42] In February 1945 the Office of Contract Settlement commended the War Department on its contract settlement performance during the preceding six months and observed that the progress made during this period was "largely due to the continued good performance of the Ordnance Department and to the great improvement made by Army Air Forces." [43]

Action on V-J Day

During the second week in August 1945, ASF gave Ordnance detailed instructions for terminating contracts upon Japan's surrender. A standard telegram to be sent to prime contractors was enclosed, along with one for the contractor to send to his subcontractors.[44] These forms were to be filed with Western Union, accompanied by a list of contractors, contract numbers, and other essential data, pending the signal for Western Union to send them out. Ordnance forwarded these plans to its district offices and arsenals with instructions to be ready for prompt action as soon as Japan surrendered. Shortly after 7 p.m. on 14 August the Japanese surrender was announced and the Chief of Ordnance received a letter from ASF to get out the termination telegrams at once. In this process some eleven thousand contracts were terminated and the district

[39] Baruch and Hancock, *op. cit.*

[40] For brief and sympathetic analysis of termination activities, see the periodic reports to Congress by the Office of Contract Settlement, particularly the Tenth Report, Jan 47, in Army Library, which summarizes the whole record.

[41] U.S. Statutes at Large, vol. 58, p. 649. See also ASF Ann Rpt FY 1945, pp. 220–26, and "Contract Settlement Act of 1944" by Sen. James E. Murray, *Law and Contemporary Problems* (Duke University School of Law), X, No. 4 (Spring, 1944), 683ff.

[42] Graphic Analysis, Progress of Ord Program, sec. 4, 20 Feb 45. See also Memo, Capt D. E. Varner for Lt Col H. T. Bodman, 28 Aug 44, sub: Analysis of . . . Contract Terminations. . . , copy in OHF; and Ltr, Robert H. Hinckley, Director OCS, to USW, 3 Feb 45, ex. 33 in Shepherd, *op. cit.*

[43] Ltr, Hinckley, to USW, 3 Feb 45.

[44] (1) Memo, ASF Director of Matériel to USW, 4 Aug 45, sub: Advance Termination Notice of V-J Day Cancellations, in ASF Director of Matériel file marked V-J Day Notices; (2) Memo, ASF Director of Matériel for CofOrd, 10 Aug 45, sub: Plng for Contract Terminations on V-J Day, same file.

TABLE 24—DOLLAR VALUE OF ORDNANCE CONTRACT TERMINATIONS: AS OF 31 DECEMBER 1945

Initiated	$16,067,601,000
Completed (settled)	9,970,894,000
(with claims)	7,302,799,000
(without claims)	2,668,095,000
In process	6,096,707,000

Source: Graphic Analysis, Progress of Ord Program, sec. 4, 23 Jan 46, p. 2, OHF.

offices were deluged with settlement work. By the end of the year, the job was well under way, as the table shows. (*Table 24*) By the end of the following year Ordnance could sum up its contract settlement record in terms of some thirty-five thousand fixed-price contracts settled—most on a no-claim basis—for a total canceled commitment value of over $13 billion. Settled cost-plus-fixed-fee contracts were fewer in number—only 184 all told—but accounted for an additional $3 billion.

Termination of cost-plus-fixed-fee contracts posed special problems. Under such contracts the government was obliged to reimburse contractors for expenses incurred in performance of their contracts. But what expenses were to be considered reasonable and proper? Each contract presented a host of puzzling questions. Seemingly small matters, such as a few cents increase in the hourly rate of pay for employees, could mount up to a million dollars on a large contract. Contractors were slow to settle their CPFF contracts because they feared that agreements reached with Ordnance or one of the other military procurement agencies would be upset later by the General Accounting Office. They declined to dispose of their inventories or close their accounts with subcontractors until the government settled their claims. The situation became so serious that Under Secretary of War Patterson appealed to the Attorney General for help. In October 1944 the Attorney General expressed the opinion that contracting agencies had the authority to make settlements of all claims and that the Office of Contract Settlement had authority to issue appropriate regulations on the subject. The Office of Contract Settlement soon published, as part of the Joint Termination Regulations, a procedure that required contracting officers to answer objections raised by the General Accounting Office during a 60-day period after the termination agreement was reached.[45]

Insofar as speed was concerned, the overall Ordnance record on terminations was good, but by January 1946 the original forecast of accomplishment had not been met. In explanation, the contract termination section reported that delays stemmed from a variety of causes. Some contractors had not submitted their claims promptly while others, having received partial payment, were content to postpone final set-

[45] This complex problem is discussed on an Army-wide basis, with specific details on the Ordnance tank contract with the Baldwin Locomotive Works, in Smith, *Army and Economic Mobilization,* Chapter XXVIII.

tlement until more urgent reconversion work was completed. Other contractors showed a tendency to insist upon getting the last dollar on each claim even though that meant prolonging the negotiation. Ordnance was at fault in some instances. The districts had underestimated the personnel they would require after V-J Day, while mandatory cuts in personnel undermined morale and disrupted normal routine. The letdown that came with the end of the war combined with the desire of civilians to get back to peacetime pursuits to create a really serious personnel problem.[46]

The conclusion that Ordnance contract settlements were, on the whole, fast and final, appears sound,[47] but it is impossible to determine precisely how "fair" they were. The settlement process left much to the discretion of the contractor and the contracting officer, and placed less emphasis on following the rule book than on following the practices of private business in drawing up an agreement acceptable to both parties. It may be assumed that contracting officers, modestly paid guardians of the public interest, must at times have grown weary of the struggle when pitted against representatives of firms with a heavy financial stake in the settlement. Pressure to settle contracts with utmost speed must at times have led them to take short cuts and to accept rule of thumb estimates that may have been overly generous. But a field survey by accountants from the Office of Contract Settlement in December 1944, including a check of twelve Ordnance district offices, concluded that contract settlement agencies were doing a good job and that many contractors were so eager to convert to peacetime business that they did not insist on all the profits they were entitled to. Later surveys sponsored by the Office of Contract Settlement came to the same conclusion.[48] The years that followed World War II brought to light no substantial evidence of unjust enrichment of Ordnance contractors. Neither did these years bring the economic paralysis and widespread unemployment feared by many. Instead, they brought speedy demobilization of the armed forces and rapid conversion of the nation's economy from war to peace production, and a relatively high level of prosperity. Friendly relations of Ordnance and its contractors, the indispensable basis for wartime co-operation, were not disturbed. Several factors contributed to this result, chief of them being the high wartime tax rates and the recapture of excess profits under the Renegotiation Act. The Internal Revenue Bureau's decision that termination payments were to be considered as income received on the day of termination, rather than on the date of final settlement, kept contractors from dragging out negotiations to take advantage of lower postwar tax rates.[49] Industry's natural desire to beat swords into ploughshares, aided by the government's enlightened contract termination and settlement policy worked something akin to an industrial miracle in postwar reconversion.

[46] Reasons for the Ordnance Department Not Meeting the Forecasts Originally Set (Termination of Contracts), 22 Jan 46, apparently prepared by Contract Termination Br of Legal Div, attached to Shepherd, *op. cit.* See also Letter, CofOrd to all district chiefs, 13 Dec 45, OO 160/19008 Misc.

[47] Memo, CofOrd for Chief Detroit Dist, 29 Jan 46, sub: Time Required to Settle Terminations, copy in OHF.

[48] War Contract Terminations and Settlements, Report by the Director of Contract Settlement to the Congress, 2d rpt, Jan 45; 4th rpt, Jul 45, and 8th rpt, Jul 46.

[49] U.S. Office of Contract Settlement, *A History of War Contract Terminations and Settlements*, p. 2.

CHAPTER XVI

Field Service: Legacy of World War I

Maj. Gen. Clarence C. Williams created Field Service as a major division of the Office of the Chief of Ordnance in January 1919.[1] Field Service was clearly a product of World War I, a war that had revealed the inadequacies of traditional supply systems. The primary responsibility assigned to Field Service was management of the Ordnance Department's huge postwar supply of weapons, ammunition, and related matériel, valued in the spring of 1921 at approximately $1,311,000,000. Within the framework of the Office of the Chief of Ordnance the new division's storage and maintenance functions complemented the development and procurement functions of the Manufacturing Service, later to be renamed Industrial Service.

Field Service had charge of all Ordnance depots; it bore responsibility for the maintenance and issue of equipment to troops, and for all salvage operations; and it was primarily responsible for training Ordnance troops. Except for a brief interlude in 1925–28, when the Manufacturing Service took over the task, Field Service had the important duty of making surveillance inspection of ammunition in storage. It was also assigned the duty of preparing standard nomenclature lists (SNL's), technical regulations, firing tables, and the tables of organization and basic allowances that determined the distribution of Ordnance supplies. To aid in carrying out this aspect of its duties, Field Service organized a publications department at Raritan Arsenal. During most of the period before 1940 Field Service consisted of four branches—Executive, General Supply, Ammunition, and Maintenance. There was some reshuffling of responsibilities among these branches during World War II, and creation of new branches, but the broad outlines of Field Service organization remained fairly stable.[2]

The supply procedures of the new division grew out of the experiences of Ordnance officers in France. To make the most of these experiences while they were fresh in men's minds, the chief Ordnance officer of the AEF, Brig. Gen. John H. Rice, in April 1919 appointed a board to prepare a manual to guide future Ordnance operations in the field. When the members of the board assembled at Tours they had before them the reports that General Rice had required of all officers commanding Ordnance installations in

[1] (1) Ord Office Order 495, 7 Jan 19; (2) WD General Orders 80, 19 June 1919, gave Field Service permanent status. See also Annual Report Chief of Ordnance, 1919, and History, Field Service, Executive Branch, vol. I, 1919–39, pt. 1.

[2] (1) Green, Thomson, and Roots, *Planning Munitions for War*, pp. 20, 99; (2) Hist, FS, Exec Div, vol. II, pt. 1 (1939–43).

France, plus a special report prepared by several officers who had visited British supply depots to make a thorough study of the British system.[3] The board members also had as a basis for their recommendations their own firsthand knowledge of the chaos of the early months of war; they recalled the lack of planning and the almost insuperable difficulty of using an outmoded system to supply a modern army. Colonel Crain was an ammunition specialist who had made a study of the French system of ammunition supply; Lt. Col. Lucian D. Booth had served as Ordnance Officer of the First Army; Maj. Keith F. Adamson and Capt. R. K. Lane knew maintenance problems intimately; and Capt. C. Huth and Capt. J. D. Ashton were specialists in stock control.[4]

The result of their deliberations was the *Provisional Manual for Ordnance Field Service . . .*, published by the War Department in 1920. It covered all phases of Ordnance work in a theater of operations: organization and operation of the office of the chief Ordnance officer; duties of the Ordnance officer at army, corps, division, and camp and port levels; methods of storing and issuing supplies; types of depots and depot layouts; ammunition supply in the combat zone; maintenance facilities; and the organization and training of ammunition companies and maintenance units.[5] The proposed ammunition supply system resembled that of the French Army; the stock control system for weapons and other general supplies was patterned on that of the British;[6] and the depot system was formed on the plan evolved by the U.S. Services of Supply by which supplies were forwarded to the front through base, intermediate, and advance depots.[7] Because it was desirable to have operations in the Zone of the Interior closely resemble those of a theater of operations, the 1919 manual formed, with some modifications, the basis for the entire Ordnance distribution system at the time Field Service was formed.[8]

The Pattern for Depots and Maintenance Facilities

The depot pattern grew out of an Army-wide realization that new methods of forwarding supplies to front-line troops would have to be evolved to meet such unprecedented conditions of warfare as those encountered in World War I. General Staff planners in France considered several choices: "Should all supplies arriving from overseas be stored at the port, being forwarded as needed, running the chances of interruption to the rail communication by air attack, storm, or the changing position of our troops at the front but minimizing the handling of the freight? Should it all be shipped to the vicinity of the troops with possibility of its destruction by air raids, or of capture or abandonment through the shifting of the battle lines? Or should it be divided into Base, Intermediate and Advance storage, in the proportions say of ten days' supply in Advance storage, twenty-five days' in Intermediate and ten in Base storage?"

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[3] Lt. Col. Lucian D. Booth, "The General Supply Division, Field Service," *Army Ordnance*, I, No. 4 (January–March 1921), 196.

[4] Interv, Maj. Gen. James K. Crain, 17 Feb 54.

[5] *Provisional Manual for Ordnance Field Service. . . , September 1919* (Washington, 1920) [hereafter cited as *Manual of 1919*], p. 3, OHF.

[6] Allied and Associated Powers, *Report of the Military Board of Allied Supply* (Washington, 1924), I, 316; II, 298.

[7] James J. Harbord, *The American Army in France* (Boston: Little, Brown and Company, 1936), pp. 120–21.

[8] Booth, *op. cit.*, p. 196.

The latter plan was the one adopted, with the advance depot feeding the Army depots or railheads in the combat zone.[9]

After the war the Army depot system in the United States similarly consisted of three main types of depots, called reserve, intermediate, and area. Reserve depots received vast stocks in bulk from factories and held most of them for use in time of war or other emergency. Intermediate depots, spread out across the country, acted as wholesale warehouses for certain areas, storing in bulk enough supplies to meet requirements for three months. Area depots were retailers, carrying enough stocks to meet their responsibilities to posts, camps, and stations for three months. The small depots at the station level kept on hand enough supplies for one month's consumption.

Along these lines the War Department maintained general depots, containing supplies of all types—weapons, food, medical supplies, and so on, and the Ordnance Department and several other supply services maintained branch depots of the reserve and intermediate types. The Secretary of War in 1920 designated eighteen Ordnance reserve depots, most of them for ammunition, and four intermediate depots. The latter were not merely storage depots but old-line repair arsenals dating from the Civil War or before.[10]

As the system worked out in the postwar years, reserves of artillery, small arms, fire control instruments, tractors, and other general supplies were stored at proving grounds or at the arsenals where they were made. Fire control instruments were kept at Frankford, small arms at Springfield, gun carriages at Watertown, and big guns at Watervliet; the greatest concentration of tank, artillery, and small arms reserves was maintained at Rock Island



LARGE-CALIBER AMMUNITION IN STORAGE *at an ammunition reserve depot, 1940.*

Arsenal in Illinois.[11] By 1929 about half of the 1920 ammunition reserve depots had been abolished; from 1929 until the World War II expansion began ammunition reserves were stored at the following depots: Curtis Bay in Maryland, Delaware and Raritan in New Jersey, Pig Point (renamed Nansemond) in Virginia, Savanna in Illinois, Wingate in New Mexico, and Ogden in Utah. The intermediate depots—Augusta in Georgia, Benicia in California, Rock Island in Illinois, and

[9] Harbord, *op. cit.*, pp. 120–21.

[10] (1) Booth, *op. cit.*, p. 197; (2) "Storage of Supplies for the Army," *Army Ordnance*, I, No. 4 (January–March 1921), 200.

[11] (1) OCO Historical Sec, Spec Plng Br, Monograph No. 8, Ordnance Field Service, 1 July 1940 to 31 August 1945, 31 Dec 45 [hereafter referred to as Monograph No. 8], p. 13, OHF; (2) Interv, Crain, 17 Feb 54.

San Antonio in Texas—also served as area depots.[12]

Maintenance problems scarcely existed before World War I. Each infantry company took into the field a small box of spare parts and a few simple tools with which the company mechanic repaired the rifles and pistols; each battery of field artillery had a store wagon, a battery wagon, and a forge limber including a blacksmith's outfit for shoeing horses. In World War I the use of motor vehicles to a degree never before known and the development of new and more complex weapons made necessary an elaborate system of maintenance. There had to be substantial base shops in the rear of the armies for major repairs on heavy ordnance matériel and large-scale repair of small arms. Advance base shops, of a rather permanent nature, had to be pushed as far forward as the safety of their stores and suitable railway facilities permitted. Mobile shops, mounted on trucks or trailers, were needed to accompany the armies. The system set up in the United States after the war corresponded to this theater-of-operations plan. Four manufacturing arsenals, Rock Island, Watertown, Watervliet, and Springfield, performed the heavy work done by base shops during the war; four depots, Benicia, San Antonio, Augusta, and Raritan, acted as advance maintenance shops for the Corps Areas they served.[13]

The Ordnance Provision System

The methods of distributing weapons at the beginning of World War I were as antiquated as the phrasing in the definition of ordnance and ordnance stores contained in Army Regulations of 1913: "Cannon and artillery vehicles, and equipments; apparatus and machines for the service and maneuver of artillery; small arms, ammunition and accoutrements; horse equipments and harness for Field Artillery, and horse equipment for Cavalry and other mounted men; tools, machinery and materials for the Ordnance service; and all property of whatever nature supplied to the Military Establishment by the Ordnance Department." [14]

To aid the troops in ordering supplies and the storekeepers in issuing them, the Ordnance Department listed all matériel in detail in a "storage catalogue" of seven volumes. Volume I, for example, listed ammunition of all kinds; Volume II, caissons and limbers; and Volume III, cannon, carriages and mounts, including fire control items. For definite identification and for convenience in ordering by cable or telegraph, each item and its various parts carried a number of several digits, the first of which was always 7, the General Staff designation for Ordnance. Thus, since 4 meant the equipment volume and 1 meant animal, a requisition for 741–1 would call for one complete "Aparejo" or packsaddle, and 741–1–2, 741–1–3 and so on, would call for specific parts of the Aparejo.[15] The classification differed little from that in use at the time of the Civil War.[16]

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[12] (1) Survey of the Ordnance Department, 20 Sep 29, Incl 6, Survey of Depots and Excess Supplies, and Incl 12, Supply and Maint of Combat Matériel in the Existing Army, 320/377 NA; (2) Monograph No. 8, p. 2.

[13] Col. Kenneth B. Harmon, "Ordnance Maintenance," *Army Ordnance,* I, No. 4 (January–March 1921), 167–72.

[14] *Manual of 1919,* p. 7.

[15] U.S. Ord Dept, *Storage Catalogue,* IV (Washington, 1919), v–vii.

[16] U.S. Ord Dept, *Instructions for Making Quarterly Returns of Ordnance and Ordnance Stores. . . ,* (Washington, 1863), pp. 39–77. Line officers reported quarterly on the weapons as-

In addition to the number of each article the catalogue gave the accepted name, or "standard nomenclature," together with a brief description that would theoretically enable an inexperienced man to identify it. But the vast numbers of inexperienced men that came into the Army in World War I, and the growing complexity and volume of Ordnance matériel, soon made it evident that new methods of identification and classification would have to be devised.

American officers who studied the British system of supply in France discovered an interesting experiment in decentralization and specialization. The British had found that it was impossible under the pressure of a large-scale war for the officer or new recruit called from civilian life to gain a thorough knowledge of all ordnance matériel; but he could learn thoroughly one particular kind of article. This was the principle behind the segregation of like stores into groups that resembled small depots within a depot. The group system had been introduced at Nantes in the fall of 1914 by Col. Thomas Heron, a retired officer of ripe experience who had tried it out in prewar years at Aldershot. It worked well in France. As a British historian explained, "No one would set a fitter to do saddler's work or vice versa; and though storekeeping involves a less specialized skill, still there is a great difference between being able to identify the particular fittings used with each type of gun and being able to piece together the various bits of leather that go to make up different sets of harness and saddlery, and knowing in each case the exact nomenclature." [17]

Knowledge of nomenclature and ability to identify were of the first importance in the accurate reporting of stocks in wartime, as Americans were to rediscover in World War II; but these were not the only advantages of the British system. The use of the records was directed toward "provision"—the replenishment of stocks—rather than merely property accountability. Each group, no matter in what depot it was located, reported promptly and simultaneously, and thus the central office knew at all times the condition of any one type of stores and could make procurement when necessary.[18]

The *Manual of 1919* directed that depots be organized on the group system, with each group acting as an independent depot, receiving and issuing property and keeping such records as were necessary; but it did not definitely designate what classes went into what groups. The Ordnance Provision System Regulations after the war not only used the British system, but also included some modifications based on American military experience and procedures used by two American mail order houses, Montgomery Ward and Company and Sears Roebuck and Company.[19] The

signed to them. A Form for Keeping a Record of Company Ordnance Property in an Ordinary Memorandum Book recounted the losses of a hypothetical Capt. A. B. Brown of Company A, 199th R.I. Volunteers, mustered into service January 1, 1862. As the company passed through New York, "Private V. Shiftless deserted, taking with him his musket and set of accoutrements"; later, at the battle of Gaines' Mill, the muskets, cartridge boxes, gun slings, bayonet scabbards, and waist belts of ten casualties had to be written off because "the Regiment was obliged to retire from the ground on which they fell." *Ibid.*, pp. 117–19.

[17] Maj. Gen. A. Forbes, *A History of the Army Ordnance Services, Volume III: The Great War* (London: Medici Society, Ltd., 1929), pp. 112–13.

[18] *Ibid.*

[19] Interv. Ernest L. Kahlert, 30 Jul 52.

term "provisioning" was defined as estimating requirements, distributing matériel, and maintaining necessary stocks at the arsenals, depots, and other Ordnance establishments issuing stores to troops. The object of the regulations was to provide the records necessary to control stocks, to place orders for new procurement, and to make special distribution in time of war. The system was entirely separate from the system of property accounting that was common to all supply departments of the Army and served a different purpose. It closely linked distribution and procurement, using one set of records for both.[20]

The Ordnance Provision System adopted after World War I placed all Ordnance supplies in groups, each group containing major items of a similar character with their own spare parts and accessories.[21] Parts common to two or more major items were placed in one general group, to avoid dividing the supply among several groups with the probable result of an accumulation in one group and a shortage in another. In its strict sense a major item was an element of matériel of sufficient importance to require individual classification or documentation. It might be an article normally issued or procured separately, even if not used separately, as, for example, a fuze for a large bomb or a carriage for an artillery piece. Generally, the major item was the weapon itself, the complete, independent, operating unit such as the rifle ready to shoot. A major combination was a single composite unit consisting of two or more major items, such as a tank and its gun, or a gun mounted on its carriage. In ammunition supply a distinction was made between the complete round, meaning the artillery shell or bomb or mine loaded, fuzed, and ready to function, and the component, which was the cartridge case, fuze, or other part that would be assembled to make the complete round.[22]

Groups of major items were designated by letters of the alphabet. Items of general supply, with their parts and accessories, were in Groups A through G; common and maintenance supplies were in Groups H, J, K, L, M, and N. Group A consisted of automatic weapons and mortars; Group B, hand and shoulder arms; Groups C through E, various kinds of artillery; Group F, sighting and fire control equipment; Group G, tank and automotive matériel; Group H, hardware: Group J, common tools; Group K, cleaning, preserving, and welding materials; Group L, targets and target materials; Group M, electrical apparatus units and parts; Group N, equipment issued to ordnance establishments, ordnance units, and certain

[20] (1) Booth, *op. cit.*, pp. 196–200; (2) General Motors Overseas Operations, *General Survey of the Ordnance Department* (May 1942) [hereafter cited as *GM Survey*], I, 58–59; 175–82, OHF; (3) OCO FS, Stock Control Division, vol. 1, History From 1921 Through 31 Aug 43 [hereafter cited as SCD Hist], pp. 15–22; (4) Memo, Maj William G. Hynds for Brig Gen Harry R. Kutz, 21 Sep 42, sub: General Supply Branch Activities as I See Them [hereafter cited as Hynds Memo], OHF.

[21] Generally speaking, an accessory was an article that was not a part of the major item but was needed to operate it successfully, such as a cleaning rod for a rifle. PSP 65, Field Service Publications, Development and Distribution, Jun 45, ex AD, OHF.

[22] (1) Col. Harry B. Hambleton, History of the Engineering Administrative Branch, Industrial Service, OCO, 19 Nov 45 [hereafter cited as Hambleton, Hist, Engr-Administrative Br], ex. 26, *Drafting Room Regulations, Ordnance Department, United States Army* (Washington, 1945), p. 147, OHF; (2) WD Cir 155, 8 Jul 43. For an explanation of the confusion that sometimes resulted from various applications of these definitions, see Ordnance Department Board Reports, Project No. 48, Establishment of Definitions and Policies Concerning Major Items, Aberdeen Proving Ground.

tactical units. Groups P through T were ammunition. When general supply items became obsolete they were transferred from their several live groups and segregated in Group OGS. Obsolete ammunition was retained in its original group because it had to be carefully watched and controlled. There was one final category, Group Z, for captured foreign matériel.[23]

Within the lettered groups, supplies were further subdivided into smaller classes of stores. These had a subgroup number that served as an identification code. Thus the .30-caliber rifle in Group B had a subgroup number, 21, making its classification B–21. A further means of identification was the "piece mark," or drawing number. The great bulk of artillery and small arms items, and some combat vehicle matériel, bore the numbers that appeared on their engineering drawings. These were usually nonsignificant numbers prefixed by "A," "B," "C," "D," or "E." The letters indicated drawing sizes, "A" the smallest, "E" the largest; the numbers assigned for each size began with 1 and continued serially. But if an article was of a common kind called "standard," like automotive parts, hardware, or tools, it would be marked with a number prefixed by four letters, the last of which was always "X." These were known as "taxi" numbers after the first number of this type, TAAX1. Standards that were common to other government agencies might carry a Federal Standard Stock Catalog number assigned by the Treasury Department: for example, 42–C–4625 was the number for a certain kind of gasoline can.[24]

The machinery for producing the records was simple. For all stores, reports known as Schedules of Stores Reports were sent periodically from field establishments—arsenals and depots alike—to Washington. They showed the stock on hand; the issues covering a definite period; the obligations, or unfilled requisitions—known as "dues-out"; the anticipated receipts from all sources—known as "dues-in"; and demands for replenishment. Distinction was made between "dues-out" to troops and "dues-out" to depots; the former meant real obligations of the Ordnance Department to the using arms; the latter, merely intradepartmental obligations. Similarly, a distinction was made between "dues-in" from original procurement and "dues-in" from depots, because the latter did not increase the total stock.[25]

The dates of reporting were spread throughout the year in order not to work a hardship on the depots. The schedule ranged from monthly to annually, but there was no hard and fast rule. Normally the greatest spread was semiannually. In the case of great activity in the volume or importance of any item, the schedule could be shortened to daily, using telephone or telegraph if necessary. But it was of the utmost importance that any given item be regularly reported by all depots on the same date. The consolidated report gave the Group Chiefs in Washington a close central control of stock. If one depot showed a shortage, he or she—most of the Group Chiefs were women—could tell whether another depot had a surplus, and if so, make a transfer. If there was a general shortage, the Chief of Field Service could recommend procurement. Because

[23] PSP 65, exs. AD and AF.

[24] (1) *Ibid.;* (2) Hambleton, Hist, Engr-Adminstrative Br, exs. 12, 24; (3) Rock Island Arsenal, History of Ordnance Drawing Numbers and Ordnance Part Numbers, 8 Oct 45, pp. 1–6, OHF.

[25] (1) GM Survey, I, 175–82; (2) Hynds Memo.

he had to make important decisions on the basis of the Schedules of Stores Reports, the Chief of Field Service took precautions to see that the figures were accurate. He directed the depot supply officers to work closely with the men actually in charge of supplies to check nomenclature carefully, and to call for physical inventory of any item whenever he had reason to suspect that storehouse records were inaccurate.[26]

Standard Nomenclature Lists

The official name of every item was established by the Ordnance Committee, composed of representatives of the Technical, Industrial, and Field Service Divisions, and of the using arms. The interested subcommittee recommending development work on a new item or adoption of a newly developed item obtained the nomenclature from a Basic Nomenclature and Classification File kept in the Office of the Chief Engineer, Artillery Branch, Industrial Division. The nomenclature consisted of the most important noun followed by qualifying nouns or adjectives in the order of importance, as, "gun, machine, cal. .30, Browning." After approval and assignment of the model numbers (prefixed by "M" for standard types and "T" for development types), which then became a part of the nomenclature, the items were listed in the *Book of Standards, Ordnance Department.*[27]

For requisitioning, stockkeeping, the guidance of maintenance units, and also for the use of procurement and distribution officials in Washington, Field Service after World War I began to publish a series of pamphlets called Standard Nomenclature Lists (SNL's). Collectively they formed the Ordnance supply catalog, and were a basic tool of the Ordnance Provision System. For each numbered subgroup of the lettered groups, such as the .30-caliber rifle, B–21, there was a pamphlet listing alphabetically the major item and all parts and equipment, with identifying numbers. There was a column for the stockkeeping number, another for the number that appeared on the engineering drawing, another for the "figure number" that was a clue to the diagrams or photographs in another section, and a column for the note symbol, a reference to notes in the back of the SNL. Two very general pamphlets served as guides, the Introduction to the Ordnance Catalog (IOC), explaining the use of the SNL's; and an index called Ordnance Publications for Supply Index (OPSI), containing a numerical and alphabetical listing of all the pamphlets and a description of the matériel in each lettered group.[28]

In some respects the SNL's were comparable to commercial parts lists; in another sense they were supplements to Tables of Organization and Equipment, Tables of Basic Allowances, and Tables of Allowances. For example, if a T/OE stated that an organization was authorized a Tool Set Unit Equipment, Second Echelon Set No. 1, the pertinent SNL, which was G–27, Tools, Maintenance, for Repair of Modern Vehicles, described the com-

[26] (1) Ordnance Provision System Regulations, 1 Jan 45, pp. 4–6, OHF; (2) Intervs, Crain, 17 Feb, 3 May 54.

[27] (1) ASF Contl Div Rpt No. 105, Nomenclature and Supply Catalog, Apr 43 [hereafter cited as ASF Rpt 105], pp. 2–3, ASF Contl Div Files G129; (2) and see Green, Thomson, and Roots, *Planning Munitions for War,* pp. 33–34.

[28] (1) PSP 65, p. 38 and exs. AD and AF; (2) Sgt. Mortimer Gordon, "Use of the Standard Nomenclature List," *The Ordnance Sergeant,* V (April 1943), 384–92.

ponents of the set in detail.[29] Close coordination with the using arms, with designers, and with procurement officials was necessary to provide the information in the pamphlets. For that reason the group charged with the preparation of SNL's was conveniently located after 1921 at Raritan Arsenal, New Jersey.[30]

The Lamp of Experience

In the House of Representatives shortly after World War I, Representative John Q. Tilson said, "The next five years will be the very best years in the century to make plans. The lamp of experience, a heart-rending experience in many respects, will be a light to guide us." [31] In France after the Armistice Ordnance officers had drawn upon their own experience and that of the Allies in the preparation of the Provisional Manual for a theater of operations, in the adoption of the Ordnance Provision System, and in plans for the organization of Field Service. In the period immediately following World War I the tremendous effort required to store the vast stocks of ordnance matériel that had to be cleared out of war industry plants, ports, and training camps justified the wisdom of creating a separate division of the Ordnance Department to handle operations in the field.[32] Field Service managed to provide shelter for this huge accumulation of stores, and this experience influenced the thinking of the men who would have to expand the depot system in World War II.

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[29] PSP 65, pp. 36–38 and ex. AD.

[30] *Ibid.* For developments in the preparation of SNL's after 1940, see Chapter XXII, below.

[31] John Q. Tilson, "Swords and Plowshares," *Army Ordnance,* I, No. 4 (January–March 1921), 165.

[32] Brig. Gen. George W. Burr, "Ordnance Field Service," *Army Ordnance,* I, No. 4 (January–March 1921), 165–66.

CHAPTER XVII

The New Depot System

The first postwar Congressional investigation into the operations of the War Department took place shortly after the Revolutionary War. On 2 October 1788 an investigating committee reported that most of the arms and ammunition left over from the War were stored at the three permanent Army arsenals[1]—Springfield, West Point, and Philadelphia. Some matériel remained at four temporary depots and at furnaces where the shot and shell were cast. The committee recommended that temporary depots be abandoned and that all stores be placed in the permanent arsenals.

Facilities at the arsenals were not ideal. The buildings at Springfield were in good condition, but those at West Point, constructed of unseasoned wood, were decaying fast. The so-called arsenal at Philadelphia consisted of rented buildings unsuited for ordnance storage and scattered inconveniently throughout the city. The construction of proper and permanent arsenals and magazines plainly demanded the serious attention of the Government. But the investigators concluded that "as the expense of erecting suitable buildings for this purpose will be great, it will perhaps be thought advisable to defer it for the present." [2]

After succeeding wars the Government repeatedly adopted a similar policy of contraction and economy. The dangerous concentration of ammunition in Atlantic Coast depots following the Armistice in 1918 made necessary the construction of two new depots in the interior in 1920, Savanna in Illinois and Ogden in Utah. But this gain was more than offset by the loss in the early twenties of nine of the Ordnance reserve depots that had been marked for retention under the National Defense Act as amended 4 June 1920.[3]

In the mid-twenties a major disaster brought the subject of ammunition storage forcibly to the attention of the public. Late in the afternoon of 10 July 1926 a bolt of lightning struck a magazine at the Naval Ammunition Depot at Lake Denmark, New Jersey. The resultant explosions killed a number of people, wrecked the Navy depot, and partially demolished

[1] As used here the term arsenal meant a storehouse for arms and ammunition. Springfield Armory was not established as a manufacturing arsenal until 1794. See Green, Thomson, and Roots, *Planning Munitions for War,* p. 14.

[2] (1) U.S. Adjutant General's Office, *Legislative History of the General Staff of the Army of the United States . . . 1775–1901* (Washington, 1901), pp. 569–71; (2) Brig. Gen. William H. Tschappat, "Early History of American Ordnance," *Army Ordnance* XIII, No. 78 (May-June 1933), 336.

[3] (1) "Storage of Supplies for the Army," *Army Ordnance,* I, No. 4 (January–March 1921), 200; (2) 70th Cong., 1st sess., Doc. 199, *Ammunition Storage Conditions* (Washington, 1928) [hereafter cited as Doc. 199], p. 48.

neighboring Picatinny Arsenal.[4] As a result, Congress directed the Secretaries of War and of the Navy to make a survey of ammunition storage, with special emphasis on the likelihood of danger to nearby communities. The Army section of the joint Army-Navy board appointed to make the survey reported that with minor exceptions there was ample safe and properly located storage to care for all Army ammunition in the continental United States. It asserted that preventing a repetition of the disaster and generally improving unsatisfactory conditions was almost entirely a matter of redistribution and rearrangement.[5] Its recommendation that a permanent Joint Army-Navy Ammunition Storage Board be appointed to serve as adviser on ammunition storage to the Secretary of War and the Secretary of the Navy was promptly accepted.[6]

An important feature of the 1928 rearrangement program was the construction at several depots of a new type of magazine. Called an "igloo" from its resemblance to Eskimo shelters, it was a low, earth-covered structure of reinforced concrete, its sides arched to form a semicircular roof. The shape directed the power of an explosion upward rather than outward. It was the best type of storage yet devised for such dangerous ammunition as loaded bombs and large-caliber shells. To take care of East Coast ammunition the Ordnance Department built twenty-four igloos at Savanna, Illinois, which was considered ideal because of its isolated situation. By building igloos in lesser numbers at Aberdeen, Delaware, and Benicia, Ordnance made those depots safe for limited amounts of larger caliber ammunition. The igloos were all completed by March of 1929.[7]

Very little other new construction was possible in the lean years of the twenties and early thirties. As a result, depots became run down. Buildings were old, railroad trackage rusted and inadequate, highways patched and narrow, docks dilapidated, and equipment insufficient and largely obsolescent.[8] It was not until the mid-1930's that the War Department gave serious attention to any considerable expansion of Ordnance storage facilities. Mobilization Regulations 4–2 of February 1935 provided for increased production of munitions, and a proposal by the Baker Board in 1934 to build up the Air Corps had brought a demand for more space for bomb storage. Moreover, the money available for the program of public works organized to combat the effects of the depression could defray some of the cost.[9]

Late in 1936 the Chief of Ordnance submitted requests amounting to approximately $21 million for new construction and repair at various Ordnance establish-

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[4] (1) Report of Naval Court of Inquiry, "The Lake Denmark Naval Ammunition Depot Disaster," *Army Ordnance,* VII, No. 38, (September–October 1926), 125–29; (2) Col. William H. Tschappat, "The Lake Denmark Explosion—Its Effect on Picatinny Arsenal," *Army Ordnance,* VII, No. 38 (September–October 1926), 131–34.

[5] Doc. No. 199, p. 7.

[6] 45 Stat. 928, 29 May 1928.

[7] (1) Doc. 199, pp. 7–15; (2) Brig. Gen. Edward E. MacMorland, "Ordnance Supply System," *Mechanical Engineering,* vol. 67 (Dec 45–Jan, Feb, Mar 46), p. 792; (3) Capt. Albert D. Lueders, Historical Report on Development and Construction, Ammunition Storage Depots, [hereafter cited as Lueders Rpt], p. 1, in History, Field Service Storage Division, vol. 101 [hereafter cited as Hist, Storage Div], OHF.

[8] Monograph No. 8, p. 12.

[9] (1) War Department Policy Concerning Sites for New Ordnance Depots. . . , Approved Site Board Reports, 1 Dec 44 [hereafter cited as Site Bd Rpts], exs. 1–13, OHF; (2) Ltr, SW to CofOrd, 22 Aug 34, sub: Storage for Air Corps Ammo, copy in Site Bd Rpts, ex. 26. There were 22 inclosures, dated 21 Sep 34 to 2 Oct 38; see résumé, *ibid.*

ments, including manufacturing arsenals as well as depots.[10] This request, and a recommendation by the Chemical Warfare Service for rehabilitation of chemical manufacturing establishments at Edgewood Arsenal, led Brig. Gen. George R. Spalding, Assistant Chief of Staff G–4, to the decision that, before any large sums of money were spent, the War Department ought to draw up a plan for an ideal system of manufacturing and storage facilities. The most important considerations were, in order of importance, strategic location to avoid destruction by enemy attack; proximity to vital raw materials; nearness to probable theaters, assuming that the most probable theaters were in the West and Southwest; economy of operation; and, finally, climate. On General Spalding's recommendation, the Secretary of War ordered the Chief of Ordnance, Maj. Gen. William H. Tschappat, to submit such a plan for his own installations. General Tschappat delegated the job to a board of five officers, headed by Col. Norman F. Ramsey.[11]

The Ramsey Board dismissed considerations of climate and economy of operation as relatively unimportant; it concentrated on strategic location and proximity to probable theaters. As to strategic location, the Secretary of War had laid down the policy that, generally speaking, after M-day there would be no construction for the storage of wartime reserves on the eastern seaboard of the United States, the area between the Atlantic Coast and the eastern slope of the Appalachian Mountains; or on the western seaboard, in the area lying west of the Cascade and Sierra Nevada ranges.[12] The Board proposed as an additional safety measure that depots be located at a reasonable distance from the northern and southern boundaries of the United States,[13] and concluded that the best locations for storing war reserves were Rock Island, for general supplies, and Savanna, for ammunition.

On the second point, proximity to theaters of operation, the Board assumed that the best system in time of peace was one that would function best in time of war. On this basis, the mountain and Pacific Coast states (IX Corps Area), and Hawaii would be best served by Ogden in Utah and Benicia in California; the Central United States (V, VI, and VII Corps Areas) by Rock Island and Savanna, both in Illinois; the Southeast (IV Corps Area) by Augusta Arsenal, Georgia. These were all existing depots. For the Southwest (VIII Corps Area) ideally there should be a new depot in Texas, but practically San Antonio Arsenal could be built up to serve. For the Northeast (I, II, and III Corps Areas) the best solution was a new depot in central Pennsylvania; but the cost was prohibitive. The Board felt that the expense was not justified and that Raritan would be adequate to serve the northeast area and also provide overseas supply of Panama, if Delaware assumed some of the

[10] *Ibid.*, ex. 17. Of this amount, $4-1/2 million was for a new bomb storage project at Cheat Bridge, W. Va. This site was later discarded because the remote mountainous country created problems of construction, transportation, and labor; also, there was no level space for an airfield. Ltr, CofOrd to Hon Jennings Randolph, 26 Dec 40, OO 675/2356 Misc.

[11] Site Bd Rpts, exs. 17, 19, 20.

[12] Ltr, SW to Chiefs of All Supply Arms and Services, 17 Feb 36, sub: Policy from Mil Point of View as to Location of Additional Construction of Storage Plants, copy in Site Bd Rpts, ex. 11.

[13] Report of Board of Officers to Prepare Secret Plan Embodying An Ideal Set-up for Ordnance Manufacturing and Storage Facilities in the United States, 15 Apr 37, copy in Site Bd Rpts, ex. 20, p. 24.

ammunition load. The Board recommended that Curtis Bay, Nansemond, and Charleston be abandoned, by a process of attrition rather than immediate transfer of the ammunition to other storage.[14]

In submitting this report to the War Department, General Tschappat suggested that a new ammunition depot might be built in the East, perhaps in West Virginia or Pennsylvania, for the ammunition stored at Curtis Bay, Nansemond, and Charleston. But he urged that the East Coast depots should be retained, if not for ammunition for some other purpose, because they were so well adapted to water shipments.[15] Thus the result of this early prewar planning did not change very much the distribution pattern that had developed in World War I, and, when G–4 in the summer of 1938 made a study of the supply depot network from the standpoint of its adequacy to serve the Protective Mobilization Plan, the investigators considered that there was still a "faulty concentration of many Ordnance establishments along the Atlantic seaboard." [16]

At the outbreak of the war in Europe in 1939 Ordnance planners reviewed the ammunition storage situation and found that roughly 65 percent of the space was in the East, 27 percent in the central portion of the United States, and only 7 percent in the West. These figures showed that the War Department's policy of 1937, to store 25 percent in the East, 60 percent in the Central United States, and 15 percent in the West, had not been followed. Savanna and San Antonio could be expanded to bring the Central area up from 27 to 39 percent, reducing the East from 65 to 55; but further than that it seemed impossible to go by expanding existing depots.[17] Money was scarce, even for storing the ammunition needed under the Air Corps Expansion Program and Initial Protective Force Program.[18] It was not until the summer of 1940, when the fall of France brought about mounting appropriations for defense, that any considerable expansion of storage facilities was possible.

Appropriations for Storage in 1940

The main trouble about planning for depot expansion in June 1940 was that nobody could say how much matériel there would be to store. Figures on the size of the army-to-be fluctuated from day to day, sometimes from hour to hour;[19] and even when a definite figure was set, there was difficulty in determining, first, how much equipment was needed and, second, how much of this equipment should be placed in storage. On 29 June the Assistant Chief of Staff G–4 asked the Ordnance Department to prepare a list of critical items for an army of two million men, and also requested estimates on the money that would be needed for storage. An answer was required by four o'clock of the same day.[20]

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[14] *Ibid.*, pp. 24–32.

[15] 2d Indorsement (Memo, Brig Gen George R. Spalding for the CofS, 8 Dec 36, sub: Location of Government Mfg Plants), CofOrd to TAG, 6 May 37, Site Bd Rpts, ex. 23.

[16] Memo, Brig Gen George P. Tyner, Asst CofS for CofS, 6 Jan 39, sub: Supply Facilities under the PMP—Revision of Oct, 1938, Site Bd Rpts, ex. 27.

[17] Ltr, CofOrd to TAG, 22 Sep 39, sub, Strategic Storage of Ammo, ex. E of Lueders Rpt.

[18] Memo, CofOrd for ACofS G–4, 20 Jan 39, sub: New Construction and Facilities Pertaining to National Defense Program, FY 1940, OO 600.1/1386.

[19] Watson, *Chief of Staff*, pp. 171–79.

[20] Memo, G–4, 6–29–49, sub: Instructions for Computation of Additional Critical Items Required for a Force of 2,000,000 Men, copy in Col James K. Crain, Diary, OHF.

The estimates for ammunition storage were prepared by Lt. Col. Robert N. Bodine, Chief of the Ammunition Supply Division of Field Service, and they were necessarily very rough, because Colonel Bodine did not know the basis on which ammunition requirements for the 2,000,000-man program were computed. He estimated $81,208,000 for igloos, magazines, and auxiliary buildings, and $12,750,000 for the procurement of land —85,000 acres at $150 per acre—making a total of $93,958,000.[21]

For general supplies, Field Service's storage planners had a figure of $1,310,900,000 worth of items on which to base their estimates. But how much of this matériel would require permanent storage in specially built warehouses? The first estimates, prepared by Col. Everett S. Hughes, Chief of the Equipment Division of Field Service, were based on storing $105,000,000 worth of items, about one-twelfth of the total amount, at a cost of $6,449,576 in warehouses and $250,000 in land. These figures seemed too conservative to the Chief of Field Service, Colonel Crain, whose World War I experience had taught him the wisdom of planning ahead. He raised the sights considerably: the estimates that went to the General Staff were based on storing approximately $655,000,000 worth of critical items, half the total amount. The warehouses were to be built of reinforced concrete, and were to be bombproof, well equipped, and strategically well located in cities like Memphis, Tennessee, where water and rail transportation was available, and where city power, lights, and roads could be used. The cost of such warehouses was estimated as $20,000,000; the land at $1,000,000. For the labor and warehousing equipment needed to receive and store the stocks, $2,225,000 was added. The total estimate for general supply storage was therefore $23,225,000.[22]

For all this planning, the General Staff, acting on a basis unknown to Ordnance, put into the Munitions Program of 30 June 1940,[23] a lump-sum estimate of $42,000,000 for all Ordnance storage, whether ammunition or general supply, and $7,125,000 for the acquisition of land. By agreement between the Chief of the Ammunition Supply Division and the Chief of the Equipment Division these amounts were apportioned between ammunition and general supply storage in the same ratio generally as had appeared in the estimates for the 2,000,000-man program, about four for ammunition to one for general supplies.[24] But the exact figures that would appear in the breakdown for defense of the estimates required careful planning by Ordnance storage experts to produce a program that would be acceptable to the General Staff and at the same time would be practicable for the special needs of ordnance storage.

Nowhere was there sharper differentiation between the two types of Ordnance matériel, explosive and inert, than in the question of storage. Because of its explosive

[21] Memo, Lt Col Robert N. Bodine, Chief Ammo Supply Div, for Chief, Fiscal Div, 29 Jun 40, copy in Lueders Rpt, ex. F.

[22] (1) Draft of Memo, ESH for Fiscal Div in Crain, Diary, OHF; (2) Memo, Col Everett S. Hughes for Fiscal Div, 29 Jun 40; (3) Memo, 23 Jul 40, sub: Defense Supplemental Estimates FY 1941 Based on the Munitions Program of 30 Jun 40, Crain, Diary, OHF.

[23] For details of this program, see Green, Thomson, and Roots, *Planning Munitions for War*, ch. III and Watson, *Chief of Staff*, pp. 178–79. It provided essential items for an army of 2,000,000 men at a cost of $2,286,254,041 and for storage and distribution costs, $435,693,570.

[24] Memo, Chief Ammo Supply Div for CofFS, 17 Jul 40, sub: Storage Required for Ammo on Program of 30 Jun 40, copy in Lueders Rpt, ex. E, OHF.

nature, weight, and extreme sensitivity to strategic considerations, ammunition demanded special methods, including storage in igloos or magazines, ample acreage to allow for safety distances between igloos, isolation from neighboring towns, and location related to possible theaters of war. There was little doubt that new ammunition depots were needed. Strategic, supply, and local considerations argued against expansion of any existing depots, except for relatively small expansion of Ogden and Benicia. Taking all these factors into consideration, Ordnance ammunition experts came up with a figure of $32,000,000 for 2,286 igloos to be located in four new depots and Benicia Arsenal, and $6,325,000 for the acquisition of land for ammunition storage depots.[25] The amount for construction fell far below later estimates for storing the $994,000,000 worth of ammunition provided for in the program of 30 June, but with possible economies in igloo design, it would do. The amount for land seemed ample, perhaps excessive if much of the new construction could be located on military reservations or on cessions from national forests, as seemed possible.[26] The total was approved by G–4 and carried in the Second Supplemental National Defense Appropriation Bill, Fiscal Year 1941.[27]

Ordnance plans for storing general supplies had rougher going. Unlike ammunition, such supplies as weapons, tanks, and spare parts could theoretically be stored in leased commercial facilities or in temporary structures. This type of storage was contemplated in the Protective Mobilization Plan under the assumption that upon mobilization troops would move as soon as possible to a theater of operations.[28] In discussions of the Munitions Program of 30 June, President Roosevelt asked the War Department for assurance that full use would be made of commercial storage.[29] Leasing was a quick and flexible way of expanding or contracting storage space to meet uncertain needs, and G–4 favored it.[30]

But leasing had many serious disadvantages. Commercial buildings were scattered, so that efficient depot management and movement were difficult; many of the most desirable warehouses in late 1940 were already occupied by the Navy or other Government agencies and most of those that were left were too old or too small to be of much use. These drawbacks were recognized by the Quartermaster Corps, whose perishable stores were better adapted to leased storage than was Ordnance matériel.[31] In the case of Ordnance, an immediate consideration was that most commercial warehouses were multistoried rather than one story. More than half of the equipment under the 30 June program consisted of tanks and combat vehicles that required storage at ground or car level. Important in the long-range view was the fact that artillery guns and carriages, fire control instru-

[25] (1) *Ibid.;* (2) Ltr, CofOrd to TAG, 17 Jul 40, sub: New Ammo Depots, OO 633/43.

[26] (1) Crain, Diary, 8 Jul 40; (2) Memo, Chief Ammo Supply Div for CofFS, 17 Jul 40, sub: Storage Required for Ammo on Program of 30 Jun 40, copy in Lueders Rpt, ex. E.

[27] (1) Crain, Diary, 17, 20 Jul 40; (2) Ltr, CofOrd to TAG, 17 Jul 40, sub: New Ammo Depots, and Indorsement, 2 Aug 40, OO 633/43.

[28] (1) General Marshall, quoted in Watson, *Chief of Staff*, p. 183; (2) Alvin P. Stauffer, Quartermaster Depot Storage and Distribution Operations, QMC Historical Studies No. 18, 1948, pp. 14–16.

[29] Watson, *Chief of Staff*, p. 179.

[30] (1) Memo, Hughes for CofFS, 23 Jul 40, sub: Storage Rqmts, in Crain, Diary; (2) Wesson's 11 O'Clock Confs, 15 Jul 40.

[31] Stauffer, QM Depot Storage and Distribution Opns, pp. 18–19.

ments, tanks, rifles, and machine guns were expensive and long-lived. Ordnance storage experts believed that this equipment ought to be stored in permanent, fireproof buildings, to which it could be returned after the emergency and be kept as a reserve for the future. From the standpoint of economy, leasing for a long period of time would be more expensive than construction.[32]

Strong representations by the Ordnance Department convinced G–4 that leasing ought to be held to a minimum.[33] The FY 1941 appropriations carried $7,244,000 for the construction of general supply warehouses and only $245,000 for leasing.[34] For land, the sum of $800,000 was allotted. Ordnance storage experts had computed 80 acres as the space necessary for the 2,068,900 square feet of storage required under the FY 1941 program, 1,207,900 of which had to be one-story construction. If the two projected depots were located near a city, such as Memphis, the land would be expensive, about $10,000 an acre.[35] Excellent choices for two depots of 40 acres each were Memphis, close to the great maneuver area of the South, and Toledo, Ohio, in the heart of the manufacturing area. But the Ordnance proposal to establish a depot at Memphis was denied by higher authority,[36] and Toledo was also ruled out, as being outside the zone that the War Department had determined to be strategically safe.[37]

As planning progressed in 1940, with no guidance from the past for such an unprecedented situation as full mobilization in time of peace,[38] the one certainty seemed to be the need for returning the equipment to storage after the emergency was over, and holding it as war reserves. Ordnance planners concluded that the best solution was to build permanent warehouses for general supplies at the projected ammunition depots; for this purpose more than six million dollars worth of land had been appropriated.[39]

The First Prewar Ammunition Depots

Within the strategic limits set by the War Department in the late 1930's the Ordnance Department planned to place the first ammunition depots roughly in the four corners of the United States, for support of forces repelling attacks from any direction. In the southwest no purchase was required because old Fort Wingate in New Mexico, which was rapidly being cleaned out of its bulk TNT by an American corporation buying for the British, could be used. In the northwest, the Montana-Idaho region was favored; in the northeast a site near Tobyhanna, Pennsylvania was considered, and in the southeast the Atlanta-Birmingham area seemed the best choice. This plan would have reduced the percentage of ammunition stored in the east and central United States and sharply increased the percentage in the

[32] (1) *Ibid.;* (2) Memo, 23 Jul 40, sub: Defense Supplemental Estimates FY 1941 Based on the Munitions Program of 30 Jun 40, copy in Crain, Diary.

[33] (1) Personal Ltr, Maj Gen Crain to CofOrd, 25 Jul 50; (2) Wesson's 11 O'Clock Confs, 15 Jul 40.

[34] Ltr, SW to CofOrd, 23 Sep 40, sub: Storage, AG 112.05 (9–19–40), copy in Lueders Rpt, ex. H.

[35] Memo, 23 Jul 40, sub: Defense Supplemental Estimates FY 1941 Based on the Munitions Program of 30 Jun 40.

[36] Monograph No. 8, p. 28.

[37] Crain, Diary, 28, 29 Jul 40.

[38] General Marshall, quoted in Watson, *Chief of Staff,* p. 183.

[39] (1) Memo, 23 Jul 40, sub: Defense Supplemental Estimates FY 1941 Based on the Munitions Program of 30 Jun 40; (2) Wesson's 11 O'Clock Confs, 23 Aug, 11 Sep 40; (3) Crain, Diary, 13, 27 Sep, 1, 12 Oct, 13, 28, 29 Nov 40.

west.[40] When the proposal for western sites was presented to the War Department, the Assistant Chief of Staff G–4 objected on the grounds that the war was in Europe, that nearly all manufacture of munitions was east of the Mississippi, and that location of depots in the west would mean long, roundabout railroad hauling. But Ordnance planners stressed the possibility that the war might extend to the Pacific. They also pointed out that experience had shown that rusting of metal was much less in the dry atmosphere of the west. Convinced by these arguments, the General Staff approved the western sites.[41]

To make the surveys necessary to determine exact locations within the general areas, Colonel Crain brought in from the field two ammunition storage experts, Lt. Col. Ittai A. Luke, commanding officer of Ogden Ordnance Depot, and Maj. Lemuel P. Crim, and gave them certain criteria to guide their investigations. He stated that a site for an ammunition storage depot should be on a railroad line, be at a safe distance from towns and cities, and have topography and soil that would reduce construction and operation costs; it should cover from six thousand to twelve thousand acres of land, depending on the shape of the tract and the number of magazines to be constructed.[42] These were the most important considerations, but there were other qualities that were desirable, such as a cool climate to promote safety, and nearness to a loading plant, for economy.[43]

The latter was one of the factors in the substitution of Ravenna, Ohio, for Tobyhanna, Pennsylvania, as the site for the northeast depot, later named Portage. There was to be a loading plant at Ravenna, from which ammunition could be put in permanent storage at minimum cost; also, depot and plant could use in common one safety distance zone, an economy in land.[44] Good transportation was the deciding factor in the selection by Colonel Luke of Umatilla, near Hermiston, Oregon, as the northwestern depot; it was directly on one railroad, the Union Pacific, and had ready access to four others.[45] Fort Wingate needed only the removal of all the old TNT and the withdrawal from the Department of the Interior of some nine thousand acres which that agency had been licensed by the War Department in 1925 to use as an Indian School.[46] The selection of Anniston, Alabama, as the site for the southeastern depot came after an investigation by Crim revealed that land within the Talladega National Forest was too rugged and that a site near Ft. McClellan lacked room for expansion and would place magazines too close to troops in training.[47] On all the new depots con-

[40] (1) Ltr, CofOrd to TAG, 21 Jun 40, sub: Additional Bomb Storage, OO 471.887/3973; (2) Crain, Diary, 19 Jun 40; (3) Monograph No. 8, p. 20; (4) Hist, Storage Div, I, pt, 2, The Depot System, Jul 39 to 7 Dec 41, p. 9; (5) Ltr, CofOrd to TAG, 17 Jul 40, sub: New Ammo Depots, OO 633/34.

[41] Personal Ltr, Maj Gen Crain to Maj Gen Ford, 25 Jul 50, OHF.

[42] Memo, CofOrd for Exec to the USW, 26 May 41, sub: H.R. Mil Affairs Comm. . . , Site Bd Rpts ex. 47.

[43] Memo, Col Booth, Chief of Ammo Div, for Brig Gen Charles Harris, Chief of Ind Serv, 3 Jan 39, sub: General Data Regarding Ord Dept Plans for Ammo in an Emergency, General Minton's Files, War Plans.

[44] Ltr, CofOrd to TAG, 23 Aug 40, sub: New Ammo Storage Depot, OO 633/69.

[45] Ltr, CofOrd to TAG, 21 Sep 40, sub: Northwestern Ammo Depot, OO 633/95.

[46] (1) Crain, Diary, 17 Jun 40, OHF; (2) Lueders Rpt, ex. K.

[47] (1) Ltr, CofOrd to TQMG, 1 Aug 40, sub: Survey for New Ammo Depots, OO 633/44 Misc; (2) Lueders Rpt, ex. L; (3) Ltr, Lt Col Ittai A. Luke to Col Robert N. Bodine, 16 Aug 40, OOD 201/404, copy in Site Bd Rpts, ex. 55, OHF; (4) Proceedings of a Board of Officers

struction began early in 1941. Umatilla was completed in January 1942 and the others in April and May 1942. Ammunition was being shipped into all four by November 1941.[48]

For maximum safety, the igloo type of magazine had long been preferred by the Joint Army-Navy Ammunition Storage Board (JANASB) and the Ordnance Safety Board for all types of ammunition except small arms. After January 1941 the Ordnance Department required that igloos be used in all future depot construction.[49] Uncertainty as to standard igloo design was "one of the most annoying difficulties" encountered in depot construction during 1941.[50] Generally, igloos ranged in length from forty to eighty feet and were about twenty-six feet wide and thirteen feet high.[51] The 60-footer, with a capacity of 250,000 pounds of explosives, was the type most often built, although a few of the 80-foot size were used. Umatilla, for example, had some 650 of the former and about 100 of the latter.[52]

In all cases igloos were built in blocks of not more than 100 each, the blocks being 1,400 feet apart. Ammunition depots required a great deal of acreage. There had to be room for a road system, administration buildings, and several aboveground magazines to serve as transfer points for the railroads. For safety considerations, there had to be a distance of 400 feet between igloos. Unless there were earth mounds before the doors to serve as barricades, the igloos had to be staggered so that the front of each was at least 800 feet from the rear of the one opposite. For each 10 igloos there was a foxhole for 10 persons. All doors faced north, to absorb less heat from the sun. Most of the igloos were sodded on the top, but at Umatilla, where wind erosion was a more serious problem than water erosion, the roofs were covered with gravel. The roads afforded some protection against the spread of grass fires. The unit cost of the 60-foot igloo was about $7,000, a figure that was doubled when the necessary roads and barricades were included.[53]

The Fiscal Year 1942 Program

Construction had hardly begun on the four new depots when ammunition pro-

convened at Fort McClellan, Alabama, by oral orders of CO, Fort McClellan, Alabama, 17 Jul 40, copy in Site Bd Rpts, ex. 59, OHF; (5) Ltr, Maj Lemuel P. Crim to CofOrd, 31 Aug 40, sub: Development Plan for the Anniston Ord Depot, Anniston, Alabama, OO 675/361, copy in Site Bd Rpts, ex. 63.

[48] (1) Lueders Rpt, exs. I, J, K, L; (2) *Time*, November 24, 1941, p. 46.

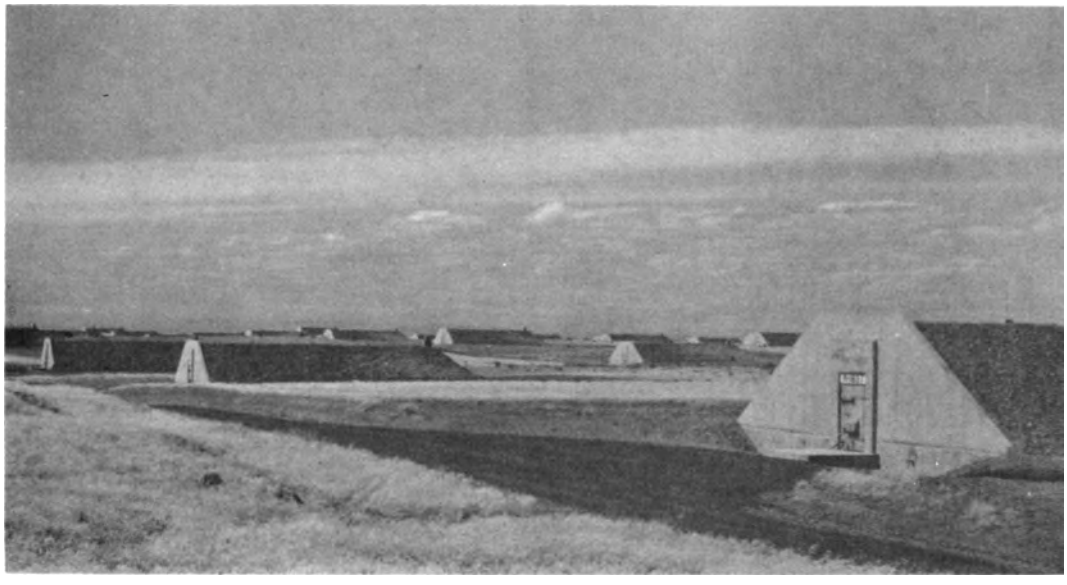
[49] (1) Crain, Diary, 30 Jul 40, Résumé of Conf . . . Attended by the Army and Navy Bd; (2) Ord Dept Safety Bull 11, 3 Jan 41, sub: Safety Distances [hereafter cited as Ord Dept Safety Bull 11], OO 633/295 Misc.

[50] Anniston Ordnance Depot, vol. I, History From the Beginning Through 30 December 1942 [hereafter cited as Anniston Hist], p. 6, OHF.

[51] (1) Crain, Diary, 30 Jul 40; (2) MacMorland, "Ordnance Supply System," *Mechanical Engineering*, vol. 67, p. 792.

[52] (1) Ltr, CofOrd to QMG, 9 Jan 41, sub: Construction Program at the Ravenna Ord Depot, OO 633/286 Misc; (2) Ltr, CofOrd to QMG, 27 Jan 41, sub: Construction Program at Umatilla Ord Depot, OO 675/3252.

[53] (1) Ltr, CofOrd to QMG, 9 Jan 41, sub: Construction Program at the Ravenna Ord Depot, OO 633/286 Misc.; (2) Ltr, CofOrd to QMG, 27 Jan 41; sub: Construction Program at Umatilla Ord Depot, OO 675/3252; (3) Crain, Diary 30 Jul 40; (4) Ord Dept Safety Bull 11; (5) Ltr, CofOrd to QMG, 9 Nov 40, sub: Construction Program at Umatilla Ord Dept, OO 633/158 Misc.; (6) Ltr, Maj Crim to CofOrd, 31 Aug 40, sub: Development Plan for Anniston Ord Depot, Anniston, Alabama, OO 675/361; (7) Ltr, CofOrd to QMG, 4 Jan 41, sub: Construction Program, Umatilla Ord Depot, OO 633/266 Misc.



IGLOOS AT UMATILLA *Ordnance Depot, Hermiston, Oreg.*

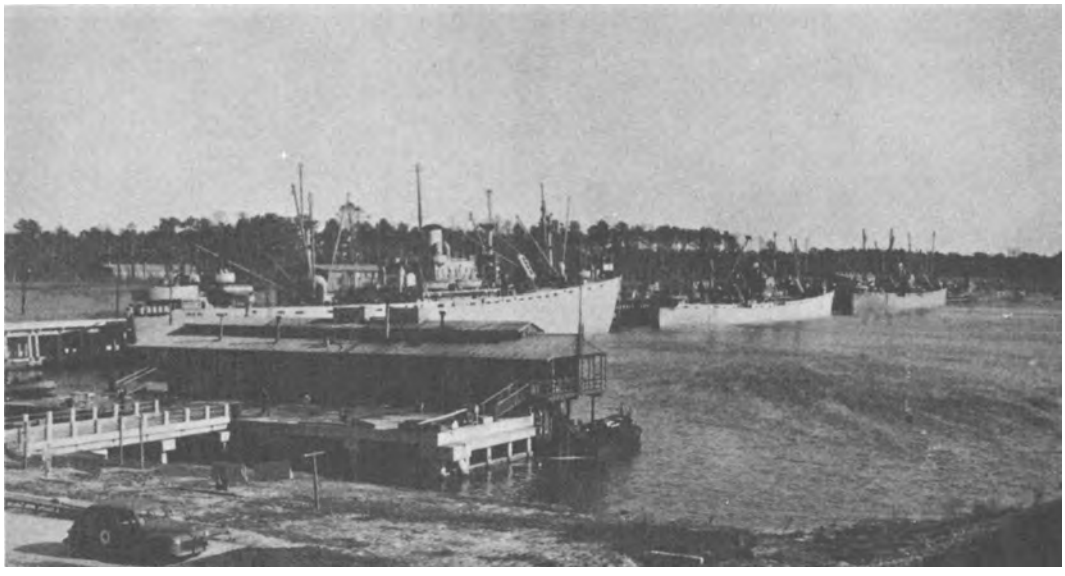
duction figures made plain the need for further expansion.[54] For the fiscal year 1942 the Chief of Ordnance in January 1941 submitted an estimate of $55,000,000 for 5,663,000 additional square feet of ammunition storage. A little more than a million square feet of this space was for expansion at Anniston, Ravenna, and Umatilla. The bulk of it was for new depots.[55]

There was need for one new depot in the south, to supply troops on maneuvers; for another in the northeast, primarily to serve Air Corps units protecting the coast line and secondarily to back up the ports from Boston to Norfolk; and for a Gulf Coast depot and terminal, primarily as a defense measure. There was at that time no ammunition shipping point on the Gulf. The region seemed important to Ordnance planners, for they did not discount the possibility that the Germans, everywhere victorious, would ultimately move against the United States by way of South America. As the munitions program advanced and lend-lease became a reality early in 1941, additional storage was needed in the East to receive the output of the factories and back up the Atlantic ports shipping ammunition to Great Britain.[56] The Secretary of War gave high priority to the acquisition of land for an ammunition

[54] Wesson's 11 O'Clock Confs, 21 Mar 41.

[55] (1) Ltr, CofOrd to TAG, 23 Jan 41, sub: Ammo Storage Program for FY 1942 and 1st Indorsement 23 Mar 41, OO 471/887/115; (2) Memo, ACofS G-4 for CofS, 28 Feb 41, sub: Ammo Storage Program for FY 1942, AG 681 (1-23-41), copy in Site Bd Rpts, ex. 44, OHF; (3) Memo, CofOrd for Lt Col Claudius M. Easley, Office CofS G-4, 18 Feb 41, Sub: Comment on Proposed Dir, copy in Site Bd Rpts, ex. 43.

[56] (1) Interv, Crain, 17 Feb 54; (2) Lueders Rpt, p. 4; (3) Ltr, TAG to CofOrd, 4 Sep 41, sub: Ammo Storage Program FY's 1942 and 1943, AG 681 (7-26-41) MO-D, copy in Site Bd Rpts, ex. 90.



SAN JACINTO ORDNANCE DEPOT DOCK AREA. *Note three Liberty ships in the background.*

depot in the western Maryland–south central Pennsylvania area and another in the eastern Kentucky–southwestern West Virginia area. From both, reasonably rapid transportation would be available to the seaports on the Atlantic Coast.[57]

For the new depot in the South, a survey by Colonel Luke revealed that Milan, Tennessee, was an excellent choice for several reasons. It was well located strategically, could serve important maneuver areas on the Gulf Coast and lower Mississippi Valley, and had good transportation facilities. Most important of all, its nearness to the Wolf Creek loading plant made possible great savings in freight and in employees for policing the two areas.[58]

The selection of the Gulf Coast site took a little longer. General Crain ruled out New Orleans because of the vulnerability of the levees to damage by saboteurs, natural causes, or an explosion. A survey of Alabama and Texas ports revealed only one site that had deep water, railroad facilities, highway connections, and enough isolated acreage with satisfactory ground. Investigated by Mr. (later Maj.) John D. Kerr, an Ordnance civilian with railroad experience, it was a tract of about five thousand acres on the Houston Ship Channel, a bayou that had been deepened to connect Houston, Texas, with the Gulf. As the site was less than half a mile from the spot where Texas colonists under Sam Houston had defeated the Mexican forces led by Santa Ana, the depot was named San Jacinto. Construction was

[57] (1) Site Bd Rpts, ex. 21; (2) Memo, OCO for ACofS G–4, 1 Dec 41, sub: Proposed Ammo Depot Site at Charles Town, Jefferson County, W.Va., OO 675/23993 Misc., in Site Bd Rpts, ex. 92.

[58] (1) Lueders Rpt, ex. M; (2) Interoffice Memo, Luke, Ord Dept, to CofOrd, Rpt on Milan, Tenn., Site for an Ammo Depot, copy in Site Bd Rpts, ex. 66.

authorized in March 1941.[59] To back up San Jacinto and help supply troops in the south central area, Red River Ordnance Depot was authorized in June. The selection of its site, adjacent to Lone Star Ordnance Plant, Texarkana, Texas, was made in a matter of days.[60]

To find a suitable site in the East, primarily for bomb storage, General Crain had Mr. Kerr make a study of several regions in New York State, and sent Colonel Luke to investigate them. The problems differed somewhat from those encountered in the west and southwest. It was hard to find enough suitable land that was on a railroad yet was not too close to a town, and hard to find a level site that was not prohibitive in price. In every case the purchase meant uprooting some families who had owned their farms for generations. Some of the land bought for Seneca Ordnance Depot in New York, for example, had been granted by the Government to soldiers in Sullivan's Expedition of 1779 and was still owned by their descendants.[61] The Seneca site consisted of about ten thousand acres in the Finger Lakes section, between Lake Cayuga and Lake Seneca, ninety miles east of Buffalo and approximately two hundred west of New York City. The price required was about twice the normal value of the land, but low-cost construction made possible by the level site made the purchase feasible. An airfield could be built if necessary on neighboring land. There was less opposition locally than Ordnance was to encounter with Kentucky and Pennsylvania sites.[62]

In the summer of 1941 the selection of two sites in the Kentucky–West Virginia–Maryland–Pennsylvania area, of about fourteen thousand acres each, was speeded by the prospect of additional funds for storage in the amount of $84 million included in a supplemental appropriation bill then before Congress, and by the allocation of $12 million in lend-lease funds.[63] General Crain appointed Maj. Carroll H. Deitrick to investigate several sites that had survived thinning-out surveys earlier in 1941. After a month's study, in October Major Deitrick recommended tracts in the neighborhood of Richmond, Kentucky, and Charles Town, West Virginia, as sites for the two new depots. The eastern Kentucky site was chosen over one in southwestern West Virginia because it was less rugged, more economical, and better suited for expansion. The West Virginia land was chosen over a tract in south central Pennsylvania because it was less productive, cheaper, and promised lower con-

[59] (1) Ltr, Luke to TAG thru OCO, 17 Mar 41, sub: Bd of Officers, copy in Site Bd Rpts, ex. 73–77; (2) Crain, Diary 23 Nov 40; (3) Lueders Rpt, ex. N; (4) San Jacinto Ordnance Depot, vols. I and II, History From Beginning Through 31 March 1943 [hereafter cited as San Jacinto Hist], pp. 4, 7, OHF; (5) Personal Ltr, Maj Gen Crain to Lida Mayo, 19 May 54, OHF.

[60] (1) Lueders Rpt, ex. O; (2) Ltr, OCO to TAG thru QMG, 12 Jun 41, sub: Bd of Officers, OO 334.3/1473 Misc., copy in Site Bd Rpts, ex. 85; (3) 2d Indorsement, AGO to USW, 21 Jun 41, sub: Bd Proceedings—Selection of Site, Texarkana, Texas, for Ammo Storage Depot, AG 601.1 (6-12-41) MO-D, copy in Site Bd Rpts, ex. 86; (4) Ltr, QMG to TAG, 7 Oct 41, sub: Bd of Officers, OO 633/2260 Misc., copy in Site Bd Rpts, ex. 87.

[61] (1) Ltr, Luke to TAG, 7 Apr 41, sub: Bd of Officers, OO 675/5905 Misc., copy in Site Bd Rpts, ex. 78–84; (2) Seneca Ordnance Depot, vol. I, Original, History to 31 December 1942 [hereafter cited as Seneca Hist], p. 13, OHF.

[62] (1) *Ibid.;* p. 1; (2) Memo, Brig Gen Crain for USW, 29 May 41, sub: Ord Ammo Storage Depot in New York State, OO 675/8730.

[63] (1) Memo, CofOrd for ACofS G-4, 26 Jul 41, sub: Locations for Additional Ammo Depots and Ocean Shipping Facilities, OO 675/13163 Misc.; (2) Site Bd Rpts, ex. 90; (3) Wesson's 11 O'Clock Confs, 8 Aug 41.

struction costs. The Chief of Ordnance and The Quartermaster General concurred in these recommendations, and early in November the Secretary of War gave his approval.[64]

Then local opposition developed to both new depots. In the case of Richmond, Senators Alben W. Barkley and Albert B. Chandler and Representative Virgil Chapman requested an investigation into the protests; it revealed, according to an Ordnance report on construction, "that all opposition was from a handful of wealthy landowners whose property was not affected." Meanwhile, the Governor's office stirred up favorable sentiment, and the Richmond project went through. The first step in the construction of Blue Grass Ordnance Depot came in mid-December.[65] The Charles Town story ended differently. Telegrams and letters of protest poured in to the President, the Secretary of War, and the Chief of Ordnance. Landowners objected to being forced out in the middle of winter, and to losing their homes, livestock, dairies, and orchards. Representative Jennings Randolph led an opposing delegation in person. In the end, G–4 decided to suspend all action with regard to Charles Town and to explore further the south central Pennsylvania area.[66]

A site of about eighteen thousand acres was found near Chambersburg, Pennsylvania. General Crain and Major Deitrick considered that it had some advantages over Charles Town: it was some four thousand acres larger, could more easily be expanded, and was farther from the town—a safety consideration. Although the cost of construction would probably be greater because the terrain was more rolling, the cost of land acquisition would probably be less. On the other hand, there was as much opposition by the local citizens as there had been at Charles Town. Telegrams of protest came from Governor Arthur H. James, Senator James J. Davis, and Representative Harry L. Haines. Not only was the entire area more productive and more thickly settled—with some eight hundred people as opposed to about fifty on the West Virginia site—but also many of the farmers were descendants of original settlers of the area. Many were Mennonites and Dunkards who were opposed to war even for defense. But the military planners had come to believe that there would be protests no matter what site was selected; moreover, Pearl Harbor occurred in the midst of the furor, and the argument of military necessity outweighed all others.[67]

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[64] (1) Site Bd Rpt, ex. 87; (2) 3d Ind, TAG to USW, 5 Nov 41, sub: Acquisition of Land for Ammo Depot, Charles Town, W.Va., Richmond, Ky., AG 681 (10–7–41) MO–D, copy in Site Bd Rpts, ex. 88; (3) Intraoffice Memo, Ammo Supply Div FS to Chief FS, 29 Jul 41, sub: Rpt of Examination of Prospective Ammo Storage Depot Sites in Eastern Ky., OO 633/1725-1/2 Misc., copy in Site Bd Rpts, ex. 89; (4) Site Bd Rpts, ex. 90; (5) Ltr, OCO to QMG, 25 Aug 41, sub: Survey of Proposed Ammo Depot Site in W.Va., OO 675/15745 Misc., copy in Site Bd Rpts, ex. 91.

[65] Lueders Rpt, ex. Q.

[66] (1) Memo, CofOrd for ACofS G–4, 1 Dec 41, pub: Proposed Ammo Depot Site at Charles Town, Jefferson County, W.Va., OO 675/23993; (2) Ltr, Col Charles M. Steese to Chief FS, 6 Sep 41, sub: Sites for Ammo Depots in Pa., Md., Va., W.Va., and Ky., copy in Site Bd Rpts, ex. 93; (3) Memo, Col S. J. Chamberlain, Actg ACofS for Deputy CofS (Maj Gen Richard Moore), 15 Nov 41, sub: Proposed Ammo Depot, Charles Town, W.Va., G–4/31866–2, copy in Site Bd Rpts, ex. 94.

[67] (1) Memo, CofOrd for ACofS G–4, 12 Dec 41, sub: Proposed Ammo Depot—Chambersburg, Pa., in lieu of Charles Town, W. Va., OO 633/2354 Misc.; (2) Min, Wesson's 11 O'Clock Confs, 19 Dec 41; (3) Hist, Storage Div, I, p. 13; (4) Interv, Crain, 30 Jun 49; (5) Memo for Rcd on Disposition Form, Brig Gen Somervell, actg ACofS G–4 to TAG, 11 Dec 41, sub:

On 2 January 1942 Secretary of War Stimson refused the request of Governor James for reconsideration, and six days later survey crews were at work on the boundary lines for Letterkenny Ordnance Depot.[68] The speed with which negotiations were pushed through was one cause of community resentment against Letterkenny, "the ammunition dump," as it was called locally. There were others. This depot, one of the largest in the whole Ordnance system, needed more than five thousand workers and drained the countryside of manpower badly needed at sowing and harvesting time. There was no large city near enough to supply a pool of labor. And the antiwar sentiment of the community was hardly conducive to good morale among the workers. One depot employee, an elderly, chin-whiskered gentleman named George B. McClellan Flora, was suspended from his church because he put on an Uncle Sam suit and sold War Bonds. In time, public relations improved, but they were always a problem and hampered depot operations to an extent that had not been foreseen.[69]

In addition to the Kentucky and Pennsylvania depots, the $84-million program of the summer of 1941 included one large new ammunition depot in the Far West, two on the plateau east of the rockies, and the expansion of facilities at Ogden. First priority in this group went to the project in the Far West, the acquisition of a site in western Nevada or eastern California for an intermediate depot to give closer support to overseas movements from the San Francisco area, and also meet the needs of the Air Corps. Second priority went to the expansion of Ogden and the construction of the two plateau depots, one in the southeastern Colorado–western Kansas area, the other somewhere in southwestern South Dakota or western Nebraska, both for long-time reserve storage. These regions had the high altitude and dry climate that would minimize rusting and other deterioration, and in the more northerly area Ordnance hoped to find a site isolated enough to make possible the storage of gas ammunition.[70]

Major Deitrick spent most of the fall of 1941 touring the West, often accompanied by members of the appropriate Zone Quartermaster's office, representatives of the transcontinental railroads, and local

Petition Protesting Location of Ammo Depot in Vicinity of Chambersburg, Pa., G-4/31866-2, copy in Site Bd Rpts, ex. 95; (6) Memo, OCO for ACofS, G-4 12 Dec 41, sub: Proposed Ammo Depot—Chambersburg, Pa., in lieu of Charles Town, W. Va., OO 633/2354 Misc., copy in Site Bd Rpts, ex. 96; (7) Memo, Brig Gen Somervell, ACofS to CofS, 17 Dec 41, sub: Site for an Ammo Depot, G-4/31866-2, copy in Site Bd Rpts, ex. 97; (8) Memo, Brig Gen Somervell, ACofS, for CofS, 26 Dec 41, sub: Site for Ammo Depot, Chambersburg, Pa., G-4/31886-2, copy in Site Bd Rpts, ex. 98; (9) Ltr, SW to Hon Arthur H. James, 2 Jan 42, G-4/31866-2, copy in Site Bd Rpts, ex. 99; (10) Memo, TAG for USW, 18 Dec 41, Site for an Ammo Depot, AG 681 (12-17-41) MSC-D, copy in Site Bd Rpts, ex. 100; (11) Memo, Brig Gen Somervell, ACofS, for CofS, 1 Jan 42, sub: Site for an Ammo Depot, Chambersburg, Pa., G-4/31886-2, copy in Site Bd Rpts, ex. 101.

[68] (1) Site Bd Rpts, ex. 99; (2) History, Letterkenny Ordnance Depot, vol. I, From Beginning Through 31 December 1942, p. 8, OHF.

[69] (1) Lt Col A. G. Erpf and Lt Col E. D. Mohlere, Report of a Visit to Letterkenny Ordnance Depot, Chambersburg, Pennsylvania [Aug 44], ASF 200.02 Contl Div files; (2) Min, Conf of Depot Comdrs, FS Div, Ord Dept, 25–26 Aug 43, p. 12, OHF.

[70] (1) Site Bd Rpts, ex. 90; (2) Hist, Storage Div, I, p. 17; (3) Ltr, OQMG to TAG thru OCO and QMG, 2 Dec 41, sub: Bd of Officers, with 1 Incl, Rpt of Bd of Officers Pursuant to Dir From SW dated 4 Sep 41—Bd to Select Site for Ammo Depots Southeastern Colo.-Western Kans. Area, copy in Site Bd Rpts, ex. 105.



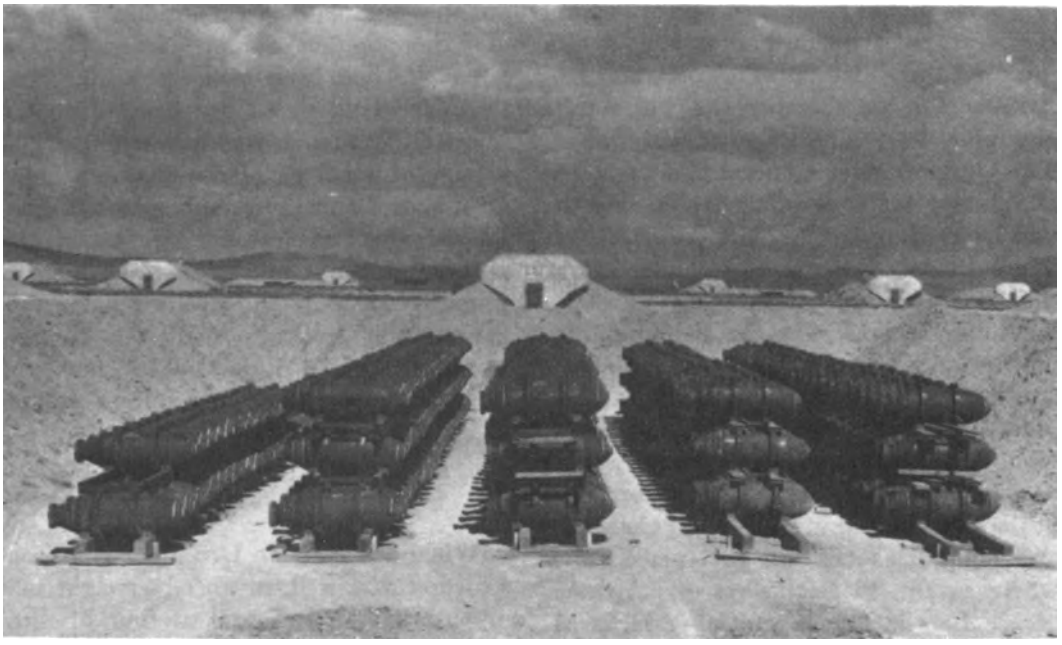
INSIDE STORAGE OF 155-MM. SHELLS *at Blue Grass Ordnance Depot, Richmond, Ky.*

officials.[71] In the eastern California–western Nevada area he found an arid valley of about forty-three square miles in the Sierra Nevada Mountains, just west of the Nevada line near Hackstaff, California, and on the edge of Honey Lake. It was about 50 miles by highway north of Reno and about 250 by highway and 400 by rail from Benicia Arsenal. After approval by the Secretary of War, the site was named Herlong, in honor of Capt. Henry W. Herlong, an Ordnance officer killed in an Air Corps crash the preceding summer. At Herlong was built Sierra Ordnance Depot.[72] In the Colorado–Kansas area Major Deitrick recommended a tract of 21,120 acres of grazing land near Avondale, Pueblo County, Colorado, which became the site of Pueblo Ordnance Depot.[73] For the second depot in the plateau country he selected 20,000 acres of sagebrush land in a very thinly populated

[71] (1) Site Bd Rpts, ex. 105; (2) 1st Indorsement, OCO to TAG Through QMG, 8 Dec 41, and 2d Indorsement, QMG to TAG, 8 Dec 41, OO 682/145, copies in Site Bd Rpts, ex. 106; (3) 3d Indorsement, AGO to CofEngrs, 16 Dec 41, sub: Bd of Officers, AG 681 (12-2-41) MSC-D, copy in Site Bd Rpts, ex. 107; (4) 4th Indorsement, CofEngrs, to OCO, 23 Dec 41, OO 682/145, copy in Site Bd Rpts, ex. 108.

[72] (1) Sierra Ordnance Depot, vol. I, History Through 1942 [hereafter referred to as Sierra Hist], pp. 1, 4, OHF; (2) Ltr, OQMG to TAG Through OCO and QMG, 2 Dec 41, sub: Bd of Officers, with 1 Incl, Rpt of Bd to Select Sites for Ammo Depots Western Nev.–Calif. Area, copy in Site Bd Rpts, ex. 113; (3) Memo, Lt Col Harold De L. Stetson, QMC, to Zone Constructing QM, Zone IX, 27 Sep 41, sub: Rpt of Inspection of Ord Sites, copy in Site Bd Rpts, ex. 114; (4) Ltr, O Zone Construction QM Zone IX to QMG, 30 Oct 41, sub: Proposed Ord Site—Western Nev., with 1 Incl, Memo, Claude L. Coray to Col Edward M. George, 29 Oct 41, sub: Ord Storage Sites near Susanville, Calif., OO 685 Western Nev., copy in Site Bd Rpts, ex. 115; (5) Exec Order No. 5827, 28 Mar 32, sub: Withdrawal of Public Land for Military Purposes, copy in Site Bd Rpts, ex. 116.

[73] (1) Site Bd Rpts, ex. 105; (2) Ltr, Con-



OUTSIDE STORAGE OF 100-POUND BOMBS *at Sierra Ordnance Depot, Herlong, Calif.*

area in South Dakota. The nearest town, Provo (population 20), gave its name to the site on which was built Black Hills Ordnance Depot.[74]

Along with the study of these three sites, Major Deitrick investigated the expansion of Ogden Ordnance Depot, Utah. He found that the depot lay in a narrow rectangle bounded by the Wasatch Mountains, the Great Salt Lake, the city of Ogden, and Salt Lake City; within this rectangle it was immediately hemmed in by a neighboring airfield, main trunk highways, and fertile farm and orchard lands. There was no way to enlarge the site. The best solution was the acquisition of a tract in the valley of the Wasatch Range of about twenty thousand uninhabited acres near the town of Tooele, Utah.[75]

In forwarding to the Secretary of War the report on the four sites, dated 2 December 1941, General Wesson suggested one change. He thought action with regard

structing QM Denver Ord Plant to QMG, 24 Oct 41, with 1 Incl, Ltr, Constructing QM Denver Ord Plant to Constructing QM, VIII Constructing Zone, 24 Oct 41, sub: Inspection of Prospective Camp Sites, copy in Site Bd Rpts, ex. 111; (3) Ltr, Constructing QM Denver Ord Plant to QMG, 8 Nov 41, with 1 Incl, Ltr, Constructing QM Denver Ord Plant to QMG, 30 Oct 41, sub: Prospective Camp Sites (Ammo Storage), 06 635 Denver Ord Plant, copy in Site Bd Rpts, ex. 112.

[74] (1) Ltr, OQMG to TAG through OCO and QMG, 2 Dec 41, sub: Bd of Officers, with 1 Incl, Rpt of Bd to Select Sites for Ammo Depots Southwestern S. Dak.–Western Nebr. Area, copy in Site Bd Rpts, ex. 117; (2) Survey for Ammunition Storage Depot in Southwestern South Dakota, Western Nebraska and Western Wyoming, copy in Site Bd Rpts, ex. 117a.

[75] Ltr, OQMG to TAG Through OCO and QMG, 2 Dec 41, sub: Bd of Officers, with 1 Incl, Rpt of Bd to Select Sites for Ammo Depots —Ogden Ord Depot (Expansion), copy in Site Bd Rpts, ex. 123.

to Tooele should be held in abeyance until the War Department had investigated a site in the Flagstaff–Prescott area of Arizona. On 4 December 1941, at a time of rapidly worsening relations with Japan, The Quartermaster General had suggested establishing water shipping facilities in the San Diego–Los Angeles area. Flagstaff was approximately three hundred miles nearer this area than was the Tooele site.[76] By the time General Wesson's memorandum reached the desk of the Secretary of War, the attack on Pearl Harbor had taken place. The War Department ordered that, without delay, ammunition storage depots of one thousand igloos each be constructed at the sites selected in California, Colorado, and South Dakota; and at a place somewhere in the Flagstaff–Prescott, Arizona, area.[77] Late in December Col. Charles M. Steese inspected several sites in the area and found a suitable tract of twenty seven thousand acres in the vicinity of Bellemont, Arizona. It became Navajo Ordnance Depot.[78]

Taking stock of the ammunition storage situation at the beginning of 1942, the Chief of Ordnance reported to G–4 that, after completion of all ammunition depot construction then in process or authorized, there would still be a shortage of 15,479,201 square feet in the amount of space required to support the force contemplated, about 3,635,000 men. Nothing like this amount of additional construction seemed advisable, because expenditures of stored ammunition would make room for the ammunition coming out of the plants. But General Wesson did recommend that about half of the 7,677,410 square feet of ammunition storage in deferred status be constructed at once. He urged the building of two new depots of 1,719,884 square feet each, one at Tooele, Utah, to carry out the long-planned expansion of Ogden, and the other at Sidney, Nebraska. The latter site had been explored at the time the Black Hills depot was decided on but rejected because it was not suited to the storage of lethal gas. Here was built Sioux Ordnance Depot. Ordnance planners considered that its location in the central portion of the United States achieved a proper geographic and strategic balance of ammunition stocks.[79] With the enlargement of the old East Coast depots and Benicia Arsenal the ammunition storage program was virtually complete.[80]

Opening the New Depots

When war came in December 1941 construction was well advanced at eight new ammunition depots, and at four of them —Umatilla, Portage, Wingate, and Anniston—shipments were already being received. But throughout 1941 and 1942, even at the most carefully selected sites, Ordnance encountered problems of construction and operation created by terrain or location. In the East, the Appalachian

[76] Site Bd Rpts, ex. 106.

[77] *Ibid.*, ex. 107.

[78] (1) Ltr, U.S. EngrO, Caddoa Dist, to WDGS G–4 through OCO and CofEngrs, 30 Dec 41, sub: Bd Rpt on Selection of Site for Ammo Storage Depot, Flagstaff–Prescott, Ariz., Area with 1 Incl, Rpt of Bd, OO 601.1/415 Flagstaff–Prescott, copy in Site Bd Rpts, ex. 109.

[79] (1) Ltr, CofOrd to TAG, 7 Jan 42, sub: Depot Storage Problem, Supplemental FY 1942, OO 471.887/1137; (2) Site Bd Rpts, ex. 117; (3) Lueders Rpt, exs. W, X.

[80] (1) Monograph No. 8, Plate V, Ord FS Facilities Existing and Authorized, as of 1 Dec 42; (2) Memo, CofOrd for TQMG, 9 Dec 41, Expediting Magazine Construction at Benicia Arsenal, OO 633/2348; (3) Memo, CofOrd for ACofS G–4, 8 Dec 41, sub: Expansion of Raritan Arsenal, OO 633/2350; (4) Personal Ltr, Maj Gen Crain to Maj Gen Ford, 25 Jul 50, OHF.

foothills made it difficult to grade the roads and railways; in the igloo area, well camouflaged as it usually was with trees and grass and often protected by natural mounds that served as barricades, there was always the danger of brush fires, and the fear of the damage an explosion might do in a more or less thickly settled region.[81] The vast Western depots, on the level floor of a high mountain valley or on a wind-swept prairie, with orderly and accessible rows of igloos stretching as far as the eye could see against a background of snow-covered peaks, had the virtue of isolation, an important consideration; yet isolation created a desperate problem of manpower.

Prewar planning, based on defense of the continental United States, had intended the use of troop labor in the event of invasion, because the depots would very likely be in the combat zone. As the danger of invasion passed, the General Staff made the decision to operate the depots with civilians.[82] In setting up criteria for location, General Staff planners had properly placed highest priority on strategic requirements, including available transportation trunk lines to areas to be served, recognizing at the time that, should these depots ever have to be operated by civilian employees, a tremendous problem of housing and personnel transportation would be posed.[83] Sometimes there were Indians in the neighborhood of the western depots who could be mustered into service, as at Navajo, where a bespectacled descendant of Chief Manygoats was driving a truck;[84] but at most of these depots labor had to be brought in, housed, and offered the facilities of a town.[85]

As an example of the problems encountered at the "big unwieldy depots out in the Western desert," one Ordnance officer cited an instance in January 1943 when the food supply at Sierra was cut off because floods had washed out the railroad tracks and road to the nearest town, thirty-five miles away.[86] After Pearl Harbor the shortage of equipment and materials of various kinds affected the new depots. The great size and complexity of these installations soon dispelled the peacetime idea that "a good Ordnance sergeant or warrant officer" could operate a depot. Trained commanding officers were needed and were hard to find. Inexperienced men were given an almost impossible job in meeting the very tight time schedules for opening the depots.[87]

By 14 January 1943, all of the sixteen new ammunition depots had been activated. They had cost altogether about $367 million. Among the individual depots the costs ranged from $37 million down to $11 million, depending on the size of the installation, the cost of the site, and the cost of construction. There were striking differences in the amounts paid for the sites. Land for Blue Grass Ordnance

[81] Depot histories in OHF.

[82] Interv with Col Carroll Deitrick, OCO Field Service Plans and Operations, vol. I, pt. 1, History From 1 June 1942 to January 1943 [hereafter cited as Hist, P&O, I], p. 92, OHF.

[83] (1) The Army Ind College Dept of Research, Study of Experience in Industrial Mobilization in World War II: Handling of Matériel, Nov 45, Rpt 28, ICAF Library; (2) Ltr, Brig Gen Deitrick to Col George White, 11 Jul 55, OHF.

[84] Navajo Ordnance Dept, vol. I, Basic History Through 31 December 1942, p. 3, OHF.

[85] (1) Hist, P&O, I, 92–121.

[86] (1) Ltr, Col Robert Sears, CO Ogden Arsenal, to Maj Gen Levin Campbell, Jr., CofOrd, 26 Mar 43, Gen Campbell's Personal Correspondence; (2) Sierra Hist, 1 Jan–31 Mar 43, p. 12.

[87] (1) Memo, Col James W. Freeman for Exec to Chief of FS, 1 Jun 45, sub: Final Rpt of Key Personnel, in FS Key Pers Rpts, OHF; (2) Lueders Rpt, ex. X; (3) Umatilla History, p. 2.

Depot, for example, cost about $150 per acre—that for Sierra about nine cents.[88]

At all the depots the igloo construction was of permanent type, but in other respects there was a difference between the buildings erected at the first eight depots, called the "A" program, and the second, called "B." At Anniston, Umatilla, Portage, Wingate, Milan, Seneca, San Jacinto, and Red River, all begun in 1941 and nearing completion in the spring of 1942 when materials became critical, most of the administration buildings, warehouses for inert supplies, and like construction were of permanent type; but at the "B" depots, Sierra, Navajo, Letterkenny, Sioux, Black Hills, Tooele, Blue Grass, and Pueblo, most construction was of a type called "mobilization," designed to last five years, or "theater-of-operations," designed to last only for the duration of the war.[89]

In acreage the depots were almost unbelievably vast compared to depots of other supply services. Quartermaster installations generally occupied between one hundred and eight hundred acres.[90] The Ordnance Department had six depots with more than twenty thousand acres each.[91] An interesting sidelight on the size and location of these great tracts was the amount and variety of the wildlife they contained; as military reservations they afforded protection from hunters. In the East, Letterkenny had quantities of deer, fox, raccoon, opossum, and ringnecked pheasant. The western depots had large populations of deer, bear, antelope, elk, and coyote. At Black Hills there were two prairie-dog towns; at Wingate, tassel-eared squirrels and deer; at San Jacinto, alligators, wildcats, and armadillos.[92]

[88] Hist, Storage Div, I, pp. 24–25 and exs. 3, 6.

[89] (1) Hist, P&O, I, pp. 88–90; (2) Ltr, Brig Gen Somervell, ACofS G–4 for CofS, 17 Jan 42, sub: Depot Storage Program, Supplemental FY 1942, AG 681 (1–17–42) G–4/32315; (3) Personal Ltr, Maj Gen Crain to Mrs. Constance McLaughlin Green, 27 Aug 50, OHF.

[90] Stauffer, *op. cit.*, p. 18.

[91] Monograph No. 8, Plate V.

[92] Public Information Br, OCO, Background Information on Ordnance Field Service, Apr 53, OHF.

CHAPTER XVIII

Revisions in the Depot System

After starting in 1941 with a depot system that could not meet all its constantly increasing needs, Ordnance faced four major problems during the war: (1) finding storage space for general supplies far in excess of original forecasts; (2) meshing motor transport facilities into the Ordnance supply system; (3) adjusting to reallocation of depot space by Army Service Forces; and (4) shifting emphasis from support of troops in training in the United States to the support of overseas theaters.

Storage of General Supplies

As noted in the preceding chapter, Ordnance did not build many warehouses in 1939–1940 for storage of general supplies, or "combat equipment" as such matériel was beginning to be called. Its main effort had been directed toward ammunition storage. But with the rising tide of war production, actual and planned, in 1940, Ordnance was allotted $7,244,000 for warehouse construction in fiscal year 1941. This appropriation was divided three ways: $2 million was to be used to add 500,000 square feet at Ogden Ordnance Depot and the rest was to be divided very nearly evenly between two unnamed depots, one in the southeast to provide 650,000 square feet and one in the central area to provide 661,000 square feet.[1]

The existing depot at Anniston, Alabama, was selected as the site for new storage space in the southeast because its location was ideal to serve the maneuver area of the south, and adjacent land was available for purchase if needed for expansion. After the site was approved, construction proceeded rapidly. By March 1942, seventeen warehouses with a combined floor area of 772,200 square feet had reached completion.[2] For the depot in the central area, Ordnance planners decided to enlarge Rock Island Ordnance Depot, traditionally a great center for general supply storage. One enormous warehouse, 1,423 by 545 feet, with a total of 767,888 square feet, reached completion in June 1942, and was the first of its size and type in War Department history. Planned to house tanks, it was one story high, covered eighteen acres, and could receive under its roof a freight train of sixty cars.[3] The forty new warehouses begun at Ogden in the fall of 1940 were at first filled with inert ammunition components and empty practice bombs; this matériel was removed to open storage when the first

[1] Ltr, SW to CofOrd, 23 Sep 40, sub: Storage, AG 112.05 (9-19-40) M-D, copy in Lueders Rpt, ex. H.

[2] (1) Anniston Hist, pp. 10–14, 44; (2) Crain, Diary, 1 Oct 40.

[3] Hist, Rock Island Arsenal, vol. II (1939–43), p. 306.

stock of general supplies arrived in March 1942.[4] Months before the new facilities at Ogden, Anniston, and Rock Island were ready, it became evident that space for combat equipment would again have to be increased because of accelerated production to meet rising mobilization objectives. In the summer of 1941 a new problem arose—the amount of lend-lease matériel that was accumulating in the United States because there were not enough ships to move it out.

In July 1941 the Ordnance Department, after a careful study of requirements, recommended that twelve million additional square feet of permanent-type warehouses for general supplies be built at the new ammunition depots; later it urged that seventeen million more square feet be provided to take care of the fiscal year 1943 program. Ordnance pointed out that the ammunition depots under construction were equally well suited for general supplies from the standpoint of transportation and strategic location. Many of them were in the high altitude region considered ideal for long-term storage. They had adequate power, water, and other facilities for expansion, and plenty of acreage.[5]

This pre-Pearl Harbor attempt at expansion was unsuccessful. At a meeting in September 1941 the War Department Budget Advisory Committee appeared uninterested in the Ordnance presentation. That fall, the War Department began to build general depots in Michigan, Illinois, Ohio, and Indiana—the area in which about 75 percent of the munitions would be produced—to regulate the flow of lend-lease supplies to ports; G–4 contemplated placing much of the new production of weapons and tanks, along with supplies of other technical services, in these depots. There were eventually eleven of them, called Defense Aid originally but soon renamed War Aid.[6]

After Pearl Harbor, the General Staff allotted to Ordnance about $39 million for new storage space for general supplies at Letterkenny, Anniston, Red River, Umatilla, Sierra, and Ogden; this sum was to provide a total of 2,747,000 square feet of warehouse space and 5,000,000 square feet of shed space.[7] But the bulk of the space allotted to Ordnance was at the eight Defense Aid depots, a total of eight million square feet of covered space and sixteen million square feet of open storage. There was also in contemplation the utilization of commercial warehouses and the end of permanent-type construction.[8]

The War Munitions Program of 11 February 1942 set extremely high production goals for tanks, artillery, and other equipment.[9] Preliminary estimates by Colonel Steese, chief of a new office established within Field Service on 2 February to consolidate all depot construction activities and planning, indicated that a total of about 119 million square feet of space would be necessary if Ordnance had to store all matériel to be produced in 1942 and the first three months of 1943. Not all of it would have to be stored, of course, for some of it would immediately go to troops or to allied nations. The best guess was that Ordnance would have to

[4] History, Ogden Arsenal, I, pt. 2 (1939–42), pp. 53–54.

[5] Monograph No. 8, pp. 28–30.

[6] (1) *Ibid.;* (2) Min, Wesson Confs, 2 Jul, 18 Sep, 21 Oct 41.

[7] (1) Ltr, SW to Chief of Engrs, 14 Feb 42, sub: Depot Storage Program Ord Dept, AG 681 (2–9–42) MO–D; (2) Memo, Brig Gen Somervell, ACofS G–4, for CofS, 17 Jan 42, sub: Depot Storage Program, Supplemental FY 1942, AG 681 (1–17–42) G–4 32315.

[8] Monograph No. 8, p. 30.

[9] See ch. IV, above.

store about 50 percent of the total production for U.S. troops and about 40 percent of War Aid production. On this basis, about 25,900,000 square feet of storage space would be needed; the Ordnance plan divided it into 13,400,000 for warehouses and 12,500,000 for sheds.

In their presentation to higher authority, Ordnance planners pointed out that postwar needs should also be taken into account, because building materials and labor would become scarce as the war went on, and funds for postwar construction would be hard to get. They also argued that sheds with walls were far better than open storage for artillery, tanks, and other combat vehicles equipped with delicate fire control instruments and radios. Granted that most of the supplies would be manufactured in the Ohio, Michigan, and Illinois area, they did not recommend that region for postwar storage because its climate would make excessive maintenance necessary. The Ordnance solution was to locate the new general supply space at twelve ammunition depots, balancing warehouse and shed space with that already authorized at Sierra, Letterkenny, Umatilla, and Ogden, and building both types in approximately equal amounts at Tooele, Sioux, Pueblo, Wingate, Navajo, Blue Grass, Seneca, and Black Hills.[10]

After a survey showed that 74 percent of the expected carload deliveries would be for tanks and combat vehicles that could not be stored in the open, the General Staff reversed its earlier decision to place Ordnance matériel at War Aid depots and approved the building of warehouses and sheds at the ammunition depots. Except for permanent buildings already authorized, all construction was to be temporary,[11] meaning mobilization or theater-of-operations type. Warehouses of the latter type were built of some flimsy material, such as plywood, and were not much better than tents. They were not suitable for housing certain types of Ordnance matériel, as the Chief of Engineers pointed out to the War Department. Nevertheless, General Somervell laid down the principle in March 1942 that, because the first consideration was economy in money, time, and critical materials, warehouses were to be of light frame construction, with fire walls only where necessary, with roofing specifications not to exceed a 10-year limit, and without excessive roof spans; sheds were to be of open-type light frame construction, without concrete floors. On 1 June 1942 the War and Navy Departments and the War Production Board set up rigid rules for wartime construction. It was to be "of the simplest type, just sufficient to meet the minimum requirements." Thus any additional construction at existing Ordnance depots, with the exception of igloos, had to be theater of operations type whenever possible. There was one loophole: masonry construction, such as concrete blocks, could be used if the material was not critical in the area concerned and if its cost would not run more than 15 percent

[10] (1) Ltr, CofOrd to TAG, 27 Feb 42, sub: Storage Requirements for Ord Gen Supplies, for 1942 and First Three Months of 1943, OO 400.-24/697; (2) Min, Wesson Confs, 4 Mar 42.

[11] (1) Monograph No. 8, pp. 31–34; (2) Personal History of Col. Lawrence J. Meyns, Ordnance Office, 1 Jul 41–Jun 42 [hereafter referred to as Meyns Rpt], FS Key Pers Rpts; (3) Ltr, SW to CofEngrs, 7 Mar 42, sub: Temporary Type Construction, Depot Storage Program, AG 681 (2–24–42) MO–D, copy in OCO FS Plans and Opns, vol. I, pt. 2, History From 1 June 1942 to January 1943 [hereafter cited as Hist, P&O II], ex. 69, OHF.



OPEN-TYPE STORAGE SHEDS *(right) at Casad Ordnance Depot, New Haven, Ind., September 1943.*

over the cost of the theater of operations construction.[12]

Not all the new combat equipment went into ammunition depots. Some of it was stored in Ordnance sections of the three Army general depots at Columbus, Ohio; New Cumberland, Pennsylvania; and Schenectady, New York. Some of it went into old-line repair arsenals such as Augusta, where Civil War caissons had to be moved out into the open to make room in the warehouses.[13] But most of the general supplies went into warehouses and sheds built for the purpose at the new ammunition depots. At the time the fifty million additional square feet of combat equipment space was estimated, no great influx of new ammunition was expected. Of all the new ammunition to be produced, Ordnance assumed that about half would be stored and half would be expended in combat or in training.[14] By December 1942, twelve of the ammunition depots that grew out of the expansion plans of 1940 and 1941—Anniston, Black Hills, Blue Grass, Letterkenny, Navajo, Pueblo, Red River, Seneca, Sierra, Sioux, Tooele, and Umatilla—each had, existing or authorized, between 900,000 and 2,500,000 square feet of combat equipment space. Anniston, Letterkenny, Pueblo, Red River, Seneca, Sierra, Sioux, and Tooele had more square feet in com-

[12] (1) Hist, P&O, I, pp. 87–92; (2) Ltr, SW to CG AAF, *et al.*, 1 Jun 42, AG 600.12 (5–30–42) MO-SPAD-M, copy in Hist P&O II, ex. 70.

[13] Crain, Diary, 28 Oct, 12 Nov 40.

[14] Min, Wesson Confs, 6 May 42.

bat equipment warehouses than they had in ammunition magazines and igloos.[15]

Early in 1942, when Ordnance storage officials planned the move of general supply stocks into ammunition depots, they were thinking in terms of reserve storage to back up distribution depots and space to store war reserves that would accumulate at the end of the war. Nobody knew at the time to what extent the great ammunition depots would be drawn into the distribution picture.[16] Problems of distribution aside—and these would become acute in 1943 when the emphasis shifted from domestic supply to overseas supply—the disadvantages of isolation came to be keenly felt in the case of combat equipment. Ordnance supply experts felt later that general supply operations were more seriously hindered by isolated locations and the lack of skilled labor resources than were the ammunition supply operations at the same depot.[17]

Yet the fact that the Ordnance Department combined equipment storage with ammunition storage and secured the necessary land at low prices stretched the funds allotted for land so that the General Staff could use some of the money for other supply services and buy the site for at least one training camp.[18] Moreover, the early construction of equipment warehouses helped to ease a critical storage situation both during the war, when the War Department could place in Ordnance warehouses and sheds large stocks of matériel of other agencies for which no adequate provision had been made, and immediately after the war, when rented commercial warehouses and railroad storage yards had to be given up. General Crain's insistence on permanent construction, in the period before building materials became scarce, provided for the first time in Army history suitable storage for war reserves.[19]

The Acquisition of Quartermaster Facilities

When the Ordnance Department in midsummer of 1942 received from the Quartermaster Corps the responsibility for motor transport vehicles,[20] the storage facilities that came with the new mission included six War Aid depots, eight motor bases, four motor supply depots, eleven motor supply sections at Quartermaster depots, and one motor reception park. At the time of transfer, a large proportion of the covered storage at War Aid depots was shed space, and a great deal of the total area, in some cases most of the total, was open storage.[21] There were maintenance difficulties, because the buildings had been hastily constructed for limited service at a time when shortages forced the use of substitute building materials. As "holding and reconsignment points" or stopping places for supplies already consigned to a destination, these depots had not had the function of filling requisitions and therefore had

[15] Monograph No. 8, Plate V.

[16] Meyns Rpt.

[17] (1) Field Service Division History, vol. XII, History of Storage Branch, pt. II, Sep . . . Jun Through Dec 43 [hereafter cited as Hist, Storage Br, II], p. 5, OHF; (2) Monograph No. 1, The Ordnance Task And Its Management, 1 Jul 40 to 31 Aug 45 [hereafter cited as Monograph No. 1], p. 71, OHF.

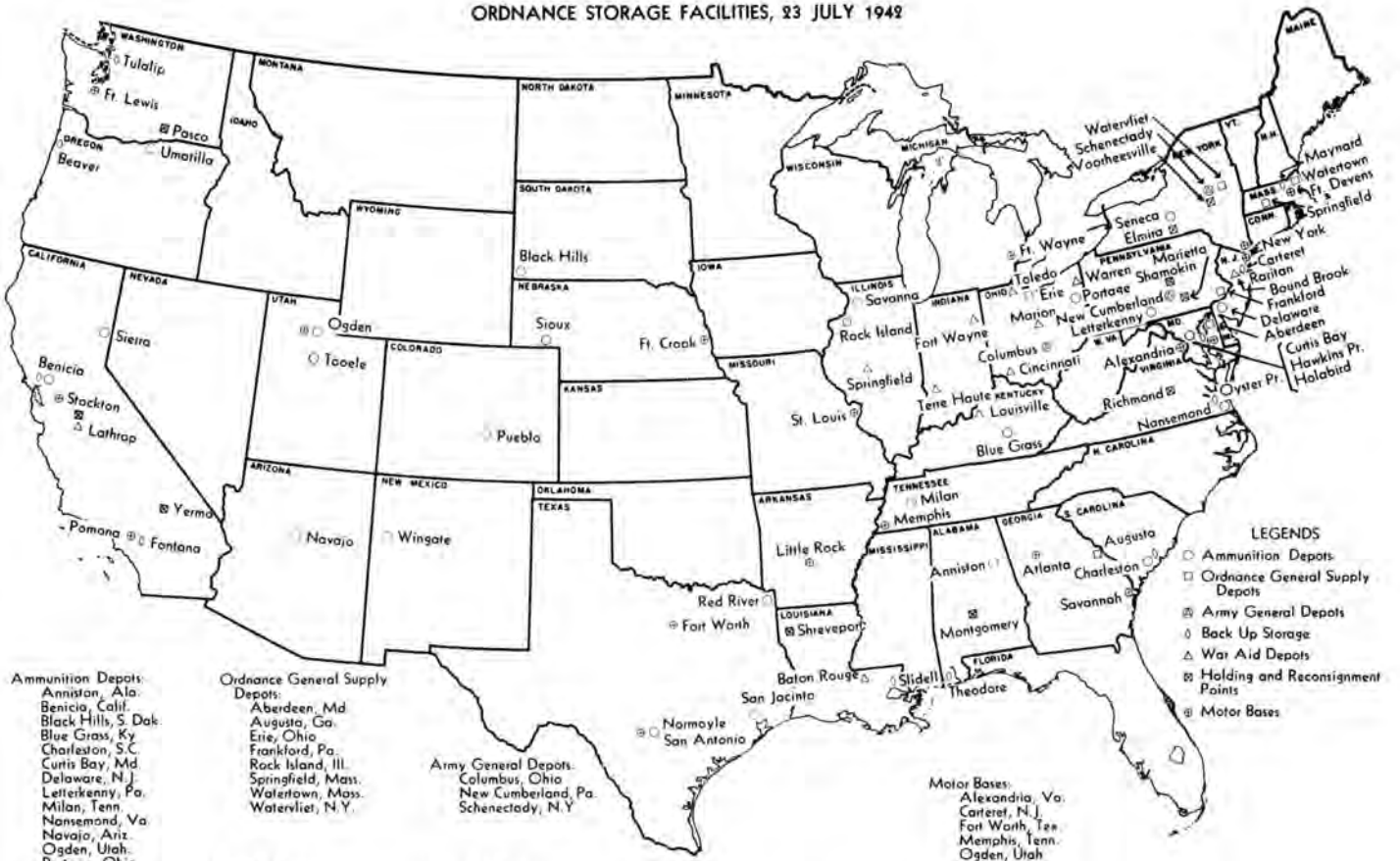
[18] Personal Ltr, Maj Gen Crain to Maj Gen Ford, CofOrd, 25 Jul 50, OHF.

[19] (1) ASF Historical Monograph, Storage Operations December 1941–December 1945, pp. 34–36, 269–71; (2) Memo, Lt Gen Somervell for CofOrd, 9 Mar 43, sub: Assignment of Space, SPOPN 400.24 (3-9-43); (3) Depot histories in OHF.

[20] For this transfer, see Chapter XII.

[21] Monograph No. 8, Plate V.

ORDNANCE STORAGE FACILITIES, 23 JULY 1942



LEGENDS

- Ammunition Depots
- Ordnance General Supply Depots
- Army General Depots
- Back Up Storage
- War Aid Depots
- Holding and Reconsignment Points
- Motor Bases

Ammunition Depots:
Anniston, Ala.
Benicia, Calif.
Black Hills, S. Dak.
Blue Grass, Ky.
Charleston, S.C.
Curtis Bay, Md.
Delaware, N.J.
Letterkenny, Pa.
Milan, Tenn.
Nansemond, Va.
Navajo, Ariz.
Ogden, Utah.
Portage, Ohio
Pueblo, Colo.
Raritan, N.J.
Red River, Tex.
San Antonio, Tex.
San Jacinto, Tex.
Savanna, Ill.
Seneca, N.Y.
Sierra, Calif.
Sioux, Nebr.
Tooele, Utah.
Umatilla, Oreg.
Wingate, N. Mex.

Ordnance General Supply Depots:
Aberdeen, Md.
Augusta, Ga.
Erie, Ohio
Frankford, Pa.
Rock Island, Ill.
Springfield, Mass.
Watertown, Mass.
Watervliet, N.Y.

Army General Depots:
Columbus, Ohio
New Cumberland, Pa.
Schenectady, N.Y.

Back Up Storage:
Maynard, Mass.
Raritan, N.J.
Hawkins Pt., Md.
Charleston, S.C.
Theodore, Ala.
Slidell, La.
Fontana, Calif.
Benicia, Calif.
Beaver, Oreg.
Tulalip, Wash.
Oyster Pt., Va.

War Aid Depots:
Warren, Ohio
Toledo, Ohio
Marion, Ohio
Terre Haute, Ind.
Cincinnati, Ohio
Baton Rouge, La.
Lathrop, Calif.
Bound Brook, N.J.
Louisville, Ky.
Springfield, Ill.
Fort Wayne, Ind.

Holding and Reconsignment Points:
Elmira, N.Y.
Marietta, Pa.
Montgomery, Ala.
Pasco, Wash.
Richmond, Va.
Shamokin, Pa.
Shreveport, La.
Lathrop, Calif.
Yermo, Calif.
Voorheesville, N.Y.

Motor Bases:
Alexandria, Va.
Carteret, N.J.
Fort Worth, Tex.
Memphis, Tenn.
Ogden, Utah
Savannah, Ga.
Atlanta, Ga.
Ft. Crook, Nebr.
Ft. Devens, Mass.
Ft. Lewis, Wash.
Ft. Wayne, Mich.
Holabird, Md.
Little Rock, Ark.
New York, N.Y.
Normoyle, Tex.
Pomona, Calif.
St. Louis, Mo.
Stockton, Calif.

little or no operating equipment, office space, lunchrooms, and so on; as reservoirs for bulk storage, they lacked bins and other facilities. But these disadvantages were offset by the location of the War Aid depots in the area in which about 75 percent of general supplies were manufactured; after extensive rewarehousing programs, they served Ordnance well. Rossford (formerly named Toledo) became the master depot for automotive parts and Lordstown the master depot for tools.[22]

The motor facilities that came with the Motor Transport Service were scattered throughout the country. The eight motor bases were at Atlanta, Georgia; Fort Crook, Nebraska; Fort Devens, Massachusetts; Holabird (near Baltimore), Maryland; Fort Lewis, Washington; San Antonio, Texas (called Normoyle); and Pomona and Stockton in California. The four motor supply depots were mostly in the central area: Little Rock, Arkansas; St. Louis, Missouri; Fort Wayne, near Detroit, Michigan; and Candler, at Atlanta, Georgia. There was one motor reception park, at Carteret, New Jersey, and there was space for motor supplies at eleven Quartermaster depots, more than half of them in the east.[23]

Space had been allotted to the Motor Transport Service on the basis of the 1942 procurement program, which consisted of approximately one million vehicles with corresponding parts, tires, and supplies. The plan for 1943 called for about the same number of vehicles but with an increase of approximately 67 percent in the volume of parts, and an 85 percent increase in tools and equipment. All this added up to a heavy load on storage facilities, beginning in the fall of 1942 when most of the matériel ordered under the 1942 program would be delivered. Against this load the Ordnance Department could count on using some space that had been intended for such material as gasoline drums, since responsibility for petroleum products remained with the Quartermaster Corps; also, some vehicles could be stored for short periods in railway transit yards. A few vehicles could be stored at factories, though Quartermaster policy had been to keep such storage at a minimum because of the bad psychological effect on labor.[24]

Ordnance storage specialists, with the aid of the experienced motor transport officers who were transferred along with their service and the reservists who continued to come into the Army from the automobile industry, worked throughout 1942 and into the summer of 1943 to mesh the Quartermaster motor bases and depots into the Ordnance distribution system. They consolidated the two Atlanta installations, the motor base and the motor supply depot, to form the Atlanta Ordnance Depot. In Texas they moved the Normoyle Ordnance activities to San Antonio Arsenal, forming the San Antonio Ordnance Center. At Pomona, California, they turned over the buildings and facilities of Pomona Ordnance Base to the Desert Training Center, which was run as a theater of operations with an Ordnance base. All the motor transport bases were designated depots, and two were renamed.

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[22] (1) Hist, P&O, I, p. 32; (2) ICAF Economic Mobilization Course, Planning Depot Systems to Meet Major Emergencies, 1940–46 (Discussion), p. 7, ICAF Library, L47–32.

[23] (1) Hist, P&O, I, pp. 19–21; (2) Monograph No. 8, pp. 35–36.

[24] (1) Depot Opns Br, Supply Div, Motor Transport Serv, Analysis of Storage Space Rqmts Through 1943, 23 Jul 42, copy in Hist, Storage Div, I, pt. 1, History From August 1942 to July 1943, ex. B, OHF; (2) ASF History, Storage Operations, pp. 15–17.

Fort Lewis in Washington became Mt. Rainier to distinguish it from other military activities at the Fort Lewis installation, and for the same reason Fort Devens in Massachusetts was renamed Whittemore, in honor of the late Brig. Gen. James M. Whittemore.[25]

Reallocation of Space by ASF

Ordnance reached the peak of its storage expansion in December 1942. At that time it had fifty-four depots in the United States, twenty sections in Quartermaster or other non-Ordnance installations, two depots in territorial areas, and storage facilities at ports of embarkation. At Ordnance depots general supplies were allocated nearly thirty-nine million square feet of warehouse space, more than eight million square feet of shed space, and about fifty-two million square feet of open storage. Some two million square feet were devoted to packing, shipping, receiving, and repairing. When Ordnance space at shipping terminals, general Army depots, and depots of the other technical services was added, the total figure for general supply storage exceeded one hundred million square feet. This made Ordnance the largest warehouse operator in the world, with more storage space at its command than all the commercial warehouses in the United States combined.

At this point, Army Service Forces began to question whether Ordnance really needed all this space. The answer was made clear by a survey showing that the depots were only about half full. Only 54.2 percent of Ordnance's net usable warehouse space was occupied, 55.2 percent of the shed space, 31.2 of the open space, and 60.7 percent of the igloo and magazine space.[26] ASF planners concluded that Ordnance had overbuilt in the early stages of the war, a conclusion that was reiterated in a postwar study by the General Staff. Conceding that it was natural enough for each service to allow itself some margin for reserve, ASF officials blamed lack of strict General Staff supervision in the early days of the war for inequitable distribution of space. In the spring of 1943 they decided to reallocate existing space on the basis of collective needs rather than add new space. They not only redistributed space among the technical services and Ground Forces but also co-ordinated requirements of the Army Air Forces, the Treasury Department, the Navy, and other Government agencies.[27]

In July 1943 Ordnance surrendered to the Medical Department the Louisville depot that had come in with the War Aid group. In the fall, two of the motor transport depots were released: Little Rock went to the Army Air Forces and Holabird to the Signal Corps. The functions of both could easily be absorbed by great Ordnance depots near by—Red River in the case of Little Rock, which had carried a small stock of tires only; and Letterkenny in the case of Holabird. About the same time, the old World War I ammunition depot at Charleston, South Carolina, was turned over to the Transportation Corps. In January 1944, two more motor transport depots were released, Whittemore to the First Service Command, and Normoyle to the Army Air Forces. By then Ordnance had also released motor supply sections at Quartermaster depots in Richmond and

[25] Hist, P&O, I, pp. 19–27.

[26] Ann Rpt of FS for FY 1944, p. 5, OHF. Only about eighty percent of total storage space was usually considered occupiable. Ann Rpt of FS for FY 1943, p. 2, OHF.

[27] ASF Hist, Storage Opns, pp. 13, 30–34.

Alexandria in Virginia, Atlanta and Savannah in Georgia, and Mira Loma in California. During FY 1944 Ordnance lost about four million square feet in warehouse space, two million in shed space, and about half a million in open space. At the same time, the percentage of occupancy rose sharply in all cases, from 54.2 to 67.7 in warehouses, 55.2 to 64.5 in sheds, and 31.2 to 65.3 in open storage.[28]

After this period of contraction there were a few minor additions and some readjustments. Facilities once a part of Fort Wayne Ordnance Depot became Palmer Woods Ordnance Depot. In the spring of 1944 a one-story rented building at Vernon, California, became Los Angeles Ordnance Depot; and the Pennsylvania Ordnance Works, transferred from Industrial Service to Field Service, was renamed Susquehanna Ordnance Depot.[29] In April 1945 space had to be provided at depots and plants to take care of the overflow of ammunition stopped on its way to Europe; but this was temporary in-transit storage lasting only from V-E Day to the time of reshipment to Japan.[30]

On the whole, the Ordnance storage space that remained after the contraction of 1943 and early 1944 carried the load throughout the war. By 1944 the emphasis had shifted to overseas supply and there was an increasing number of direct shipments that bypassed the depots. Better warehousing and depot management and, in some cases, better methods of stock control also aided in the supply of armies much larger than had been estimated in early planning.[31]

The Changing Pattern of Distribution

For ammunition storage, at the beginning of 1943 there were three types of depots—reservoir, area, and transshipment. Typical of the reservoirs were the big depots in the interior that stored slow-moving stocks—Black Hills, Blue Grass, Milan, Navajo, Ogden, Portage, Red River, Sierra, Sioux, and Wingate. Area depots were Pueblo, San Antonio, and Savanna; along with Anniston, Letterkenny, Seneca, and Umatilla, they had the responsibility in certain areas of supplying posts, camps, stations, and air bases. San Jacinto was primarily a transshipment depot, a kind that handled ammunition shipments en route to ports and awaiting ship movements. Other transshipment depots were Charleston, Curtis Bay, Delaware, Nansemond, and Raritan on the East Coast, and Benicia on the West Coast. Some of the reservoir depots had had from the beginning the responsibility for "backing up" various area depots and ports. During 1943 and 1944, as the emphasis shifted to overseas supply, a number of depots of all three types were given "back-up" or "intermediate" duties, in order to regulate the flow to the overburdened ports. Some of the reservoir depots began to supply the service commands in their own areas. Generally the tendency was to reduce the number of depots that were exclusively reservoir or transshipment and to increase the area and intermediate missions. In 1944 there were some changes in terminology: reservoir became "reserve," area became "distribution." [32] But on the whole there was no

[28] (1) Hist, P&O, I, p. 28; (2) Hist, Storage Br, 1, p. 38; (3) Ann Rpt of FS for FY 1944, pp. 4–5.

[29] OCO FS Storage Div, vols. III, IV, V, VI, VII, History from 1 January 1944 to 31 March 1945, p. 2.

[30] Monograph No. 8, pp. 40–41.

[31] See ch. XX, below.

[32] Hist, Storage Br, I, pt. II, Depot Missions, pp. 22–32.

major revision in the ammunition depot system. The most significant change in the pattern of ammunition supply from 1943 on was the trend to ship direct from plants to ports, training camps, the Navy, or other users. And, to avoid unnecessary movement of this heavy and dangerous matériel, better stock control methods were evolved.[33]

In planning for the distribution of the tremendous quantities of weapons, tanks, and other general supplies produced after Pearl Harbor, Field Service officials relied on the old-line general supply depots, backed up by reserve stocks stored in warehouses and sheds at the new ammunition depots. Seneca and Letterkenny were to back up Raritan, which handled the First, Second, and Third Service Commands and supplied the Atlantic bases; Anniston would back up Augusta, which served the Fourth Service Command, Red River would back up San Antonio; Ogden would back up Benicia, which served the Ninth Service Command and supplied the Pacific bases. Space at the great high altitude depots like Sierra, Pueblo, Sioux, and Black Hills would be used to store the reserves that were expected to accumulate after the war.[34] This plan was feasible enough as long as general supplies consisted mainly of weapons and combat vehicles. But when the heavy load of motor vehicle responsibilities was added, involving an unprecedented spare parts problem, it became evident that the depot system would have to be revised.[35]

In December 1942 the storage experts of the Supply Branch of the Tank-Automotive Center in Detroit, which now had most of the responsibility for general supplies, drew up a plan for the distribution of parts, tools, and equipment. It contained the germ of the change in depot missions that took place in 1943. The planners proceeded on the premise that distribution depots ought to be kept to a minimum and ought to keep their stocks at the lowest possible level consistent with requisitioning demands. Keeping the number of such depots to a minimum would avoid undue dispersal of critical stocks and would permit the concentration of office and warehouse equipment, key personnel, and labor, all of which were becoming scarce. Getting rid of excess stocks would free more space for fast-moving items and would cut down on physical handling and paper work. The depots would be kept fluid. Current stocks over and above those needed to fill requisitions would be moved into Master Supply, or wholesale, depots, from which they could be withdrawn by the distribution depots as needed. Current stocks in excess of the capacity of the Master Supply depots would be shipped into Reserve Storage depots, on a bulk basis. Obsolescent items would be concentrated in one depot.[36]

In applying these principles, the planners brought into the active distribution pattern some of the large new ammunition depots and revised the missions of some of the motor transport and War Aid depots acquired from the Quartermaster Corps. For example, in the eastern area the distribution depots serving the First, Second, and Third Service Commands and the ports of Boston, New York, and Hampton Roads in the fall of 1942 were Schenectady, Raritan, and Holabird. In the future,

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[33] See pp. 428–35.

[34] Meyns Rpt.

[35] Monograph No. 8, pp. 47–48.

[36] Storage and Issue Sec, Supply Br, T–AC, Present and Future Distribution Plan for Parts and Supplies and Tools and Equipment of Ordnance General Supply, copy in Hist, Storage Div, I, pt. 1, ex. E.

Letterkenny was to be the distribution depot for all parts, supplies, tools, and equipment, with one exception—tools and equipment for tanks and tractors were to come from Lordstown, the distributor for this kind of matériel to all service commands and ports of embarkation except those on the West Coast. The substitution of Letterkenny would free Raritan to be the requisitioning point for the eastern ports of embarkation for all parts and supplies except those of wheeled and semiwheeled vehicles, which would come from Toledo (soon to be renamed Rossford), a kind of reservoir for autombile parts in the same sense that Lordstown was for tools and equipment.[37]

The Master Depot System

From this early planning stemmed the Master Depot concept that profoundly influenced the Ordnance depot system. By April of 1943 the pattern was clear. Parts, supplies, tools, and equipment flowed through four major types of depots: master, distribution, storage, and arsenal. There were only four master depots, but each stocked every item required for the maintenance of certain classes of matériel. Rock Island was responsible for tank, tractor, artillery, and small arms parts and supplies; Rossford for wheeled and half-track parts and supplies; Lordstown for tools and equipment, except for fire control instruments; and Frankford for parts, supplies, tools, and equipment for fire control instruments. Their stocks were available for immediate movement into combat theaters or into domestic activities, as the situation demanded. Supplies from master depots flowed through the distribution depots, the second major type.

In the category of distribution depots were several groups, the most important of which were the "retail" or domestic depots that supplied the service commands within their respective areas. In the eastern area, Letterkenny supplied everything needed; in the south, Atlanta furnished motor transport matériel and Anniston everything else; in the middle west and west, Ft. Wayne and St. Louis supplied motor transport matériel and Rock Island everything else; in the southwest, Red River carried the full line, as did Ogden for the West Coast. Second in importance in this category were the filler or export depots that supplied the ports of embarkation: Raritan serving Boston, New York, and Hampton Roads; Atlanta serving Charleston and New Orleans; Anniston serving Charleston; Red River serving New Orleans; Mt. Rainier serving Seattle; and Stockton and Benicia both serving San Francisco. Less important than the retail depots and the filler depots, but still in the category of requisition points, were the "special stock" depots that carried parts for major items that were in limited supply because they were substitute standard, obsolescent, or experimental. For this type of matériel St. Louis issued parts for wheeled and half-track vehicles and Rock Island parts for weapons, tanks, tractors, and fire control instruments; Ft. Crook issued tools and equipment for all major items, with some assistance from Lordstown.[38]

The storage depots, the third of the four major types, were the largest in number.

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[37] *Ibid.*

[38] (1) Ord FS Bull No. 2–15, 1 Apr 43; (2) Lt Col W. W. Townsend, Depot Supply of Ordnance Parts and Tools, in Transcript of Talks, Depot Comdrs' Conf, 13–14 Apr 43, St. Louis, Mo., OHF.

There were twenty-two in all. Five of them were Ordnance sections in ASF depots, five were 1940–41 war-reserve depots such as Black Hills and Sierra, nine were former motor transport or War Aid installations, and three were old-line Ordnance depots. Of the latter, in a reversal of roles, Augusta was now supporting Anniston, and San Antonio, Red River. Some of the storage depots were well located geographically to support filler, rather than domestic retail, depots. Known as "advance" depots, they temporarily held boxed or crated parts and tools until the Ports of Embarkation called for them on movement orders. Others had processing layouts to assemble certain classes of matériel into sets, and box and crate it. Assembly and processing were important functions also of the fourth type, the arsenal depots at Springfield, Watertown, and Watervliet, and also at Aberdeen and Erie Proving Grounds. At these Industrial Service installations, workers assembled the parts, supplies, tools, and equipment that accompanied the major items that went forth to the requisitioners.[39]

By the time the new depot system went into effect, on 1 July 1943, the trend from domestic to export business had already set in. Fifty-seven percent of all general supply tonnage was being shipped overseas. But the impact of this shift on the new depot system did not become plain to Ordnance planners until late in 1943 when the campaign in Italy was well under way and stockpiling had begun for the invasion of Europe. Then it became apparent that the weakness in the new system was the bottleneck that could be caused by an inadequate filler depot. Raritan, a comparatively small installation, was attempting to supply the eastern ports with stocks of weapons parts, general purpose vehicles, combat vehicle parts, and cleaning and preserving materials; and it was falling behind. Ordnance storage experts decided that it was better to depend for export less on the "country store" type of filler depot and more on the master depot specializing in certain lines. Two of the master depots had been shipping for export direct to ports for some time, Lordstown for tools and Rossford for automotive parts.[40]

With the emphasis increasing on master depots rather than distribution or filler depots, in the spring of 1944 General Campbell, acting on the advice of Mr. Lewis H. Brown, president of the Johns-Manville Corporation, and Mr. Keller, president of Chrysler, decided to use the master depot technique to speed the flow of tank and automotive supplies to troops overseas, concentrating at one depot all parts for a certain make of vehicle, such as Chevrolet, and at another all parts for a certain kind of vehicle, such as heavy duty trucks. The object was to achieve better control of stocks by concentrating like and interchangeable parts in one place and enabling depot employees to specialize more narrowly; to simplify requisitioning; and to give more flexibility in meeting overseas demands.[41] As of August 1945 the principal master depots were Rock Island, Frankford, Palmer Woods (a new depot added in the spring of 1945), Rossford, St. Louis, Letterkenny, Terre Haute, Fort Wayne, Lincoln, and Atlanta. Depots with more limited master depot responsi-

[39] FS Bull No. 2–15, pp. 12–13.

[40] (1) PSP 56, Depots, Field Service, Mission and Management, Jun 45, exs. B and E, OHF; (2) Monograph No. 8, p. 53.

[41] (1) FS Div Order 29–44, 3 Apr 44, sub: Master Depot Distribution Plan for Tank-Automotive Parts and Tools, OHF; (2) Hist Storage Br, I, pt. I, Storage, pp. 18–19.

bilities were Watervliet, Watertown, the Submarine Mine Depot at Fort Monroe, Anniston, Blue Grass, Aberdeen, Ogden, and the Ordnance section at Columbus General Depot.[42]

General Campbell believed that the master depot plan for automotive supplies "contributed greatly to the lessening of serious bottlenecks in the overseas supply problems." [43] But stocking by make of car, such as Dodge or Chevrolet, ran counter to the parts-identification system set up in 1944.[44] Another obstacle to smooth functioning was the inability of the Ordnance Department after May 1945 to operate the master depots strictly as wholesalers shipping bulk quantities in unbroken cartons or boxes. ASF Manual M411 of 1 May 1945, Procedures for Processing Overseas Requisitions, required that if an item was anywhere in the depot system, any customer was entitled to it, regardless of the quantity desired. Consequently, retail depots were forced to requisition small lots from the master depots, which had to set up retail departments. Ordnance storage experts believed strongly that wholesale and retail operations could not be efficiently combined.[45]

Even under the master depot system, missions were not clearly defined. One depot usually had several functions; that is, it might be some combination of the master, distribution, filler, or storage type of installation, and the missions varied, not only as to type of depot but as to type of matériel. For example, by June of 1945 Anniston was a master depot for parts and supplies for scout cars and K and L groups (cleaning and preserving matériel and targets). It was also a distribution depot for the Fourth Service Command for tracked and wheeled vehicles, K and L matériel, supplies and equipment for automatic weapons of 20-mm. and above, and for field artillery; for the same matériel, excepting wheeled vehicles and K and L items, it was a filler depot to the Charleston Port of Embarkation.[46]

Instability in Depot Missions

Changes in missions were common in the last two years of the war. A case history, perhaps an extreme one, is the story of Letterkenny. One of the large ammunition depots of the 1940–41 group, it first came into the general supply distribution pattern in January 1943 as a reserve storage depot to back up Raritan. In the changeover to the master depot system that took place on 1 July 1943 it became the distribution depot for the First, Second, and Third Service Commands. When congestion became apparent at Raritan late in 1943, Letterkenny became a filler depot to assist Raritan for Dodge, Ford, and General Motors parts. In addition to these major changes, there were several minor changes in types of matériel handled and requisitioners supplied; in September 1943, for example, the Army Air Forces in the area became one of the depot customers. In the words of the depot historian, "The missions given to Letterkenny during the year speeded and picked up like a snowball rolling downhill. Heterogeneous carloads of matériel were rolling in to a depot with incompleted bins and ware-

[42] Monograph No. 8, p. 56.
[43] Campbell, *The Industry-Ordnance Team,* p. 339.
[44] See pp. 405–09.
[45] PSP 56, ex. F.
[46] PSP 56, p. 4.

houses while back orders were accumulating for matériel that was not yet stored." [47]

Early in 1944 the depot took over Raritan's filler responsibilities and ceased being a domestic distribution depot except for targets and cleaning and preserving matériel. Six months later came another important change. In July 1944 Letterkenny became the master depot for parts and supplies for Chevrolets, the distribution depot for combat, wheeled, and semi-wheeled vehicles for the First, Second, and Third Service Commands, and the filler depot for eastern ports for wheeled vehicles, common hardware, parts common, and major items. Early in January 1945 storage planners at Detroit, seeking to relieve the overburdened Ft. Wayne installation, gave Letterkenny the master depot responsibility for heavy duty trucks, taking away certain parts supply functions.[48]

Criticism by higher authority that the Ordnance Department failed to achieve stability in depot missions appears to be justified; and there is evidence that instability placed heavy burdens on the depots.[49] When mission changes were made, Ordnance tried to keep interdepot movements of matériel to a minimum, using them only when it was not possible to deplete stocks through attrition; but they were necessary at times and often required not only shifting stocks but extensive rewarehousing, moving bins and other storage equipment from one depot to another, and retraining workers.[50]

Some rearrangement of the depot system was doubtless inevitable to correct faults caused by the improvisation of the early expansion period. Some changes were adjustments to decisions of ASF, such as the loss in the summer of 1943 of some of the motor transport depots that had been integrated into the master depot system.[51] An Ordnance study made in June 1945 ascribed the large number of mission changes in the second and third year of the war to the fact that planners had had to work by trial and error. With very little basis on which to forecast the quantity of matériel to be shipped, or the rate at which such shipments would be required by the theaters, they had found it almost impossible to forecast depot loads with any degree of accuracy.[52] Also, there were defects in organization, notably an unfortunate division of responsibility for distribution between Detroit and Washington.[53]

But it is permissible to speculate whether some of the changes in depot missions might not have been avoided by more careful planning. At the time the Master Depot system was evolved early in 1943, the congestion at Raritan might have been foreseen. And if the change-over to stocking master depots by make of car such as Chevrolet or Dodge was desirable it might better have been effected then rather than

[47] Hist, Letterkenny Ord Depot, vols. II, III, IV, V, History for the Period 1 January 1943 thru December 1943 (hereafter cited as Hist, Letterkenny, 1943), p. 4.

[48] Hist, Letterkenny Ord Depot, X, History, 1 January 1945 through 31 March 1945, pp. 5–7.

[49] (1) Ann Rpt of FS for FY 1945, p. 14; (2) Maj. A. W. Coopes, Key Pers Rpt, 4 Apr 46, in Key Pers Rpts OCO–D. See also other key personnel reports in this file.

[50] (1) Ann Rpt of FS for FY 1944, p. 304; (2) Hist, Letterkenny, 1943, p. 7.

[51] FS Supply Bull 2–15, 1 Apr 43, p. 12.

[52] PSP 56, ex. B.

[53] (1) Project 91, Relationships Between the Office of the Chief of Ordnance in Washington and the Office, Chief of Ordnance–Detroit, OHF; (2) Memo, Col John A. Barclay, Deputy Chief FS Suboffice for Chief FS Suboffice, Rock Island, 6 Jun 45, sub: Stock Contl Activities 1941–45 (hereafter cited as Barclay Rpt), in FS Key Pers Rpts, OHF; (3) Green, Thomson, and Roots, *Planning Munitions for War*, ch. IV.

in 1944, after the by-item system had gone into effect. Col. W. C. Gamrath, an experienced Ordnance supply officer, feelingly expressed one point of view on shifting patterns of distribution:

"The methods of distribution of ordnance supplies seemed to be a target of many 'experts' within the Ordnance Department, within Headquarters ASF, and from industries on the outside. There was a period during 1943 and 1944 when it seemed in vogue to change the methods. . . . I have observed and studied a sufficient number of businesses to realize that there are several different methods under which materials similar to Ordnance supply may be successfully distributed. I am of the firm opinion that it would have been far better to select one of these approved methods and stick to it throughout the war than to go through a constant state of change." [54]

Though some alteration in the pattern of supply was contemplated to meet the emphasis on a one-front war in the Pacific, changes in 1945 were kept to a minimum. Looking to the postwar period, Field Service began comprehensive planning to achieve a stable program of supply. The program envisaged a network of permanent depots carefully selected on the basis of the facilities that were available, the workload that could be handled, the sources of labor that could be tapped, and the technical knowledge of the workers. To these permanent depots there would be gradually transferred the functions of the less desirable installations, which would be closed out. Generally speaking, the pattern of distribution after the war would be based on two factors. One was the correct location of depots, with distribution responsibilities assigned to depots situated in the area they served. The other was storage by commodity, with related types of matériel stored at specific depots.[55]

The Ordnance experience in World War II showed that the efficiency of a supply and distribution system depended on many factors, chief of which were the location of depots, the nature of depot facilities, and availability of civilian workers. In its final report, Logistics in World War II, ASF observed that, "As the war progressed, it became evident that the entire distribution system depended for its efficiency upon the location of the depots." Unfortunately, no pattern of depot locations would serve all purposes equally well. Nearness to manufacturers was an advantage that had to be weighed against nearness to ports of embarkation. In terms of safe storage of ammunition, vast desert tracts were ideal, but in terms of labor supply they left much to be desired. At the start of the defense period the War Department permitted each technical service to develop its own system of distribution and storage with the result that there was no integrated plan for the Army as a whole. As far as Ordnance was concerned the result was overexpansion of depots in the early years. But the choices of sites were generally good, and the excess capacity created in the 1940–42 period was readily redistributed by ASF in the 1943–44 period. The capability of individual depots as measured in terms of buildings, equipment, and labor supply was also of great importance to efficient operations. On this score, the lack of adequate provision in the early years for storing general supplies—as distinguished from ammunition—proved to be the biggest shortcom-

[54] Memo, Lt Col W. C. Gamrath, Chief, Supply Operations Br, for Exec to Chief of FS, 22 Mar 46, sub: Final Historical Rpt, in FS Key Pers Rpts, OHF.

[55] Ann Rpt of FS for FY 1945, p. 14.

ing. But it was rather quickly remedied after Pearl Harbor, as was the other major problem of integrating with Ordnance depots the storage space acquired from the Motor Transport Service. Not so easily solved were the problems of supply terminology, stock control, and maintenance discussed in the following chapters.

CHAPTER XIX

The Language of Supply

One of the important lessons of World War II, according to the Hoover Commission, was the need for a better means of identifying and classifying military stores.[1] This conclusion was based to a large extent on Ordnance experience, for Ordnance failed to solve this problem satisfactorily during World War II. In spite of persistent efforts, Field Service did not work out an effective means of identification and communication, so that the soldier in the field, the storekeeper in the depot, and the official in Washington could all speak the same language.

The problem mainly concerned spare parts.[2] A tank, a gun, or a truck could be identified at sight, even though its nomenclature might sometimes cause trouble. But its parts were a different matter. They were numerous, and many were hard to identify. In the critical months of preparation for the invasion of Europe, a report that there was a shortage of spare parts startled men who were familiar with the great flow of production after Pearl Harbor. The Chief of Ordnance found it "inconceivable that there can be an actual physical lack of spare parts *per se*"; he believed that "parts are available but they are not recognized and are not identified. They are, in other words, in effect, lost." [3]

In the late 1930's a British expert on logistics suggested that the art of war might be read in terms of the spare—human and material—and that in the warfare of the future the emphasis might conceivably be on the mechanical rather than the human reinforcement. A missing or faulty part, small, inexpensive, and ordinarily negligible, that immobilized a tank on the eve of battle assumed a value greater than even a replacement for the tank commander himself. A man could replace a man but nothing else a particular part. And the time, place, and occasion of the need for it was unpredictable. Nobody could say with certainty what part would break or fail, or when or where. Therefore spare parts control in the sense of seeing to it that the man in the field had the part when he needed it was "the essence of supply." [4]

With each lot of one hundred tanks, guns, or other major products, it was Ordnance policy to order enough spare

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[1] MBCA Newsletter, Munitions Board Cataloging Agency, I (30 Jun 50), 6, filed in Office of Cataloging in Office of Secy of Defense.

[2] See Chapter XIII for discussion of spare parts procurement.

[3] (1) Ltr, Maj Gen Campbell, to Col John B. Medaris, 14 Dec 43, in General Campbell's Personal Files; (2) Memo, Col W. W. Townsend for Exec to Chief of FS, 29 Aug 45, FS Key Pers Rpts, OHF [hereafter cited as Townsend Rpt]; (3) Lt Gen Somervell, Talk to Key Pers of ASF, 9 Mar 45, ASF Prod Div Files, 470.8 Tanks.

[4] Brevet Lt. Col. George C. Shaw, *Supply in Modern War* (London: Faber and Faber, Limited, 1938), p. 303.

parts to last a year. But what was "enough"? The best estimates were often wrong, because of differences in climate, terrain, and operations in a world-wide war; and for newly developed items there was no maintenance experience at all.[5] Shortages developed in certain parts, though in general the tendency was to provide too much rather than too little. The spare parts required to maintain one hundred medium tanks for one year filled twenty boxcars. For one jeep, Ordnance undertook to stock and furnish 1,006 different spare parts, a total that seemed large, though actually it was less than half the 2,500 different parts, totaling 9,000 individual pieces, that were required to manufacture the jeep.[6] The effort to provide machinery capable of keeping records on these huge stocks began in 1940. It involved a new spare parts organization within Field Service and the use of electrical accounting apparatus made by the International Business Machines (IBM) Corporation.

A New Spare Parts Organization

In the late summer of 1940 the Ordnance Department requested Lawrence Barroll, formerly a representative in Sweden of General Motors Overseas Operations, to make a study of Ordnance procedure for initial spare parts requirements and a survey of the spare parts organization of Field Service. Barroll spent two weeks in Washington, two weeks in the Detroit area consulting with General Motors parts specialists, and three days at Raritan Arsenal where Standard Nomenclature Lists were published. This short survey convinced him that the traditional Ordnance Provision System procedure for parts control by which major items and their spare parts were handled by the same persons, using the same form of stock record cards, was inefficient. He therefore recommended on 8 October 1940 that all spare parts, regardless of their nature, be segregated in one organization in Field Service, and that this organization manage not only parts distribution but also the determination of parts requirements.[7]

The Chief of Ordnance approved the recommendation for centralized control of spare parts distribution. He agreed to the separation of parts from their major items and on 16 December 1940 employed Barroll to build up a new Parts and Accessories Unit to assume responsibility for them.[8] But from the beginning the new spare parts unit was plagued with troubles. It was, according to Barroll, unable to get enough experienced help, office space, or even supplies. Furthermore, it was hampered by the confusion resulting from the simultaneous installation of electrical accounting machines for stores reporting.[9]

The Use of IBM Machines

In the spring of 1940 the Office of the Assistant Secretary of War had proposed that IBM machines be installed in all

[5] This problem is discussed above in Chapter IV.

[6] Campbell, *The Industry-Ordnance Team,* pp. 351, 358, 363.

[7] Barroll Rpt, 1942, pp. 5–7. Mr. Barroll also criticized the Ordnance system of depot commodity specialization; for example, he believed that placing most tank parts at Rock Island Arsenal, small arms parts at Springfield, and so on, resulted in "poor geographic availability and also left stocks in a very vulnerable position for enemy sabotage or offensive measures."

[8] (1) *Ibid.*, p. 8; (2) Crain, Diary, 30, 31 Oct 40; (3) Ord Office Memo 510, 21 Jan 41.

[9] Barroll Rpt, 1942, p. 8.

Army depots. Considered much more flexible than the bookkeeping machines, such as Elliott Fisher, which had been adopted by Ordnance in the mid-twenties, these electrical accounting machines (EAM) could prepare in hours reports that by manual procedures would take days or even weeks. The IBM Corporation tested its apparatus at several Quartermaster depots, pronounced it suitable for military record-keeping,[10] and was given the job by the War Department. On a directive from the Assistant Secretary of War that the IBM Corporation be given all assistance in installing its machines, on a rental basis, the Chief of Ordnance ordered the machines to be used in all Ordnance stock control operations for spare parts. This involved the bulk of general supply articles, since major items, which were not included, represented only about eight hundred out of a total of about eighty thousand items. Some Ordnance officials had misgivings, not only as to the superiority of the IBM system over competitors like Remington-Rand, but also as to the wisdom of employing the machines on a rental rather than a sales basis.[11] Col. Lawrence J. Meyns, who became chief of the General Supply Branch in July 1941, thought that the decision to use the machines was good, because he believed that stock cards on the spare parts that were coming off the production lines in an ever-mounting flood could not be kept posted on the old system.[12]

Whatever the ultimate merits of the new system, it soon became apparent, to Colonel Meyns among others, that Ordnance had rushed it through too fast and had not planned the timing and installation with enough care and foresight.[13] Decided upon in the fall of 1940, the installation of the machines was accomplished with the aid of the IBM Corporation the following spring and the changeover took place in July 1941.[14]

Almost at once there was a lag rather than a speed-up. In a tight manpower market there was the difficulty of obtaining, and keeping, trained machine operators. This could hardly have been avoided. Another obstacle to smooth operation grew out of the failure to foresee the necessity for converting a commercial system more fully to military operation before installing it. For example, the stock record card as originally drawn up had no provision for "demands," a term not used in business, although essential in military supply. Such drawbacks to the new system, together with lack of understanding of it in the depots, or downright opposition to it, were not peculiar to Ordnance. The Quartermaster Corps had similar problems in some degree.[15]

The greatest problem presented to Ordnance by the machine system was that of adapting to it the numbers hitherto used for requisitioning, procurement, and distribution. Stores reports, which were actually carbon copies of depot stock ledgers, used the numbers found in Standard Nomenclature Lists—the Group letter, the number indicating the class of stores, and the piece mark. For example, in reporting a bayonet catch the depot officer used the SNL designation B8 plus the piece mark

[10] Stauffer, QM Depot Storage and Distribution Opns, p. 159. This monograph also contains a description of the actual functioning of the machines, pp. 159–60.

[11] Interv with Kahlert, 14 Apr 53.

[12] Meyns Rpt.

[13] *Ibid.;* (2) Barclay Rpt.

[14] Min, Wesson Confs, 12 Sep 40, 28 Jul 41.

[15] (1) Hynds Memo; (2) Stauffer, *op. cit.*, pp. 160–65, 178–79, 187–88.

B147058. In the spring of 1941 Field Service considered the possibility of adopting the piece mark as the universal means of identifying and reporting stores. But a study of stores reports revealed the fact that there were hundreds of items in stock that had no piece mark; furthermore, the Industrial Division was too busy with procurement to stop and assign them. In any case the IBM machine cards then available could not take "taxi" numbers such as BECX3G, because they fell in a field of the card that could not take letters of the alphabet. Some kind of coding was necessary.[16]

In this dilemma Field Service turned to a numbering system that had been devised in prewar years for a statistical report on parts usage by maintenance echelons. It was a code number consisting of three elements. The first four digits represented the SNL letter and number; the next two digits, the section of the SNL in which the item was listed; and the last five digits the item within the section of its particular SNL. Thus the item code number assigned to the bayonet catch was B008-01-00030, that for the item next below it in the same section was B008-01-00040.[17]

For the job of assigning item code numbers to all Ordnance parts the chief of the Equipment Division set up a coding section in the Machine Records Unit. After coding an item the Machine Records Unit punched a master card containing the piece mark or drawing number, the nomenclature, and the new code number, and sent copies of it to all reporting installations. The coding operation, which included items coming off production lines as well as those in stock, was gigantic, and the Coding Section was understaffed. It soon fell behind. By mid-June of 1941 coding was in "lamentable condition." [18]

The Parts Control Division

After Pearl Harbor it became evident that something had to be done to improve spare parts supply. This was the greatest problem facing the Ordnance Department, according to a survey made in the spring of 1942 by General Motors Overseas Operations. This survey recommended that Ordnance create a Parts Control Division on the same administrative level as Industrial Service and Field Service. General Campbell acted on this recommendation after he became Chief of Ordnance in June 1942. But this attempt to solve the problem was short-lived, for several reasons. Floor space, equipment, and experienced people were lacking. There was disagreement, even among the GM officials who made the recommendation, as to whether the new organization should take over spare parts operations directly or merely set up controls over the people responsible for operations.[19] The Parts Control Division was abolished in July 1942. In the reorganization that took place at that time the Field Service spare parts organization, which included the Machine Records Unit, was renamed the Parts and Supplies Section and placed under the General Supply Branch. It now had a staff of 267, but according to Mr. Barroll was "still comparatively green" and much remained to be accomplished in "future

[16] (1) Barclay Rpt; (2) Col W. C. Gamrath, History of Official Stock Number (Item Stock Number) [hereafter cited as Gamrath, Hist], 17 May 45, pp. 1-3.

[17] PSP 65, ex. AF.

[18] (1) PSP 63, ex. 2; (2) Gamrath, Hist, pp. 3-4.

[19] (1) General Motors Survey, vol. II, p. 10; (2) Meyns Rpt; (3) Barclay Rpt; (4) Ch. XIII above; (5) Green, Thomson, and Roots, *Planning Munitions for War*, ch. IV.

development, training of personnel, and refinement of operating procedures." [20]

Effects of the Motor Vehicle Transfer

At this critical stage in parts control planning, Army Service Forces directed that Ordnance take over motor transport vehicles, formerly supplied by the Quartermaster Motor Transport Service. It was a logical step, because combat vehicles and transport vehicles had parts in common; but it tremendously increased and complicated the problems of distribution, especially that of stock control. Before the merger, Ordnance handled a total of some 80,000 items. Estimates of the items handled by Motor Transport Service varied from 75,000 to 150,000. Accurate figures did not exist. There were some 400,000 item numbers, but thousands were duplicate names for the same item.[21]

As a result of the transfer of motor transport the Chief of Ordnance established the Tank-Automotive Center in Detroit on 1 September 1942. This step drastically affected the whole Ordnance distribution system. To Detroit went the Parts and Supplies Section of the General Supply Branch along with three other sections—Automotive, Tools and Equipment, and Storage and Issue.[22] Stock control of major items for Groups A to F, small arms, artillery, and fire control, remained in Washington because their Group Chiefs, whose unique technical knowledge made them irreplaceable, refused to move, but stock control of spare parts for this matériel went to Detroit.[23] The move centered in Detroit the direction of distribution for virtually all Ordnance installations except those handling ammunition. The planners intended that henceforth the Washington office would set forth policy, the Tank-Automotive Center would carry it out.[24]

Colonel Raphael S. Chavin, Chief of the General Supply Branch, justified the decentralization to Detroit of stock control for all spare parts, for weapons as well as vehicles, on two grounds: first, it complied with the general directive to reduce the number of employees in Washington, and, second, it permitted the concentration of the IBM stock control installation in one central place.[25] Another explanation was that in the planning stage the Ordnance Department had considered moving to Detroit the major item units handling weapons; at that time the pattern of the T–AC as a product center had not fully crystallized.[26]

But this further separation of spare parts from major items caused forebodings. To Colonel Meyns, the movement of weapons parts from Washington to Detroit was "a terrible setback." [27] Major Hynds of the General Supply Branch, who doubted the wisdom of setting up the Parts and Accessories Unit in the first place, believed that the real reason for moving all spare parts to Detroit, parts for small arms and artillery as well as vehicles,

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[20] (1) Barroll Rpt, 1942, p. 9; (2) ODO 285, Change 1, 28 Jul 42.

[21] (1) Hynds Memo; (2) Memo, Maj Gen Julian S. Hatcher to CofOrd, 5 May 1945, sub: Rpt of Activities in World War II [hereafter cited as Hatcher Rpt], OHF.

[22] (1) GS Br Order 13, 14 Oct 42; (2) GS Br Order 20, 7 Dec 42.

[23] (1) Interv with Col William F. Sadtler, 25 Aug 52; (2) Statement by Maj Gen John K. Christmas, 11 Oct 49, OHF.

[24] Remarks by Brig Gen Julian S. Hatcher, Chief FS Div, at Depot Comdrs' Conf, 13–14 Apr 43.

[25] Ltr, Col Raphael S. Chavin to Thomson, 9 Aug 49, OHF.

[26] Barclay Rpt.

[27] Meyns Rpt.

was that "spare parts have been placed in such a rigid, inflexible grouping that we now find it is impossible to separate them, regardless of how advisable such a division might be." [28] He pointed out that if parts had remained with their major items, as provided in the Ordnance Provision System Regulations, the move of Group G, the automotive items, to Detroit "could have been accomplished with scarcely a ripple to disturb the effective operations of the other groups." [29]

As it was, the disturbance to Field Service supply operations approached the proportions of a tidal wave. Detroit, now the stock control center for Ordnance, the place to which depots and district offices sent their stores reports and the place where these reports were combined into the Consolidated Stores Report that was the heart of the supply system, became an impossible bottleneck. By December 1942 the posting of Consolidated Stores Report data on parts distribution and other card records in Detroit was seriously in arrears —as much as one month behind on distribution cards and several months behind on order cards. These delays made the data misleading, since the figures did not reflect the situation as it was at the moment.

Moreover, the records were not accurate because depots frequently reported parts under wrong code numbers.[30] The Coding Unit was handicapped by lack of the tools essential for its job. The engineering drawings for small arms, artillery, and fire control instruments were not available in Detroit; parts lists and reference data from manufacturers were still far from complete. The engineers of the Parts and Supplies Section, who had formerly supplied the necessary technical information, worked in a separate building. Because of continual engineering changes and undependable records, knowledge of the product was at a premium.[31]

In the move to Detroit, Field Service lost a number of trained people who were badly needed. The Parts and Supplies Section lost 50 percent of its engineers. When the move was announced some of the engineers accepted commissions in the Army and others transferred to other government agencies in Washington. Some who went to Detroit soon left government service to take jobs in the automobile industry at increased salaries.[32] The manpower situation grew worse in February 1943 when the Chief of Ordnance directed personnel cuts throughout the Tank-Automotive Center. The Parts and Supplies Section protested that it could not operate on the ceiling then existing, much less on a lower ceiling.[33]

Parts supply required manpower, in quantity and in quality.[34] A sympathetic understanding of this fact in the War Department and the Army Service Forces would have helped solve Ordnance's problems. But as late as the fall of 1944 the Mead Committee found that neither the Army nor the Navy recognized "the extent of the paper work and bookkeeping work required in order to maintain the flow of

[28] Hynds Memo, p. 18.
[29] *Ibid.*
[30] Barroll Rpt. 1942, pp. 12–13.
[31] *Ibid.*, pp. 18–20.
[32] Meyns Rpt.
[33] Memo, Lt Col Martin P. Vorberg, Chief Plng and Contl Div, for Chief FS Div, 11 Jun 45, sub: Chronological Hist of Events Concerning Martin P. Vorberg's Connection With the Ord Dept (hereafter cited as Vorberg Rpt), FS Key Pers Rpts. The broad picture of civilian personnel problems is presented in Green, Thomson, and Roots, *Planning Munitions for War*, Chapter VI.
[34] Barroll Rpt. 1942, p. 19.



BRIG. GEN. JULIAN S. HATCHER *(seated at desk), Chief of Field Service, in his office at the Pentagon, 1943. From left, Col. James L. Hatcher and Brig. Gen. Raphael S. Chavin.*

materials." [35] The Chief of the Parts and Supplies Section complained that he was "constantly criticized and harassed by higher authority for not doing an efficient job and at the same time this same higher authority was reducing the personnel available to do the job." [36]

The Crisis Early in 1943

By the beginning of 1943 it was evident that mistakes had been made in the hasty revamping of traditional Ordnance supply procedures to meet the exigencies of war and that the stock control situation was critical. Late in 1942 General Somervell had stated that "distribution is rapidly becoming our number one consideration." [37] An avalanche of supplies was coming from the factories, and some more efficient way had to be found to get them to the users. Big-scale troop movements were just getting under way. Complaints about Ordnance spare parts provision and distribution began to come from the using arms, The Inspector General, and the Army Service Forces.[38] Disability reports from the Inspector General's Office, surveys by ASF, and special studies and analyses by the Ordnance Department all stressed the seriousness of the situation.[39] At ASF depots in England preparing for TORCH

[35] Rpt Mead Comm., 78th Cong., 2d sess., S. Rpt No. 10, pt. 20, p. 23.

[36] Barclay Rpt.

[37] Stauffer, *op. cit.*, p. 4.

[38] (1) PSP 63, ex. 18, Memo, Col Sadtler to CofOrd, 11 May 43, sub: Adequate Provision of Spare Parts; (2) Maint Div, Hq ASF, Maintenance Problems: A History. . . , pp. 66, 114, copy in OCMH files.

[39] Lawrence S. Barroll, Reduction of Back Orders, Transcript of Talks at Depot Comdrs' Conf, 13–14 Apr 43, p. 24.

in 1942, the changeover to a different parts identification scheme had necessitated retraining thousands of workers and created "an almost hopeless confusion." [40] In a nationwide radio broadcast on 11 March 1943, the anniversary of ASF, General Somervell said, "Stock or inventory control requires immediate attention." [41]

General Campbell in February 1943 replaced Brig. Gen. Harry R. Kutz, whose health had not been good, with Brig. Gen. (later Maj. Gen.) Julian S. Hatcher as Chief of Field Service. He also had Field Service operations reviewed by his personal advisory staff, Messrs. Baruch, Lewis H. Brown, Benjamin F. Fairless, and Keller, to which had been added Mr. Fowler McCormick, president of International Harvester, General Robert E. Wood, president of Sears Roebuck and Company, and B. Edwin Hutchinson of Chrysler Corporation. These eminent industrialists did not propose any radical changes in operations; they confined themselves to a few helpful suggestions. But their visit to OCO and their belief that hard and detailed work would bring Field Service out of its difficulties were a boost to morale.[42]

In the field the General Supply Branch made an intensive effort to find out why unfilled requisitions, or back orders, were piling up at the depots. Investigators surveyed two typical depots, Atlanta for automotive parts and Augusta for weapons parts. Analysis of some seventeen thousand back-order items showed that poor records were responsible and that the depots and the Tank-Automotive Center shared the blame equally. Most of the trouble in the depots was caused by failure of the storekeepers to identify items in stock. The greatest percentage of errors by the Tank-Automotive Center was failure to correct a shortage in one depot by transfer from another, a failure that might have been prevented by accurate and timely Consolidated Stores Reports.[43]

To purify records and improve the reporting system became matters of great urgency. The first step was to find a single workable system of parts numbering to replace the many systems in use, because the fact that identical parts could have different numbers made it difficult to locate the parts and impossible to reflect true stock levels. The second step was to decentralize stock control on a product basis, relieving the bottleneck at Detroit and placing control in the hands of people who had technical knowledge of the particular item. These two objectives occupied some of the best brains in the Ordnance Department from 1943 on.

Parts Numbering

"The Numbers Racket," as Ordnance men called it, was clearly in need of reform even before the end of 1942. No less than seven different parts numbering systems were being used. In addition to Ordnance drawing numbers, taxi numbers, and Federal Stock Catalog numbers, there was still another number that might be stamped on the part—the manufacturer's number, brought into the picture by the transfer of

[40] Ruppenthal, *Logistical Support of the Armies*, vol. I, p. 158.

[41] Col Lawrence J. Meyns, Stock Control Program, Transcript of Talks at Depot Comdrs' Conf, 13–14 Apr 43, p. 36, OHF.

[42] (1) Memo, Maj Gen Campbell, for Brig Gen Harry Kutz, 8 Jan 43, OO 020/368; (2) Ltr, Maj Gen Campbell, to Brown, 8 Jan 43, OO 020/368; (3) Campbell, *The Industry-Ordnance Team*, pp. 335–36; (4) Ltr, Maj Gen Edward E. MacMorland to Lida Mayo, 18 Mar 54, OHF.

[43] Lawrence Barroll, Reduction of Back Orders, Transcript of Talks at Depot Comdrs' Conf 13–14 Apr 43, pp. 24–25.

motor vehicles to the Ordnance Department, and by the fact that more and more automobile companies were manufacturing parts for tanks.

The manufacturer's number opened a Pandora's box of troubles. It might be either that of the end-item manufacturer or that of the component-item manufacturer; that is, it might be either the number assigned by the Ford Company making the car, or the Timken Company making the axle. Most likely it would be that of the automobile manufacturer, and this fact caused incalculable confusion, because several automobile manufacturers would buy components from a single source and put their own numbers on them. A bearing that appeared in a Packard, a Ford, a Chrysler, a Dodge, and a Plymouth could have five different numbers—but it was the same bearing.

Four types of numbers—Ordnance drawing, Ordnance standard parts (taxi system), Federal Standard Stock Catalog, and manufacturer's—were primarily for procurement purposes. They were also used to some extent in requisitions, especially the manufacturer's number, because of the many manufacturers' catalogs in the hands of troops. For stockkeeping, there was the item stock number that had been designed by Field Service as a basis for the depot and Detroit records under the IBM system.[44] This item stock number was not physically applied to parts but was marked on tags and containers, in most cases along with the drawing numbers. The item stock numbers were a change-over from the SNL system, but the coding had proceeded so slowly that some SNL's were still being used. Also, in the interim before the change-over could be accomplished, depots had been forced to assign temporary item stock numbers for stores reporting. There were, therefore, three possible stockkeeping numbers in addition to four procurement numbers, and the fact that parts were procured under one number and stored under another—and might be requisitioned under a third—contributed immeasurably to the confusion.[45]

Interchangeability of Parts

Another aspect of the parts numbering problem was the need for information on what parts were interchangeable between truck and truck, or truck and tank. The desirability of being able to substitute one part for another could hardly be overemphasized, from the standpoint of reducing the number of individual parts or part numbers in the stock control system, and of maintaining in operation equipment that would otherwise be deadlined for lack of parts.

The necessity for compiling and disseminating interchangeability information on automotive parts had long been obvious. In 1940 The Quartermaster General had begun such a project. But at that time the size and urgency of the wartime task could hardly have been foreseen. The emphasis then was on procurement, rather than on distribution; further, it was difficult to find, and keep, personnel with sufficient technical knowledge for the work. The job was far from complete

[44] See above, pp. 396–98.

[45] (1) Report of Board Appointed to Develop Method of Numbering Standard Parts (Ordnance Department Special Orders 129, paragraph 5, dated 31 May 1943), 23 Jun 43 (hereafter cited as Wells Bd Rpt), copy in Hambleton, Hist, Engr-Administrative Br; (2) Interv with Sadtler, 25 Aug 52; (3) Hynds Memo. See also FS Key Pers Rpts and OCO-D Key Pers Rpts in OHF.

when the Motor Transport Service was transferred to the Ordnance Department. There now arose the problem of relating the parts of trucks to parts of tanks and other Ordnance items. The Ordnance Department had for years maintained at Raritan Arsenal a file of data that showed by SNL number all the major items on which each part was used, and thus provided complete interchangeability for each part number. But with the added load imposed by the incorporation of the Motor Transport Service, these records could not be kept current. The Special Parts and Interchangeability Group was overloaded with work even on general purpose vehicles. The task was made more difficult by the proprietary interests of some manufacturers who refused to make their interchangeability data available. Ordnance did not undertake a definite program to compile interchangeability data until the spring of 1943 when the whole parts numbering system became so critically obstructive that it had to be completely revamped.[46]

Early in 1943 a breakdown in the effort to convert manufacturers' numbers to the Ordnance taxi system resulted in the formation at Detroit of a committee to study the whole numbers problem. But reports by this and other committees accomplished little, and in April the Supply Branch, T–AC, called a conference of depot commanders from Ordnance and Motor Transport installations to map out a plan of action. These men recommended that, except for standard commercial parts common to other services, which would continue to be carried under the Federal Stock Catalog Number, every part be given one number, to serve in place of the drawing number, piece mark, manufacturer's number, or any other, and that this number be the item stock number, plus a classification code, if an item stock number had been assigned. They further recommended that new items, or items to which no item stock number had been assigned, be given a simple numerical number starting with 5,000,001. To study this plan and various suggested modifications of it, the Chief of Ordnance appointed an Ordnance Numbering Board consisting of Brig. Gen. Gordon M. Wells, Artillery Branch, Industrial Division; Col. Graeme K. Howard, Director of Spare Parts, T–AC; and Mr. Lawrence S. Barroll, Supply Branch, Field Service. Representatives of the Board held meetings with the Detroit committee at Detroit and examined witnesses there and at Washington between 7 and 22 June 1943.[47]

The Wells Board decided to throw out the item stock numbers and concentrate on a system using seven digits, between 5,000,000 and 9,999,999, for all Ordnance matériel except Federal Stock Catalog items. But it also decided that the seven digit number would have some relation to the piece mark that was stamped, embossed, or otherwise marked on Ordnance components and recommended an ingenious method that would permit incorporating the piece mark, which consisted of six digits plus a letter, in the seven digit number. To A drawing numbers were assigned the block of numbers from 5,000,000 to 5,499,999, to C numbers, 5,500,000 to

[46] (1) Maj Gen Levin H. Campbell, Jr., Spare Parts History, 24 Jun 44, ex. E–12; (2) Ordnance Spare Parts in Mechanized Warfare, Aug 44, pp. 18–21; (3) Comments on draft of this chapter by Brig Gen John A. Barclay, Apr 57, OHF.

[47] (1) E. J. Almquist, History of Engineering Administrative Branch—later Engr and Inspection Br—Executive Division, 20 Nov 45, OHF; (2) Gamrath, Hist, pp. 5–6; (3) Wells Bd Rpt.

5,999,999, to B numbers 6,000,000 to 6,499,999, to D numbers, 6,500,000 to 6,899,999 and to E numbers, 6,900,000 to 6,999,999.[48] Thus, the new number for a part stamped with A-277276 would be 5,277,276. One drawback to this system was the fact that the sizes of the engineering drawings, which the letters A to E represented, were sometimes changed. Therefore, the numbers from 7,000,000 to 9,999,999 were reserved to be assigned consecutively to all new Ordnance parts prepared after the system went into effect, without regard to drawing size.

The next consideration was the administration of the new system. The Board found strong evidence that the existing confusion stemmed partly from the fact that the assignment of numbers and the making of rules for their use had been left to a subordinate agency in the Artillery Branch that did not have sufficient prestige or authority to enforce a uniform system, and recommended that a new agency be set up immediately. Accepting the findings of the Wells Board, the Chief of Ordnance directed the change-over to the new numbers and placed responsibility for it with an Engineering and Administrative Section headed by Col. Harry B. Hambleton.[49]

Colonel Hambleton and his staff began immediately an exhaustive study of the whole parts numbering problem, visiting depots, ports, product centers, and the Tank-Automotive Center. As the investigation proceeded it became clear that the problem was one of stock control rather than engineering. Since stock numbers were being assigned at Detroit, a suboffice was established there under the direction of Major Charles M. Buhl to administer the new system. Further study by Major Buhl and members of his staff made it increasingly evident that the engineering or part number phase was a relatively minor factor when compared with the confused stock number situation and that the provision of Ordnance Department Order 69 for identifying all Ordnance standard parts by Federal Stock Numbers was impractical. Consequently on 14 September 1943 the Chief of Ordnance issued a revision of Ordnance Department Order No. 69. It scrapped existing Ordnance numbering systems and provided for the assignment of one Official Ordnance Part Number to almost every new part. The revised order became the Bible of the parts numbering and interchangeability program.[50]

Implementation of the New Numbers Program

From the new system the Engineering Administrative Branch evolved an Official Stock Number that became the key to the whole numbering and interchangeability program. It was made up of the Official Ordnance Part Number, when one existed, prefixed by a classification code that might be either the SNL Group prefix or the manufacturer's code. The problem now was to bring under the Official Stock Number all the other numbers that an identical or interchangeable part might carry, such as that of the part manufacturer, unit manufacturer, or the old taxi number. The Branch began the preparation of a cross reference list of Ordnance

[48] It will be noted that "C" drawing numbers were assigned lower stock numbers than "B" drawing numbers. Wells Board Report, pp. 4–8.

[49] (1) Wells Bd Rpt, pp. 4–8; (2) ODO 69, 9 Jul 43; (3) ODO 65, 25 Jun 43; (4) ODO 169, 16 Jul 43.

[50] Hambleton, Hist, Engr-Adminstrative Br, pp. 1–5, including copy of Revision 1 in app.

part and stock numbers in two sections, one listing serially the number stamped on the part, with the corresponding stock number or numbers opposite. This information was progressively turned over to Field Service, which sent to depots that had IBM equipment a master stock card carrying the new number and showing all other reference numbers and a corresponding number card for each corresponding or "alias" number on the master card. This theoretically enabled the depot to put into one bin all interchangeable items, no matter what number they bore.[51]

The implementation of the new numbers program took time. Concurrently with the interchangeability project, designers both in Ordnance and industry had to be given blocks of the new official part numbers to apply to new parts. New drafting-room regulations had to be developed. The cross referencing job (except for Federal Stock Catalog numbers, which were handled in Washington); the assignment of numbers; the screening of parts; and the elimination of duplicate numbers were assigned to the Parts Number Control Section, OCO–D, under the direction of the Engineering Administrative Branch. But it was woefully short of personnel. Strenuous efforts by Colonel Hambleton and Major Buhl resulted in the employment by contract of employees of a commercial firm, Smith-Hinchman and Grylls. From this source there were added to the Section a day shift averaging forty-four persons and a night shift of about forty-eight. These made possible a round-the-clock operation from October 1943 to May 1944. For the cutting of master cards to send to the depots, Field Service's Machine Records Section also had to rely on a contractor, the R. L. Polk Company.[52]

In June 1944 the Cross Reference List of Ordnance Part and Stock Numbers, known as ORD 15, appeared in two parts of ten volumes each. ORD 15–1 was based on part numbers, ORD 15–2 on stock numbers. Twenty-two thousand sets were printed and distributed to users such as bases, depots, and stock control points. Revisions in the spring of 1945 increased the total of the numbers listed from 600,000 to 750,000, and so great had the demand become that 32,000 sets had to be distributed. The realization that a similar cross reference list was needed for tools and tool equipment resulted in the publication of ORD–5, Stock List of Items, and ORD 5–1, Numerical Index of Manufacturer's Part Numbers and Drawing Numbers. ORD 5, listing the official nomenclature, was made necessary by the fact that one element of the Federal Stock Number was the initial letter of the principal noun; for example, 11–P–600 was the number for an oil barrel pump. Also published during the latter part of 1944 and early 1945 were interchangeability lists for tanks and vehicles of related chassis and for general purpose and wheeled combat vehicles, known respectively as ORD 14–1 and ORD 14–2.[53]

Nobody claimed that the new numbering system was perfect. The Ordnance

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[51] (1) Campbell, Spare Parts Hist, ex. F–4; (2) *The Ordnance Sergeant,* IX (March 1945), OHF; (3) PP 66, Parts Numbering System 1940–45, p. 34, OHF.

[52] (1) Hambleton, Hist, Engr-Administrative Br, pp. 5–6 and ex. 23; (2) Final Report of Committee to Make Survey of Ordnance Numbering System and Depot Operations, 2 May 45 [hereafter referred to as Safford Comm. Rpt] p. 7, in Numbers Racket folder; (2) Memo, Lt Col John D. Witten for Director, Contl Div ASF, 10 Jan 44, sub: Contract for Tabulating Work, T–AC, ASF Contl Div Files, 413/51.

[53] (1) Hist Engr-Administrative Br, pp. 7–17; (2) PP 66, pp. 35–39; (2) *The Ordnance Sergeant,* IX (March 1945).

Department admitted that it was a compromise. Obviously, in the midst of war, all supply functions could not be stopped pending the ideal solution to the numbering problem; nor could all past mistakes be rectified at once and all future situations foreseen. Controversies arose over such matters as the correct components for the Official Stock Number; the proper method of marking packaged matériel at the facility in the absence of identification information; and the fixing of responsibility for the determination of the right SNL or Stock Class Code for each item.[54]

The greatest impediment to smooth operation of the new plan was the inauguration early in 1944 of the Master Depot system for storing at one depot all parts pertaining to a single vehicle or group of closely related vehicles. The new Official Stock Number incorporating the SNL number connected the part with the end item in which it was most frequently used; on the other hand the master depots stocked items on the car-line system followed by the automobile industry, in which all parts for a particular make of vehicle, Ford, Dodge, Chevrolet, and so on, were stored at one depot.[55]

Because of unavoidable delay in getting cross reference lists disseminated and in use at all levels, no really fair trial of the Official Stock Number system was possible during the war. On the credit side, by June 1945, parts formerly identified by 862,000 numbers were for stock purposes and review identified by 315,880. Control of the assignment of numbers had been effectively centralized, and the basic compilation of interchangeability and cross reference data had been completed.[56] Shortly after the issuance of ORD 15, the Cross Reference List of Ordnance Part and Stock Numbers, an ASF report noted that the publication had "met with enthusiastic response and . . . led to many requests for its extension and the furnishing of similar information by other services." [57]

Unfortunately it was not entirely successful. Users found that it was "rife with errors." [58] This was perhaps inevitable because in the rush of the war years the compilers had not had time to give to every spare part the painstaking analysis that was essential to produce ideal interchangeability data.[59] But ORD 15 was at least a step in the right direction, and in the opinion of General Hatcher, Chief of Field Service, "accomplished more to simplify parts supply, as well as eliminate apparent shortages than all previous attempts to arrive at an answer to this complicated problem." [60]

A Common Language of Supply

The complexity of Ordnance matériel, the vastness of the organization required to produce and use it, and the lack of experience among wartime employees, brought to the forefront another problem of identification—the correct name for the individual weapon or vehicle. It was exceedingly difficult to solve. There were changes in model, disagreement as to the characteristic to be emphasized, and nu-

[54] Gamrath, Hist, pp. 6–8.

[55] See ch. XVIII.

[56] (1), PP 66, pp. 45–51; (2) ODO 43–45, 19 Apr 45.

[57] Griffenhagen and Associates, Report on Item Identification, vol. I, sec. IV, p. 13, ASF Contl Div Files.

[58] Maj. Gen. James Kirk, Chief of FS, "Streamlined Supply," *Ordnance,* XXXIV, No. 179 March–April 1950), 350.

[59] *Ibid.*

[60] Memo, Hatcher to CofOrd [n.d.], sub: Rpt of Activities in World War II, copy in OHF.

merous other opportunities for misunderstanding. Sometimes an item had no more accurate name than just device. The preparation of a major item Standard Nomenclature List could not begin until a model had been constructed, tested, modified, and adopted. Then followed disassembly and the examination and cataloging of every part. Publication might take months or even years.[61]

In the middle of the war the time required for publishing SNL's was shortened, and major item lists were brought up to date, but confusion in nomenclature seemed inherent in a system that divided the function between the procurement and the distribution services.[62] A promising solution was the assignment of responsibility for standardizing nomenclature and matériel identification to a single agency. In June 1943 the Chief of Ordnance gave the job to Industrial's Engineering Administrative Section.[63] The new unit made a study of such matters as proper nomenclature for major combinations as well as major items; the crying need for a simple and uniform system of model numbers, that is, the T and M numbers that appeared in OCM's; and the advisability of setting up an organization that would control nomenclature and model numbering and co-ordinate the work of design offices, stock control offices, and the Ordnance Technical Committee.

The need for devising a common language of supply for the use of the Army as a whole was recognized in early 1943 by Army Service Forces.[64] After some preliminary investigation of the problem, ASF employed a commercial firm of management consultants, Griffenhagen and Associates, to make a study of item identification. Reporting 31 August 1944, the firm recommended a uniform system of article description and numbering for all the technical services;[65] but ASF felt that no new system or even any major revision of the old systems should be attempted during the war.[66] The only co-operative venture was the preparation of the ASF Tool and Tool Equipment Catalog, in which the Federal Standard Stock Catalog nomenclature and stock number for every tool were indicated, together with the stock number of each of the technical services. The Ordnance Department, which had major interest, was given responsibility, with the assistance of the other technical services.[67]

This was but a small step toward the solution of a problem that was increasing in importance and size by 1945. During World War II the Federal Standard Stock Catalog had failed to be readily expansible to meet the needs of the armed services, and the Treasury's cataloging staff was inadequate to develop a uniform system. Each service, bureau, and command had to establish its own system, resulting in duplication that was costly in manpower and money. According to one

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[61] ASF Rpt 105, pp. 14–15.

[62] (1) ASF Rpt 105, pp. 2–3, 5–8, 13–15; (2) Hynds Memo; (3) FS Sub-Office, Frankford Arsenal, Major Items—Major Combinations. . . , conf, 10–11 Jan 45, p. 2, OHF.

[63] ODO 65, 25 Jun 43.

[64] ASF Rpt 105, p. 1.

[65] Griffenhagen and Associates, Rpt on Item Identification. The firm acknowledged the aid it had received from Colonel Davies, Colonel Hambleton, Lt. Col. Roger H. Hemion, Major Coopes and Maj. John A. Mathews of Ordnance and commended the Ordnance Department, especially Hemion, for its work on cross reference, I, iv–v.

[66] Memo, Brig Gen Theodore M. Osborne for CG ASF, 29 Nov 45, sub: Item Identification and Cataloging Program, ASF Contl Div Files.

[67] (1) ASF Ann Rpt FY 1945, p. 257; (2) Hambleton, Hist, Engr-Administrative Br, pp. 14–15.

estimate, the lack of a uniform system of cataloging in World War II cost the government five billion dollars in unneeded matériel.[68]

On 18 January 1945 President Roosevelt instructed the Director of the Bureau of the Budget to prepare a United States Standard Commodity Catalog employing all systems then in use by the Government insofar as they conformed to a central plan. The Board established for the purpose submitted a plan for a uniform Federal Catalog system; but an effective start toward implementing any plan in the postwar years required action by President Truman, the military departments, and Congress. After May 1948 the catalog program became the responsibility of the Munitions Board Cataloging Agency.[69]

[68] Lecture, Lt Gen Joseph T. McNarney, West Point, 8 Jan 51, copy in Dept of Defense R&D Bd files.

[69] MBCA Newsletter, I (30 Jun 50).

CHAPTER XX

Stock Control

A clear language of supply and a workable system of parts numbering were essential to the preparation of accurate stock reports by field installations. But to achieve full usefulness such reports had further to be speedily consolidated into one report that would provide figures for procurement and distribution officials to act upon. Detailed knowledge of the quantities of stocks on hand—and their exact location—was the key to orderly supply operations. It was to provide such knowledge as a means of controlling the distribution of supplies that the system known as stock control came into use. After the war the final report of Army Service Forces stated that the development and adoption of an Army-wide stock control system was "the most important single wartime improvement in distribution operations within the Zone of the Interior." [1]

Departures From the Ordnance Provision System

The Ordnance Provision System, based on the experience of World War I, was potentially an effective method of keeping records on stocks. Unfortunately, in the period between wars the money allotted for stock control purposes was infinitesimal, in proportion to the immense dollar value of Ordnance stores.[2] Between 1920 and 1940 the office staff in Washington, organized in sections or groups, dwindled. For example, Group C, light artillery, and Group G, tank and combat vehicles, which each had fifteen persons in 1918, were reduced to two each.[3]

In the spring of 1940 the staff had to be expanded. But the new employees who were brought in were entirely unfamiliar with the organization of the Army, with War Department procedures, and with Ordnance matériel. No systematic training program existed to prepare them for their jobs. The group chiefs, all of whom had been with Ordnance since World War I, were reluctant to entrust responsibility to inexperienced clerks. Furthermore, there were never enough new employees to set up and maintain the greatly increased records on issues, particularly the quantities of equipment transferred to foreign governments. At the time of the Dunkerque evacuation, when the United States shipped large quantities of armament to Great Britain, it was all but impossible, because of the great urgency of the need, to maintain accurate records by

[1] Logistics in World War II, Final Report of the Army Service Forces, rpt to USW and CofS by Director of Servs, Supply and Proc Div, WDGS, 1947, p. 79.

[2] Interv, Kahlert, 30 Jul 52.

[3] SCD Hist.

model and quantity of each weapon involved.[4]

The confusion that resulted caused some Ordnance stock controllers to wonder whether the Ordnance Provision System, which theoretically provided a cadre of trained persons on which to build a wartime staff, was indeed capable of expansion to meet wartime needs. Colonel Meyns, who became chief of the General Supply Branch in July of 1941, concluded that, "Whereas this type of organization was very valuable in that it concentrated the production knowledge at one point and had been used to advantage for over 25 years, it was not flexible enough to provide for the rapid expansion required by the velocity of war activities." [5] But other supply experts pointed out that sufficient time had not been allowed to prepare and organize special training courses for inexperienced employees.[6]

More attention in the 1930's to planning for the enlargement of stock control operations in the event of war might have made possible orderly and efficient operation when the emergency came. The question remained theoretical. Although the Ordnance Provision System Regulations were not rescinded, remaining in effect throughout World War II, Ordnance supply experts whose memories went back to World War I observed that the regulations were not followed in their essentials.[7] One departure was the establishment of a set of records for distribution only, whereas the Ordnance Provision System used one set of records for both procurement and distribution. Another was the separation of spare parts from their major items.

Both actions were taken in the emergency period before Pearl Harbor. The effects of these innovations, the problems they created, and the solutions to the problems, became increasingly important in the early years of the war. By December 1942 the situation had become critical. The bottleneck at Detroit caused by the concentration there of stock control for all spare parts had delayed the posting of the Consolidated Stores Report figures until they were out of date; the immense recoding operation cast doubt on the accuracy of the data.

Decentralization of Stock Control

A simple answer was decentralization, and some planning along this line was in progress in the spring of 1943.[8] Colonel Sadtler, Assistant to the Chief of Ordnance for Parts, suggested that Field Service, organized at the operating level on a functional basis, be decentralized on a product basis, as had been successfully accomplished by the Technical and Industrial Divisions. Colonel Sadtler's plan called for bringing major items and their spares and tools back together, as in the old Ordnance Provision System, and for concentrating upon each product the best technical skill available by locating in one place all Ordnance activities connected with each type of product. Colonel Sadtler argued that this plan would lift the burden of operations from top-level Field Service agencies and enable them to perform better the important job of planning and supervision.[9]

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[4] (1) *Ibid.;* (2) Meyns Rpt.

[5] Meyns Rpt.

[6] SCD Hist, p. 22.

[7] (1) Hynds Memo; (2) Intervs with Kahlert and Sadtler, Jul 52.

[8] Memo, Raaen to Statistics and Progress Br, Contl Div, ASF, 3 Apr 43, sub: Improvement of Reporting and Rcd Systems.

[9] (1) Memo, Col William Sadtler for CofOrd, 11 May 43, sub: Adequate Provision of Spare Parts, copy in PSP 63, ex. 18.

The complete product center concept was not followed, but the Chief of Ordnance did decide to set up Field Service suboffices that would administer stock control, supervise storage, and direct maintenance operations for certain types of matériel. The first was at Frankford Arsenal. On 23 August 1943 Frankford received responsibility for fire control and antiaircraft matériel distribution operations formerly performed at T–AC, and on 31 December was assigned stock control functions for certain major items of this kind. The second suboffice was established at Rock Island on 15 January 1944 for mobile artillery and small arms, exclusive of major items. By that time stock control had been further decentralized along several lines. In addition to Frankford and Rock Island, three stock control points for items of general supply had been designated. For automotive items and end parts, districts and arsenals sent their stores reports to Detroit, for tools and tool equipment of tank-automotive items to the St. Louis Ordnance Depot, and for cleaning and preserving materials and major items of small arms and artillery to the Office, Chief of Ordnance in Washington. Effective 24 January 1944, reports on the status of ammunition stocks went to the Ammunition Supply Office in Philadelphia.[10]

The job of reporting approximately three hundred fifty thousand items of general supply each month from forty different locations was large and involved. No stock control system could automatically solve all problems, but there is evidence that decentralization brought about improvement almost at once. After only ninety days of operation, the Rock Island suboffice, for example, had cut the time for consolidating stores reports to a little more than two weeks, as compared with approximately six weeks formerly required by the Stock Control Branch in Detroit. This was accomplished mainly by promoting familiarity with the item. Rock Island broke down the organization into small groups handling no more than two thousand items and provided records that gave the complete distribution and replenishment history of each item. Another effective technique, followed also at the Frankford suboffice, was to clear the records of all duplicate and dead numbers. In this way Rock Island reduced the thirty-nine thousand items formerly handled at Detroit to 17,600. Frankford reduced its items from fifty thousand to twenty-five thousand and by July 1944 had achieved better than 90 percent availability on all fire control and antiaircraft matériel.[11]

By the fall of 1944 General Campbell felt that the results completely justified his decision to decentralize Field Service operations, and he planned to continue the process as fast as it could be done without disrupting supply at that critical period. After V–E Day, for example, he would transfer to Rock Island stock control operations for major items of small arms and mobile artillery as well as parts. In the meantime he thought that some of the

[10] (1) ODO 85, 23 Aug 43 and Change 2, 31 Dec 43; (2) ODO 96, 8 Nov 43; (3) ODO 107, 24 Dec 43; (4) ODO 108, 24 Dec 43; (5) ODO 17–44, 20 Jan 44; (6) ASF Contl Div, Report on Adequacy of Stock Accounting and Stock Reporting Procedures. . . , 29 Aug 44, Table A–1, sec. 7, ASF Contl Div Files; (7) Min, Conf of SC Ord Officers, 28 and 29 Jan 44, Cincinnati, Ohio, p. 12, OHF.

[11] (1) Report Covering the Present Status of the Rock Island Field Service Division Sub-Office—15 April 1944, and Ltr, Col Hiram B. Ely to Col Fred A. McMahon, 22 Jul 44, both in folder, Gen Campbell's Personal Correspondence; (2) Ann Rpt of FS for FY 1944, p. 25; (3) Interv with Col William Sadtler, 25 Aug 52; (4) Vorberg Rpt.

hazards of dividing stock control responsibilities between Washington and the field could be avoided by a realignment of the Stock Control Division in Washington to place emphasis on supervision rather than operations and by an Ordnance Department Order clarifying the responsibilities of the various divisions.[12]

Ordnance supply experts believed that the establishment of the Frankford and Rock Island suboffices went a long way toward solving distribution problems as far as "shooting Ordnance" was concerned.[13] This belief was substantiated by General Somervell's statement in February 1945 concerning his conversations with members of the War Department General Staff: "The only thing I have not heard any complaints about was spare parts for weapons." [14]

Special Problems of Automotive Parts Supply

Automotive parts were another matter. Ordnance troubles "smelled of gasoline." [15] The size of the problem faced by the vehicle supply operation in Detroit is indicated by the fact that vehicles, including spare parts, tools, and equipment, accounted for $19 billion out of a total of $26 billion worth of Ordnance major model types procured and scheduled between 1942 and 1945, as compared with $3 billion for small arms and $4 billion for artillery and fire control items.[16] At the end of December 1943 Ordnance was paying more than $100 million a month for automotive parts alone. In the light of these figures it seemed to the Chief of Ordnance "inconceivable for anyone to say there are no spare parts." [17]

But theater commanders were saying so, and were saying it as emphatically as they could, especially those planning the invasion of Europe. Maj. Gen. Everett S. Hughes, a former chief of the Equipment Division, Field Service, who was now deputy commander of the North African theater, considered that the Ordnance Department had underestimated the requirements for parts, basing estimates too much on the peacetime experience both of the automobile industry and military planners. Yet he also recognized distribution factors that could not have been foreseen.[18]

The Stock Control Branch at Detroit, which had just been given responsibility for spare parts replenishment, worked with the Industrial Service to improve production.[19] As for distribution, some of the volume of paper work at Detroit was relieved by the establishment of the tools and equipment suboffice at St. Louis. At the same time the Chief of Ordnance, who was spending "a tremendous amount of time . . . in spare parts and Field Service matters," [20] considered using master depots as stock control points for tank-automotive supplies. Automotive parts

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[12] (1) Ltr, Maj Gen Levin Campbell, to Sadtler, 23 Oct 44, in folder, Gen Campbell's Personal Correspondence; (2) ODO 10-44, 7 Oct 44.

[13] Interv, Sadtler, 25 Aug 52.

[14] Min, Spec ASF Staff Conf, 21 Feb 45, ASF 200.02.

[15] Interv, Sadtler, 25 Aug 52.

[16] Ord Spare Parts in Mechanized Warfare, Aug 44, p. 10.

[17] Ltr, Maj Gen Levin Campbell, to Brig Gen Henry Sayler, 14 Dec 43, folder, Gen Campbell's Personal Correspondence (Overseas Material).

[18] Ltr, Maj Gen Everett Hughes to Maj Gen Levin Campbell, 30 Jan 44, Gen Campbell's Personal Correspondence (Overseas Material).

[19] For the spare parts procurement story, see Chapter XIII above.

[20] Maj Gen Campbell, to Col Thomas H. Nixon, Ord Officer Hqs I Armored Corps, 3 Feb 44, folder, Gen Campbell's Personal Correspondence (Overseas Material).

planners intended that master depots would eventually be completely responsible for their own items, including keeping the stock control record.[21] But the new Parts Numbering and Interchangeability Program, creating the necessity for several installations to stock the same parts, made it inadvisable after 1944 further to decentralize stock control functions to master depots.[22]

Safford Committee Findings

Investigations in the spring of 1945 by the Safford Committee probed deeply into the fundamentals of automotive spare parts supply. One thing the members of the committee agreed upon—the problem of effective control of stocks was staggering and had no easy solution. In the words of Colonel Clifford of OCO–Detroit, "There are so many points of view on it and any time a decision is made it means so many thousands of tons of iron moving around that it makes you shiver." [23] Some Field Service officials felt that the Industrial Service had placed too much emphasis on the assignment of Official Stock Numbers and not enough on their use. There was also disagreement on the subject of the master depot plan for automotive supply. General MacMorland of Field Service believed that the master depot plan by carline had not been outstandingly successful. Members of the committee from Industrial Service pointed out that the close relationship between the master depots and manufacturers had helped on questions of identification and in other ways, and that the committee could not wait to achieve the ideal system but had to take action to improve parts supply quickly without disrupting operations.[24] In planning for the postwar period the committee leaned toward a scheme to recode the Official Stock Numbers by manufacturer's codes.[25]

The By-Item Supply Plan

There was a growing sentiment in the field, however, for a return to the by-item supply plan of the Ordnance Provision System, which specifically provided a "home" for each item in its catalog. Citing the case of a former Ford man in Cherbourg who had opposed the Ordnance Provision System for a long time but had finally become converted, Col. Waldo E. Laidlaw of the New York Port of Embarkation testified during the committee investigations that, "I have never talked to anyone from the highest echelon that I deal with to the lowest that doesn't state that the system we used in 1925 was the best one that was devised." [26] Long experience in Ordnance supply during World War II, especially automotive supply, convinced Gamrath that the Ordnance

[21] (1) The Master Depot Distribution Plan for Tank-Automotive Parts and Tools, Revised 1 May 44, OHF; (2) FS Div Ord 29–44, 3 Apr 44; (3) Min, Conf of SC Ord Officers 28–29 Jan 44; pp. 12–13; (4) PSP 63, ex. 9; (5) 1st Indorsement (Memo), CG OCO–D to CofOrd, 27 May 44, in Campbell, Spare Parts Hist, 24 June 1944, ex. F–4, Mead Comm.

[22] Safford Comm. Rpt., p. 8.

[23] Telcon among Col Waldo E. Laidlaw, New York Port of Embarkation, Clifford, and Coopes, OCO–D, 18 Jan 45, sub: Spare Parts Numbers Subcomm., in Gen MacMorland Numbers file, p. 80.

[24] Min of Comm. to Make Survey of Ord Numbering System and Depot Opns—Mtg at Office of CofOrd–Detroit, 6 and 7 Feb 45, 14 Feb 45, pp. 8–10, in Gen MacMorland Numbers file.

[25] *Ibid.*, p. 9.

[26] Telcon among Laidlaw, Clifford, and Coopes. OCO–D, 18 Jan 45, pp. 80–81.

Provision System was "a sound method of operation." [27]

The Influence of ASF

Beginning in January 1943, the month in which, according to an Army Service Forces official, "stock control was conceived," [28] ASF held a series of conferences on the subject, called for reports from the chiefs of the technical services, and began the preparation of a manual for posts, camps, and stations. Appearing in tentative form in March, the manual was also a directive. It placed stock control procedure, under the general policies of ASF, in the hands of the chiefs of technical services. Each of these chiefs was to organize a stock control agency, set stock levels at depots and stations, establish inventory procedures, and supervise the distribution and redistribution of stocks to maintain an efficient balance between supply and demand. An important result, not specifically set forth in the manual, was the placing of full responsibility for handling requisitions on the depot commanders; the new system put a stop to the earlier practice of referring requisitions to the Service Commands for processing.[29]

The Ordnance Department was reluctant to establish a stock control agency because this move increased the functionalism in Field Service organization that had already caused trouble. General Campbell and General Hatcher both favored assigning supply responsibility on a product basis. But efforts at compromise with ASF were fruitless, and a Stock Control Branch was established in August 1943.[30] In the meantime the Field Service Division took action to extend Ordnance stock control, which had hitherto mainly operated by means of the Ordnance Provision System between factory and depot, more effectively to the level below the depots—posts, camps and stations.

Some benefits of the new program were apparent immediately; for example, during the month of June the Normoyle Ordnance Depot recovered 1,155,370 pounds of excess stocks;[31] but all problems were not immediately solved. In spite of frequent inspections at stations by stock control teams sent by Ordnance, the Service Commands, and ASF, there continued to be hoarding, on the one hand, and, on the other, shipments to depots of stocks that were not true surpluses and might be requisitioned by the same post a few days later. Excesses sometimes arrived improperly packaged and unidentifiable.[32] On the credit side, more than 110,000,000 pounds of critically needed parts, supplies, tools, tires, and tubes were returned to supply channels from posts, camps, and stations during fiscal year 1944 as compared with 30,000,000 for the year preceding.[33]

By early 1944 large surpluses of usable parts were accumulating in stations and key supply points as troops began to move

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[27] Memo, W. C. Gamrath, Chief Supply Opns Br, FS, to Exec to Chief of FS, 22 Mar 46, sub: Final Historical Rpt, in Key Pers Rpts, OHF.

[28] Col Creswell G. Blakeney, Gen Staff Corps, Spec Asst to Director of Rqmts and Stock Contl Div, ASF, "The Control of Supplies," *Military Review*, XXIV, (October 1944), 67.

[29] TM 38-220, 3 May 43.

[30] Green, Thomson, and Roots, *Planning Munitions for War*, Ch. IV.

[31] Dr. Rolfe Allen, ICAF Research Project 116, History of Stock Control ASF, U.S. Army, January 1948, p. 129 [hereafter cited as ICAF R-116].

[32] (1) Min, Conf of SC Ord Officers, 28-29 Jan 44, p. 2; (2) Ord-SC Conf, 8-9 May 44, p. 33, OHF; (3) ICAF R-116, pp. 130, 143-45; (4) ASF Cir 10, sec. VIII, 8 Jan 44, sub: Stock Control.

[33] (1) Ann Rpt FS FY 1943, p. 2; (2) Ann Rpt FS FY 1944, p. 19.

out of the United States for the invasion of Europe. Recapturing this excess material was in the opinion of one stock control officer Field Service's "No. 2 job" [34]—second only to getting supplies overseas. Once the parts came into the stock control system of the depots they could be used to fill overseas lines or to recondition vehicles for shipment to Europe.

Stock Levels

The setting of proper stock levels was a matter of greatest importance, for determination of the amount of a particular item to be kept on hand was the keystone of all supply operations. In July 1943 ASF instructed the technical services to establish levels according to a formula that provided for a Maximum Distribution Level (MDL) consisting of minimum stock, working stock, and provisions for replenishment. In addition there could be several types of reserves. It was expected that levels would vary; no rigid figures were given, only examples.[35] In February 1944 the War Department authorized an over-all allowance of a 105-day supply on hand in the United States. Of this, except in a few special cases, supply for 45 days was to be carried in depots, 45 days in stations, and 15 days in transit between depots and stations. This meant, in effect, that depots might maintain a 60-day supply of items for issue to posts and overseas, plus the various reserves then authorized —strategic, contingency, utility, and production. When the computation of these levels and reserves proved too great a task, ASF sought and obtained a revision in May 1944 that provided for a 90-day supply plus a strategic reserve.[36]

Nothing was clearer than that levels of stock at the various stages in the supply system had to be determined, yet it became equally clear as time went on that the correct computation of these levels depended greatly on the good judgment of individual supply officers. In Ordnance, as in other technical services, there was a tendency to base the formula unduly on past experience rather than on intelligent projection into the future.[37] It became necessary for ASF in a 1944 revision of TM 38–220 to state specifically that past demands of a nonrepetitive nature not anticipated in the future were not a proper base for an increase in station levels. Nor was simple projection into the future enough. Careless or uneducated guesswork could hinder the process of orderly supply. Late in 1944, for example, the Chief of Ordnance found that the repair of automotive vehicles was handicapped because station supply officers and depot representatives had underestimated future requirements and moved too much matériel out of stations.

ASF Supply Control Program, 1944

The phasing of requirements by months for the immediate future and by quarters for the years ahead was one of the most

[34] Lt Col F. Von Schlegell, The Current Distribution Pattern, Min, Conf of SC Ord Officers, 28–29 Jan 44, p. 14.

[35] Memo, CG ASF for TQMG and others, 13 Jul 43, sub: Depot Stock Levels, 400.291, QM files.

[36] (1) WD Cir 85, 25 Feb 44; (2) ASF Cir 67, 7 Mar 44; (3) ICAF R–116, pp. 141–48; (4) ASF Ann Rpt FY 44, p. 64.

[37] (1) ICAF R–116, p. 208; (2) Rpt Mead Comm., S. *Report* No. 10, 78th Cong., 2d sess., pt. 20, 1944, p. 24; (3) Ltr, Maj Gen Wilhelm D. Styer to Deputy Chief of Staff for SC's *et al.*, 29 Oct 43, sub: Stock Contl Conf, ASF 401.1; (4) Min, Ft. Wayne Ord Depot Stock Contl Conf, 23 Sep–2 Oct 44, talk by Capt K. J. Kolosky, Scope of Station Supply Plan, pp. 1–3.

important characteristics of the ASF Supply Control System announced in March 1944. By then the supply task was to maintain an 8-million-man Army that had already been equipped, and the job had to be done without unnecessarily increasing production. Careful adjustment of supply to demand required that all factors for each principal item be assembled on one sheet of paper—past issues, stock levels, reserves, and so on. After studying these data, ASF officials projected the future demand, by intervals of time. Against this were balanced deliveries from production, the amount of stocks on hand, and anticipated returns to stock. Reliable data were the essence of the whole operation. As a high-ranking ASF officer, Lt. Gen. LeRoy Lutes, stated after the war:

> With the inauguration of the Supply Control System, it quickly developed that the process of controlling supply was in the last analysis entirely dependent upon basic records and paper work in depots, procurement district offices, and other installations in the field. The data for the supply control form could only be assembled from these sources.[38]

To determine whether the data available on stocks provided the information needed for the supply control form, the ASF Control Division in August 1944 made an analysis of the technical services' depot stock accounting and reporting procedures. The survey revealed that most of the services could meet the requirements of supply control, although some deficiencies were noted in methods. In the case of the Ordnance Department, for example, the investigators counted as a deficiency the fact that stock records were maintained manually on major items, a slow method that might produce errors because of multiple postings of identical data.[39] In general, the greatest criticism of the technical service procedures was that they were not uniform. The technical services protested that, to achieve uniformity, they would have to rewrite manuals and retrain personnel; they contended that errors were bound to occur during the change-over and that there would certainly be a large loss in punch cards and report forms. They also argued that the transition would take time and should not be attempted so late in the war. After considering these objections, the surveyors still maintained that the advantages of standardization outweighed the disadvantages.[40]

ASF then began the process of converting existing procedures in stock reporting into one uniform system, with stock status reports conveying the same information from all the services. This took the greater part of the winter and spring of 1945. Manual 413–1 putting the program into effect did not appear until August 1945. In the meantime ASF planners, discovering that the quantities of stocks in depots often varied from recorded stock balances, turned their attention to improving inventory procedures. On this project Ordnance worked closely with ASF's Control Division in the preparation of a manual. The draft of the manual was test-checked in an Ordnance depot; in its final form, issued 15 May 1944, it incorporated Ordnance recommendations.[41]

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[38] Lecture, Lt Gen LeRoy Lutes, Army Supply Program, 23 Sep 46, ICAF.

[39] Contl Div, ASF, Report of Adequacy of Stock Accounting and Stock Reporting Procedures With Respect to Supply-Control and on the Feasibility of Standardizing Such Procedures, 29 Aug 44, p. 1–4, ASF Contl Div files.

[40] *Ibid.*, p. 6.

[41] (1) History, Control Division, Army Service Forces, 1942–45, app. (Compilation of Projects), pp. 171ff; (2) ASF Manual 413–1, Stock Accounting and Reporting Procedures, 31 Aug 45; (3) Memo, Maj Gen Clinton F. Robinson, Di-

The Supply Control program did not radically change Ordnance reporting and inventory procedures; such changes as were made came late in the war. During fiscal year 1945, ASF placed responsibility for control of supplies on the stock control point rather than the depot. But this emphasis on the stock control point as the key to the distribution system, "the most important development in the fiscal year in the stock control field," [42] was not new to Ordnance, which had already established six such organizations before February 1944.

Perhaps the most important effect of the ASF program on Ordnance Field Service operations was the establishment of lower stock levels for spare parts.[43] Early in 1944 ASF set depot maximum stock levels at ninety days. After the Normandy landings in June and the successes of the summer of 1944 the maximum level was reduced to sixty days. Manual 416 of November 1944 directed that stockpile quantities above this level would have to be reviewed and approved by the Commanding General of ASF. In late December combat losses in the Battle of the Bulge suddenly increased demands from the theater and threatened to reduce stocks to the danger point. There was not time to seek ASF approval for a cushion of stocks. General Campbell took the problem personally to General Somervell and obtained authority to put in a liberal factor for battle losses, a factor to be based on the Ordnance Department's own best judgment.[44] After the crisis was over, stockpiling was discontinued. In April 1945 ASF set at ninety days the normal stock level for parts and special tools for weapons, for fire control instruments, and for combat vehicles; and at sixty days, that for items needed in the civilian economy, including automotive and standard parts. After V–E Day, the narrowing of the war to the Pacific area focused the attention of Ordnance stock controllers on problems of redistribution and disposal.[45]

Redistribution and Disposal

Early attention to the disposal of unneeded Ordnance supplies was brought about by the shortage of critical matériel late in 1942 that also started the nationwide scrap-collection program. At that time the Ordnance Department directed depot commanders to scrap all matériel that had been declared obsolete by the Ordnance Committee and much other matériel that was no longer standard issue and was not being manufactured. Matériel that was surplus, carefully considered so in the light of depot requirements, possible future demands, and national needs, was to be moved out of distribution depots.[46] Later, the work of clearing obsolete and unauthorized items from stock became a continuing function of stock control points and master depots, and the reporting of excesses, for redistri-

rector ASF Contl Div, for Director of Supply, ASF, 2 Oct 44, sub: Depot Inventory Procedures; (3) Statement, Maj Gen LeRoy Lutes, Items for Discussion at Staff Conf, 24 Oct 44, sub: Inventories; (4) FS Ann Rpt FY 1945, p. 21.

[42] ASF Ann Rpt FY 1945, p. 240.

[43] Hist, OCO FS Stock Contl Div, III (1 Apr–30 Jun 44), p. 5 and IV (1 Oct–31 Dec 44), p. 26.

[44] PSP 63, sec. 5, pp. 4–5 and exs. 1–14.

[45] (1) *Ibid.*, exs. 15–25; (2) ASF Manual M413, 10 Apr 45; (3) ASF Ann Rpt FY 1945, p. 240; (4) FS Ann Rpt FY 1945, p. 23.

[46] Lt Col John A. Barclay, Chief Parts & Supplies Sec, Supply Br, T-AC, Disposition of Obsolescent Matériel, Transcript of Talks, Depot Comdrs' Conf, 13–14 Apr 43, pp. 40–41.

bution or disposal, an important factor in supply control. Stores reports were adjusted to reflect this information, and they helped to prevent unnecessary procurement.[47]

In the summer of 1944 floods of excess stocks began to inundate the depots. Fort Wayne Ordnance Depot, for example, which received in April 9,060 items weighing 110,404 pounds from 29 stations, by the following September was receiving 20,652 items weighing 1,240,364 pounds from 94 stations. These were only about 60 percent of the total items reported, as they did not include items extracted to master depots, unauthorized items reported to Detroit, or obsolete items reported to the Treasury Department.[48] Between 30 June 1944 and 30 June 1945 Army Service Forces made available for redistribution or disposal some $946 million worth of property; about 60 percent of it was Ordnance matériel.[49]

Control of excess stocks began with a "station excess stock account" kept in the depots on individual item cards showing nomenclature, unit, item stock number, and SNL group or manufacturer's code. The depots transmitted this information to stock control points on their stores reports under a special heading, Condition Code No. 4.[50] The stock control points, whose records showed the national stock position, then determined whether the item was truly excess. Thereafter, disposal action depended on whether the excess stock consisted of principal, or major items, for convenience called P items, or of secondary items—accessories, parts, supplies, tools and equipment—termed S items. The stock control point reported P items at once to Field Service's Matériel Control office, which declared them surplus, obtaining prior approval from ASF for items valued at more than $500,000. S items were circularized for thirty days to other Ordnance establishments, other War Department agencies, and the Navy; only those that were unneeded were reported in the Office of Matériel Control. After that office made the surplus declaration on P and S items, it issued disposition instructions to the stock control point concerned, which in turn instructed the depots.[51]

To set up a reporting system for excess stocks was not difficult, but to be reasonably sure that the figures were accurate was another matter. Errors in the amount and type of excess stocks began when troops departing for overseas turned in their equipment to the stations. Because of lack of time or lack of the technical knowledge required for identification, the turn-in figures were often inaccurate. Sometimes, rather than perform the necessary paper work, troop units abandoned their excess equipment, in one instance dumping it on a neighboring farm and in another throwing it into a lake.[52]

The problem of item identification appeared again at the stations and even in the depots, which often received items in mixed lots without tags, physical markings, or written records. Station classification as to serviceability was meaningless

[47] (1) Ltr, Col Ely to Col McMahon, 23 Jul 44, in Gen Campbell's Personal Correspondence; (2) ODO 98-44, 20 Jul 44; (3) ODO 107, Revision 2, 1 Oct 44, p. 10.

[48] Carl H. Mott, Chief of Inventory Contl Br. Disposition of Excess Property at Posts, Camps, and Stations, p. 3, in Min, Stock Contl Conf, Fort Wayne, 23–25 Oct 44, OHF.

[49] ASF Ann Rpt FY 1945, p. 246.

[50] (1) ODO 107 Revision 2, 1 Oct 44; (2) FS Order 122-44, 14 Oct 44.

[51] (1) Min, SC-Ord Supply and Maint Conf, 16–17 Feb 45, pp. 33–34, OHF; (2) ODO 32-45, 22 Mar 45.

[52] ASF Contl Div Rpt, Survey of Returns to Stock, Jan 45, pp. 4, 6–7, Contl Div files, OCMH.

when careless packing resulted in damage in transit. Big axle assemblies might be thrown in the same box with delicate gages. One package received at Red River Depot contained a shovel, a hydrometer, and a pressure gage; another was a jumble of instruments and old iron of all kinds.[53] To the problem of unidentifiable and damaged stocks the best solution seemed to be closer co-ordination between the depots and Service Commands. Ogden Arsenal found that sending out small, fast-moving Station Excess Stock Teams composed of a Service Command representative and two civilian experts from the Arsenal was effective.[54]

The orderly disposal of surplus stocks became increasingly important as the end of World War II came in sight. The board set up under the Surplus Property Act of 3 October 1944 made the Reconstruction Finance Corporation the disposal agency for industrial-type property and the Treasury that for consumer-type items, which represented about 90 percent of Service Command matériel.[55] As stocks began to pile up in Ordnance depots from posts, camps, and stations at a rate averaging twenty-one million pounds per month during Fiscal Year 1945,[56] the storage problem became extremely troublesome because the Treasury lacked space and manpower; the problem of locating, identifying, and reporting the individual items in this vast hoard, the first step in moving them out, was also serious. Ordnance's main disposal official, Col. Fred A. McMahon, stayed in close contact with the ASF Stock Control Division, but found that the great number of hazy and sometimes conflicting regulations from above made the task of reporting excess stocks extremely difficult.[57] By the summer of 1945 there were nearly one hundred separate War Department and ASF instructions dealing with the disposition of excess and surplus property.[58]

After the Ordnance Department complained that the directives were difficult to interpret and apply, the ASF Control Division surveyed the situation and recommended certain improvements in procedure. General Somervell appointed a working group that by the middle of August 1945 succeeded in consolidating the numerous instructions into four basic documents, including two manuals in which terms such as disposition, redistribution, transfer, and excess were carefully defined. Other results of the group's work were some degree of decentralization of disposal authority to depots and stations, better systems of reporting and circularization, and a general tightening of the ASF organization for property disposition. The fruits of these efforts would come after V–J day.[59]

Stock Control in Retrospect

More imaginative planning in the period between wars might have averted many of the mistakes in the wartime management of general supplies, especially spare parts. Caught unprepared by the flood of parts coming off the production lines in 1940, the Ordnance Department turned to the business world for advice, and, on the recommendation of an expert from in-

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[53] (1) *Ibid.*, p. 10; (2) Ord-SC Conf, 8–9 May 44, pp. 39–40.

[54] Min, SC–Ord Supply and Maint Conf, 16–17 Feb 45, p. 51.

[55] *Ibid.*, p. 39.

[56] FS Ann Rpt FY 1945, p. 20.

[57] Min, SC-Ord Supply and Maint Conf, 16–17 Feb 45, p. 35.

[58] History of Control Division, ASF 1942–45, app. (Compilation of Projects), sec. 158, ASF Contl Div files, OCMH.

[59] *Ibid.*

dustry, set up a new organization to control all parts. Sent to Detroit in the fall of 1942 when the Tank-Automotive Center was established there, the new parts unit suffered badly in the move, losing experienced employees and access to technical records that remained in Washington. Moreover, the new unit was burdened with a huge coding operation made necessary by the installation of IBM machines in the summer of 1941.

Electrical accounting machines were doubtless necessary to keep records current; but here again there was not adequate planning. Instead of adapting the IBM cards to military purposes, Ordnance set up a new system of parts identification to suit the machines. The change-over to the new item stock number lagged behind production and was swamped when more than one hundred thousand automotive items came into the Ordnance system in the summer of 1942. For this reason, and because of inability to keep up with the records at Detroit, the stock control machinery was on the verge of a breakdown by December 1942.

After replacing his Chief of Field Service, General Campbell reviewed Field Service operations with a committee of advisers from industry, and took several steps to improve supply. One was the appointment of a board to study parts numbering. Another was the removal from Detroit of stock control responsibility for weapons parts, fire control parts, tools, and other items of equipment, and the establishment of suboffices, or stock control points, for these types of matériel. But there still remained at Detroit the very large operation for tank-automotive items, and from the theaters in the crucial first months of 1944 came complaints of a shortage of vehicle spare parts. To speed up the flow from factory to port, the Chief of Ordnance, again consulting with industrial experts, set up master depots stocking everything needed for a certain make of vehicle such as Dodge. The master depot plan was helpful in some respects but conflicted with the new parts numbering system that had in the meantime been evolved by the Ordnance Numbering Board.

The assignment of a new number for every part, cross referencing to it all the old numbers that the item might have, was one of the major supply efforts of the Ordnance Department. The whole question of item identification in relation to stock control, including accurate and uniform nomenclature of all items, became increasingly important throughout the Army. Early in 1945 the President set in motion a program for preparing a uniform Federal catalog for supplies of all kinds.

The influence of Army Service Forces on the management of stocks was felt mainly at the level below the depots—in posts, camps, and stations, and in the establishment of stock levels. The ASF stock control manual for depots did not appear until August 1945; the ASF item-identification program, for a common language of supply for all technical services, was postponed until after the war. Generally speaking an Army-wide appreciation of the need for effective stock control and the amount of manpower it took to achieve it came too late in the war to be of much value.

Looking back over the experiences of World War II many Ordnance supply experts felt that Ordnance had placed too much reliance on civilians who were familiar only with commercial stock control and did not understand military procedure. Some felt a better solution to the

problem caused by Army inexperience in stock control would be the assignment of Army officers to commercial concerns for training in peacetime.[60] The success of the experiment in decentralization by commodity, the stock control points, lent weight to proponents of the product center concept, in which procurement, issue, storage, maintenance—and stock control—of both major items and spare parts would be located in one place, with one set of records.

[60] (1) Vorberg Rpt; (2) Memo, Maj W. L. Kelly to Chief Stock Contl Div FS OCO 8 Oct 45 sub: Final Report of Key Personnel, in FS Key Pers Rpts (hereafter cited as Kelly Rpt).

CHAPTER XXI

Ammunition Supply

The control of ammunition stocks presented peculiar problems because of strategic considerations and the nature of explosives. Ammunition was distributed more widely and at the same time was kept under tighter control than other supplies. The Ordnance Department supplied small arms ammunition, artillery shells, rockets, bombs, mines, grenades, pyrotechnics, propellent powders, and explosives not only to the Army but also to the Navy, Marine Corps, Coast Guard, other executive departments, states, and foreign governments. Most of the ammunition produced after Pearl Harbor was destined for shipment overseas, either to U.S. forces or lend-lease countries. Because of safety requirements, the first consideration was to get it from loading plants to ports as quickly as possible; the foremost problem in stock management was how to cut down the time in transit.[1] Because of the War Department policy of keeping tight control of ammunition, none could be shipped from Ordnance depots—other than interdepot transfers—without approval of the Secretary of War. Because War Department decisions on the quantities and types of ammunition to be shipped were based on the status of stocks in the depots, accurate and timely records were important.[2]

Means of Identification

For ammunition, item identification did not present the problem that it did in the case of spare parts. Soldiers and storekeepers could easily identify a round of ammunition by the color of its projectile, by the lettering on the packing container, or, where size permitted, on the item itself. Explosive bombs, artillery shells, grenades, and mines were painted olive drab, for camouflage purposes; chemical types were gray.[3] Against these neutral backgrounds, bands of color provided further identification as to filler. On olive drab, yellow meant high explosive, purple meant incendiary. On gray, green meant casualty gas, red meant harassing gas, and yellow meant smoke. Small arms cartridges

[1] (1) Brig Gen Harry R. Kutz and staff, The Mission and Operation of the Field Service Division, Ordnance Department, 27 Jan 43, pp. 19–27; (2) OCO FS, Ammo Supply Div, History of Ammunition Supply Division in World War II, 30 Sep 46 [hereafter cited as Hist, Ammo Supply Div], vol. XI, pt. 1, pp. 32–34, OHF; (3) Interv with Col Charles M. Steese, P&O Hist II, ex. 1.

[2] (1) Ltr, SW to CofOrd, 18 Dec 41, sub: Distribution of Ammo, AG 471 (12–15–41) Misc-D; (2) Ord Stock Contl Manual, Apr 43, p. 1, OHF.

[3] Explosive ammunition was painted yellow at the beginning of the war.



SOLDIERS LOOKING UP SNL NUMBERS
to order needed artillery parts, France, 1944.

did not require painting, but bullet tips were colored to denote certain types such as armor piercing (black) or incendiary (blue). The lettering on the packing container or the item always gave two essential pieces of information, the standard nomenclature and the lot number.[4]

The lot number was essential. It identified a quantity of complete items of one specific type of ammunition loaded and assembled by the same manufacturer under controlled conditions kept as uniform as possible. In firing some weapons, successive rounds had to be from the same lot to achieve maximum accuracy. For this reason all ammunition was stored, issued, inspected, tested, and accounted for by lot number. Assigned at the time of manufacture, it consisted of the manufacturer's initials and a series of digits differently arranged for each lot.

During the Sicilian campaign the Seventh Army complained to the Ordnance Department that certain calibers of its artillery ammunition were inaccurate. Investigation showed that lots had been indiscriminately mixed when the ammunition was issued to the firing batteries. The best solution was to have on hand the largest possible amount of one lot; the minimum asked by the overseas theaters was ten thousand rounds. Beginning in 1944 Field Service made strenuous efforts to increase the quantities of a single lot sent to one user and to obviate the possibility of mixed lots. By fall, ships arriving in ETO carried sizeable quantities of individual lots. But failure by the services and the combat arms to achieve complete lot integrity up to the firing line hampered ammunition supply throughout the war.[5]

In addition to lot number and nomenclature there were two other means of identifying ammunition, the Ammunition Identification Code (AIC), primarily for field use in reporting and requisitioning, and the item stock number, used in depot accounting in the United States. The AIC was an ingenious substitute for nomenclature. Ammunition had been identified by codes in an Ordnance field manual published about 1930, but the codes, assigned arbitrarily, were meaningless and were not widely used. Early in 1942 Col. Grosvenor F. Powell, an officer at Aberdeen Proving Ground, suggested the AIC, a code that really described the item. The first two characters indicated the SNL in which the

[4] TM 9-1900, 18 Jun 45, pp. 5-24.

[5] (1) Ammunition, Monograph No. 4, p. 66, OHF; (2) PSP 64, Ammunition Supply, June 1945, pp. 17, 69-72, OHF; (3) Hist, Ammo Supply Div, p. 71-74; (4) Roland G. Ruppenthal, *Logistical Support of the Armies*, vol. II, UNITED STATES ARMY IN WORLD WAR II (Washington, 1959), ch. V, pp. 57-61.

item was listed, such as T1; the third indicated the weapon in which it was used, or the general class, such as Grenades; the fourth, the type and model of the ammunition; and the fifth the method of packing. The AIC proved to be so useful, especially in messages transmitted by wire, that it was placed on SNL's and before the end of the war was employed on requisitions, shipping documents, property accountability records, and all other documents where the lengthy standard nomenclature was not definitely required.[6] SNL's were revised to include AIC symbols about 1 July 1942. At the same time, revisions were made to include item stock numbers similar to those used for general supplies. These numbers were made necessary by the decision to employ IBM machines to speed up the reporting of ammunition stocks.[7]

The Search for Better Methods of Reporting

Ammunition was exempted from the change-over to the IBM system of stores reporting made effective for general supplies in the spring of 1941. But it became clear early in the emergency period that the methods of reporting ammunition stocks needed improvement. The Supply Section of the Ammunition Supply Division was hampered by lack of current information from two sources, plants and depots.

With ammunition it was vitally important to know the status of shipments: the time of loading on cars at plants, the time the cars got in motion, and the time of arrival at depot, camp, or port. Before 1941, there was no effective procedure for obtaining this information. Plants reported the loading by telephone, then awaited instructions from Washington on routing and destination. Preparation of these instructions took time. The Supply Section had to find out what depot could handle the shipment and then obtain routing from the Quartermaster Freight Traffic Branch. At last the instructions went out, and then nothing more was heard in Washington. If the officials of the Supply Section wanted to find out what had become of the shipment—and they received constant requests for this information, particularly from ports—they had to make inquiries, often by telephone.

This clumsy procedure was streamlined in the summer of 1941 on the recommendation of two members of the Supply Section, Lt. Col. Samuel L. Smith and Mr. Arthur Hinchcliffe. Under the new system, prompt reports came in to Washington showing the status of shipment at every point. At the time of loading the plant sent to Washington a notice of availability, an Availship, followed by a report of transfer to Field Service and shipment, a Transrepship. The depot sent in a report of arrival, a Reparrive, and when the ammunition went forth again, to camp or port, a report of shipment, a Repship. Eventually plants and depots consolidated all transactions of this kind for a 24-hour period into a daily teletype.[8]

Stores reports showing the status of stocks in depots were carbon copies of

[6] (1) Hist, Ammo Supply Div, pp. 27–28 and ex. 8; (2) Memo, Lt Col Samuel L. Smith to Exec to Chief of FS, 28 May 45, sub: Final Rpt of Key Pers, FS Key Pers Rpts [hereafter cited as Smith Rpt]; (3) ODO 122–44, 17 Oct 44.

[7] (1) Hist, Ammo Supply Div, p. 28; (2) Chapter XX, above.

[8] (1) Smith Rpt; (2) Rpt of Maj. Richard T. Burroughs, Jr., 28 Jul 45, in FS Key Pers Rpts, OHF [hereafter cited as Burroughs Rpt].

stock records prepared on Elliott-Fisher machines. Monthly for active groups, quarterly for less active, and semiannually for the least active, the depots reported SNL ammunition groups P, R, S, and T to their respective group chiefs in the Supply Section. Each group chief maintained his own central stock record, wrote shipping orders, and, in a sense, operated as a distinct supply section.

In the summer of 1942 a survey by Lt. Col. Samuel Smith revealed that the procedures of the groups were not uniform and the workload was not evenly distributed. One commodity group, for example, the S group handling primarily bombs and pyrotechnics, might be overburdened with work at a time when another group was having a lull. In the reorganization that followed this survey, one central group was established to receive and consolidate all ammunition stores reports. The P, R, S and T groups were reduced in strength and relieved of all but technical supervision. The change from a commodity to a functional organization for stock control saved manpower. It was also one means of tightening stores reporting procedures.[9] Another way, considered even earlier, was a change-over to IBM machines.

IBM Machines for Ammunition Stores Reports

Soon after the installation of IBM machines for general supplies in 1941 the Ordnance Department decided to try them for ammunition also and shipped machines to several depots. But this early attempt was not very successful. The system had been designed principally to accommodate General Supply matériel. It was true that item code numbers were less of a problem for ammunition than for general supplies, for fewer changes would be encountered and there would be less difficulty in identification. But this advantage was more than offset by the fact that for ammunition the total stock on hand for any one item had to be broken down into various reserve balances such as special reserves for task forces, ammunition credits, and so on; these balances had in turn to be broken down into individual organizations, such as the corps area.[10] All this greatly complicated the reporting of stocks. Moreover, since the assistance of the IBM Corporation was directed mainly toward improving spare parts reporting, the Ammunition Supply Branch had no expert help with its greatly expanded ammunition stocks. As a result, the processing of stores reports took so much time that the central stock records were out-of-date and useless by the time they were available.

The first hope of improvement came in the spring of 1942 with the commissioning of an officer who had been with IBM in civil life, Lt. Richard T. Burroughs, Jr., and the loan of Mr. John Schick by IBM. These experts made a survey of machine operations both in the depots and in the central office and established better procedures. The new procedures were tried out at Portage Ordnance Depot and were then explained to representatives of all depots at a series of training courses at Portage from September 1942 to March 1943. The educational program was slowed down by the recall of Mr. Schick to active duty with the Adjutant General's Office shortly after the first course opened, but Major Burroughs took over the supervision

[9] Smith Rpt.

[10] (1) *Ibid.*; (2) Notes on Ammo Stock Control Procedure, in Manual—The Application of Electric Accounting Machines to War Department Supply Records.

of the whole program. By the summer of 1943 most of the depots had installed the machine system and satisfactory stores reports were coming in.[11] Then in September 1943 ASF directed the Chief of Ordnance to cut down on IBM equipment in depots. A survey had in some degree substantiated charges that the use of punch card machines had been carried to an impracticable and inefficient extreme throughout the War Department, and in 1943 a cut in the production schedules for tabulating equipment led to rationing by the War Production Board and stricter control by ASF.[12]

Faced with the order to cut down on the machines in the depots, General Campbell decided to apply it to ammunition rather than general supplies.[13] He returned the preparation of ammunition stores reports to the manual system, effective 1 December 1943. Forms were redesigned and distributed to the depots, and Major Burroughs had to begin another program of education, conducting a 3-day conference at Blue Grass for all Eastern depots and at Ogden for the Western. The manual system remained in effect in ammunition depots for the rest of the war, and, thanks to Major Burroughs' procedures, stores reports continued to come in satisfactorily.[14]

The next objective was to improve the consolidation of reports in Washington. The central stock records had been converted from manual to machine on 1 February 1943, but the Machine Subgroup had been placed too far down in the organization of the Stock Control (formerly Supply) Section's Inventory Control Unit.[15] The accuracy of the reports that came to it depended on an Analysis Subgroup that interpreted the documents before transmitting them; little or no use was made of stores reports. In December 1943 Major Burroughs, who had been placed in charge of the central IBM installation the summer before, brought about a reorganization of the Inventory Control Unit to bring into one group, the Records Group, all activities devoted to the production of current operating figures —the IBM Sub-group, the Analysis Subgroup, and a group auditing stores reports. The new organization soon found that it was hampered by inability to secure enough civilians to do the job, especially civilians who would work the night shift necessary to process the transactions of the day. The most promising solution was to move out of Washington.[16]

The Move to Philadelphia

The Chief of Ordnance decided to move the Records Group to Philadelphia, where

[11] (1) Burroughs Rpt; (2) Hist, Ammo Supply Div, pp. 21–23; (3) Manual, The Application of Electric Accounting Machines to War Department-Ordnance Department Stock Control Ammunition Items, Revised 10 Sep 42.

[12] (1) Burroughs Rpt; (2) Rpt, Methods Management Br, Contl Div, AGO, 19 Nov 42, sub: Study of Comments and Recommendations of Machine Records Contained in Final Report of Stevenson, Jordan and Harrison, Inc., 12 Nov 42, ASF Contl Div files, 413.51. (The study found that, if approved commitments for additional punch card machines were executed, ASF would be paying approximately 15 million dollars a year in rental); (3) Memo, CG ASF for Directors of All Staff Divs and Chiefs of Supply and Administrative Servs, 11 Mar 43, sub: Business Machines, ASF Contl Div files, 413.51; (4) ASF Contl Div Rpt 154, Mar 44, sub: Utilization of Machine Tabulating Equipment in the Ord Dept., ASF Contl Div files.

[13] (1) Interv with Sadtler, 4 May 53; (2) Final Rpt of Maj Robert E. Nutt, 24 Oct 45, FS Key Pers Rpts.

[14] (1) Burroughs Rpt; (2) History, Blue Grass Ordnance Depot, 1 Jul 43–31 Dec 43, OHF; (3) History, Ogden Arsenal, vol. V, 1 Oct Through 31 Dec 43, pp. 104–5, OHF; (4) Smith Rpt.

[15] PSP 64, ex. 4.

[16] (1) Burroughs Rpt; (2) Smith Rpt.

a field office of the Ammunition Supply Branch had been established late in 1942 to take care of war aid supply, records of resources, and records of surveillance and renovation.[17] To this organization, known as the Philadelphia Ammunition Supply Office (PASO), the new group was attached on 24 January 1944. Misgivings about separating current operating records from the daily operations in Washington were allayed by establishing twice-a-day courier service.[18]

The assignment of a detachment of thirty-three WAC's to operate the machines made possible a three-shift operation. Even so, progress toward producing accurate and current central records was slow. The WAC's were inexperienced and needed training. Time was lost during the move to Philadelphia. There was a heavy backlog of work, and not until March did the office receive from Washington the files it needed for reference purposes. Beginning in June there were a number of mechanical failures in the machines and even major breakdowns. Service by the IBM Corporation was poor until December 1944, when the appointment of a service manager for the Philadelphia area brought about improvement.[19]

An essential step toward more accurate figures on the amount of stock in all depots was the reconciliation of depot and central records, but this proved to be exceedingly difficult. The first efforts failed. In June 1944 a new chief scrapped all previous methods, overhauled organization and procedures, stepped up training, and achieved closer co-ordination with the depots and closer liaison within the office. The reconciliation project finally got under way but it was February 1945 before it was complete for all depots and all items.[20]

By that time, depot stock records for ammunition were lessening in importance. Late in 1943 the Ordnance Department had begun to ship ammunition directly from manufacturing plants to ports and training camps; by February 1945 about half of all ammunition shipments were bypassing the depots, and the trend was continuing.[21] The Records Group by the spring of 1945 was furnishing reports on the tonnage of ammunition moved by direct shipment, as well as an audit and follow-up on such movements, and keeping records on returns of ammunition from overseas, an increasingly important phase of its work. After V–J Day the Group was returned to Washington.[22]

At least one officer felt that the records and reports groups should henceforth remain in Washington. But the Records Group in Philadelphia had worked under heavy handicaps that were not all a matter of location. Frequent changes in required reports to ASF and other agencies for the purpose of control and requirements computation revealed the inadequacy of existing records from time to time. Whenever procedures for gathering and recording data were changed the new records resulting from the change were not reconcilable with previous records and reports. This trial-and-error approach was extremely

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[17] (1) ODO 361, 26 Nov 42; (2) ODO 17–44, 20 Jan 44.

[18] (1) Smith Rpt; (2) Maj Henry B. Davidson, Personal History, 8 Oct 45, FS Key Pers Rpts.

[19] Lt Francis E. Boesche, Rpt, 23 Jul 45, sub: Job History . . . , [hereafter referred to as Boesche Rpt], FS Key Pers Rpts.

[20] (1) *Ibid.;* (2) Lt Theodore Doll, Jr., Rpt, Job History . . . , [hereafter referred to as Doll Rpt], FS Key Pers Rpts; (3) Burroughs Rpt.

[21] (1) Maj Daniel J. Strauss, Personal Historical Rpt, 9 Feb 46, OHF; (2) Capt Joseph J. Calhoun, Rpt, 1 Aug 45 [hereafter referred to as Calhoun Rpt], OHF; (3) PSP 64, p. 13.

[22] (1) Boesche Rpt; (2) Doll Rpt.

costly in man-hours and provided records of dubious value. Co-ordination between Industrial and Field Service records had been faulty. The efforts of 1943 and 1944 had been largely devoted to correcting the mistakes of the past.[23]

Improvements in the Pattern of Distribution

In 1940 and early 1941, American strategists were thinking in terms of defense. All Ordnance depots stocked every type of ammunition that might be needed in the defense of a particular area. The depots received their stocks under the direction of the Supply Section's Groups, P, R, S, and T, handling each type of ammunition. Working independently, each group received reports of production on its own type of ammunition from manufacturing plants and found a depot to store it, without regard to instructions issued by other groups. As a result, some depots would become overstocked or would face a sudden, heavy workload with little notice. Depots were equipped for handling a certain amount of ammunition, expressed in carloads to be moved in and out each day. If a depot with a 25-carload-a-day capacity was assigned shipments which required its entire handling capacity, no additional shipment could be made to it without incurring demurrage charges.

After Pearl Harbor it became evident that prewar methods of stocking the depots would not work under wartime conditions. Closer co-ordination at the top was essential. Consequently, in the summer of 1942 when Groups P, R, S, and T were relieved of all but technical supervision, the Chief of Field Service created one central group to handle distribution. This gave better regulation of the flow into the depots and improved record-keeping.[24]

The second step toward improving distribution was even more important. It dealt with the flow out of the depots to the ultimate users. Ammunition was not subject to requisitioning in the ordinary sense, because it fell into the category of controlled items, under the Mobilization Regulations of 5 January 1940. The amount to be distributed to troops for training was decided upon monthly by the War Department General Staff, and the Ordnance Department simply directed a certain depot to make it available or credit it to a certain Corps Area or other specified user. Once credited, the ammunition was no longer reported under the heading of stocks available. These credited stocks were essentially the same as a deposit in a bank account; shipment to the user represented a withdrawal from the account. For lend-lease users, ammunition was also distributed on instructions from higher authority. When an allied nation submitted a request to the War Department, Ordnance determined which depot had the right ammunition in stock and earmarked the quantity desired for the lend-lease account. The depot was also instructed to honor the shipping instructions of the foreign government, to obtain a Quartermaster Release (QMR) and eventually to move the ammunition to the designated port of exit.[25]

The great defect in this system was that the depot where the stock was earmarked

[23] (1) Smith Rpt; (2) Davidson Rpt; (3) Burroughs Rpt; (4) Interv with Col Samuel L. Smith, 4 Aug 53.

[24] (1) PSP 64, pp. 2–4; (2) Hist, Ammo Supply Div, pp. 2–12.

[25] (1) Memo, Brig Gen Richard Moore, ACofS for CofS, 5 Jul 40, sub: Supply Under MR 4–1, G–4/31793; (2) Hist, Ammo Supply Div, pp. 89 and 246, and ex. 51; (3) PSP 64, pp. 43–44.

might be at a great distance from the place where the ammunition was eventually needed. Troops moved from training camps near the depot to camps far away. As for lend-lease distribution, Field Service's War Aid Section had no way of knowing what the port of exit would be. The matériel was reserved at whatever depot had unobligated stock. As a result, a West Coast depot might have to ship the ammunition to an East Coast port, or vice versa. A close check on shipping tickets by the War Aid Section in June 1942 revealed that crosshauls and backhauls were increasing along with increased production and increased assignments. For example, on 8 June one carload of 30-caliber armor-piercing cartridges was shipped from Raritan Arsenal, Metuchen, N.J., to San Francisco; one day later two carloads of the same item were shipped from Ogden, Utah, to Jersey City, N.J.[26]

Lend-Lease Shipments

Contributing to wasteful crosshauls and backhauls was a directive of April 1942 requiring lend-lease nations to ship all their matériel out of a depot within forty-five days after the date of its availability. Otherwise it would be returned to Ordnance stock. Very often shipment abroad was not possible within that period, as vessels were scarce. In that case the foreign government had the matériel shipped to another location in the United States, possibly across the continent from the probable port. Sometimes when a ship did become available, ammunition at a distant depot could not reach the port in time to meet the sailing deadline and had to be freighted back to storage. In one instance the cost of returning a carload of high explosives from Philadelphia to Letterkenny Ordnance Depot at Chambersburg, Pennsylvania, the nearest depot, and reshipping it later to the port was approximately one thousand dollars.[27]

One suggested solution to the problem of crosshauling was to request in advance from the foreign government agencies the name of the intended port. But the agencies were seldom able to comply with such requests. The shortage of ships made ports and sailing dates uncertain; lack of information from overseas headquarters made uncertain the name of the ultimate consignee. Another solution was to arrange with the Traffic Control Branch of the Transportation Corps to notify Ordnance when it received releases from War Aid nations from depots at a distance from the port to which the ammunition was to be shipped. Upon notification, Field Service's War Aid Section could find out whether a depot nearer the port had the matériel, and, if so, could cancel the shipping order at the original depot and set up new obligations. This procedure eliminated some crosshauls, but it was cumbersome; it required a tremendous amount of paper work and many long-distance calls to depots and foreign agencies.[28]

In the end, the best answer to the problem was a system evolved in the War Aid Section in the summer of 1942. This plan, suggested by Lt. Leon M. Leathers, Jr., Chief of the Supply Unit, was simple. It consisted essentially in not earmarking stocks. After the War Aid Section received

[26] (1) PSP 64, pp. 44–45; (2) Hist, Ammo Supply Div, pp. 246–47.

[27] (1) Hist, Ammo Supply Div, p. 252; (2) PSP 64, p. 59.

[28] (1) PSP 64, p. 49; (2) Kenneth W. Stillman, "Ammunition Credit System," *The Ordnance Digest,* XXVII No. 10 (October 1945), p. 12.

authority for release of materiel to a foreign government, it issued a credit to that government against U.S. stocks, without specifying any particular depot. Then, when the government in question received shipping instructions, it notified the Ordnance Department, giving the port of export and the date when the matériel should arrive there. After that, the War Aid Section requested the Supply Section to convert the credit to physical stock at the Ordnance depot nearest the port of exit.

Notwithstanding its simplicity and feasibility the plan was not adopted until the spring of 1943. A survey had to be made showing the wastefulness of the old scheme of distribution, and numerous agencies outside Ordnance had to be consulted, including lend-lease nations, Army Service Forces, Transportation Corps, and the War Shipping Administrator. One obstacle in the way was a War Shipping Administration directive stating that the point of origin had to be known before a shipping number could be assigned; another was opposition from one member each of the British Purchasing Commission and the British Ministry of War Transport. But the Chief of Ordnance was eventually able to get the directive amended. In general the British were enthusiastic about the plan, as were the officials of the ASF International Division and the International Branch of the Transportation Corps.

In January 1943 a War Department circular placing responsibility for avoiding crosshauls and unnecessary movement on the procuring services gave impetus and authority for implementation, buttressed by directives from ASF early in 1943 to conserve manpower and transportation. In the meantime, Ordnance had established the Philadelphia Ammunition Supply Office to handle the distribution of greatly increasing lend-lease matériel, expected to amount to one hundred thousand tons per month; and the Chief of Transportation assigned a liaison officer to PASO at the request of General Campbell. The credit system for War Aid shipment of standard items was placed in effect in May 1943. The first shipment under it occurred on 15 May. In the first few months of operation there was a reduction of 49.5 percent in mileage over the old method, representing a tremendous saving in time, facilities, labor, communications, and storage. The British reported "great benefit," and the Transportation Corps noted that the system might well be applied to other technical services. It was so successful that it was extended that fall to nonstandard items, bulk explosives, and chemicals.[29]

Training Ammunition

Not long after the new system was suggested for War Aid ammunition, attention was given to the problem of efficient routing of shipments to U.S. troops. The impetus came from Capt. Hollis M. Carlisle, an officer whose entire civilian experience had been in merchandise distribution and stock control, first with Montgomery Ward and later with the Carlisle Hardware Company. Assigned to the Shipping Section's Distribution Unit in December 1942, Captain Carlisle turned a fresh and critical eye on established procedures. He found them based on an outmoded system of strategic distribution developed at a time when ammunition was in extremely short supply. Every week each producing plant submitted a report

[29] (1) WD Cir 12, 7 Jan 43; (2) PSP 64, exs. 55–58, 61–62, 75, 79–85.

to the Ammunition Supply Branch showing the number of carloads to be expected the following week. The Supply Section then determined the distribution according to three factors. First was the most desirable strategic location of stocks—roughly 65 percent in eastern depots, 12 percent in central, and 23 percent in western. The second factor was the current status of each depot's handling capacity, reported weekly by the Depot and Facilities Section. The third consisted of the maximum and minimum levels of each type of ammunition prescribed by each depot. Within the restrictions imposed by these three factors, the Distribution Unit tried to avoid crosshauling and backhauling by sending the ammunition to the nearest depot or to one on a straight line between the plant and the ultimate user.[30]

But the restrictions made efficient routing all but impossible. An investigation by Captain Carlisle of all shipments from plants to depots and from depots to using services during January, February, and March of 1943 uncovered some striking examples of crosshauling and backhauling. For example, 2,000-pound bombs produced at Ravenna, Ohio, were shipped to a depot at Anniston, Alabama, and reshipped to the New York Port of Embarkation; 1,000-pound bombs produced at McGregor, Texas, were shipped to Seneca, N.Y., and then to the Charleston Port of Embarkation.[31]

An analysis of these findings and of maps showing the unnecessarily long distances traveled by ammunition items resulted in a new conception of the depot. It was no longer thought of as a complete supply source for all types of items regardless of their probable ultimate destination but rather as a stopover point in transit to the user. Unlike earlier years, 1943 brought a steady flow of ammunition from the plants every week. To cope with it, Ordnance drew up a revised distribution plan in March. All depots east of the Mississippi River were to be considered as a common supply source for all East Coast ports; all those west of the river would supply West Coast ports. As for training ammunition, estimated requirements in the immediate area would govern allocations to depots.[32]

Plans for speeding the flow of training ammunition were discussed during the spring of 1943 by Ordnance officials with representatives of Army Ground Forces, Army Service Forces, Army Air Forces, and the War Department General Staff. By June 1943 they reached an agreement and established a system similar to that applied in May to War Aid ammunition. Matériel was not earmarked at any one depot but each station submitted its requisition to the Chief of Ordnance, and the Ammunition Supply Branch directed shipment from the nearest depot or loading plant. In September the practice was applied to ever-increasing amounts of ammunition going to U.S. troops overseas.[33]

In the meantime, the Distribution Unit was making a critical examination of its

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[30] (1) Memo, Chief Supply Sec for Exec Asst FS, 5 Feb 43, sub: Cross Haul in Ammo Movements, ex. 28 of Hist, Ammo Supply Div: (2) Maj Hollis M. Carlisle, Terminal Report, 9 Oct 45, FS Key Pers Rpts, OHF [hereafter cited as Carlisle Rpt]; (3) Smith Rpt.

[31] Memo, Chief Supply Sec to Maj. Edgar Tiner, Captain Mullikin, and Capt. Frank Eccles, 2 Mar 43, sub: Analytical Study, ex. 29 of Hist, Ammo Supply Div.

[32] (1) Carlisle Rpt; (2) Ltr, Chief of FS to CO's All Ord Ammo Depots, sub: Plan of Ammo Distribution and Supply, 5 Apr 43, OO 471/1904 -31.

[33] (1) Smith Rpt; (2) Hist, Ammo Supply Div, pp. 78–102; (3) PSP 64, pp. 7–8.

method of distributing ammunition allocated by the Munitions Board to the Navy. The journey to the user seemed long and wasteful. In May 1943 a striking instance was uncovered in which a plant at Carbondale, Illinois, shipped a consignment of 500-pound bombs to the Ordnance depot at Tooele, Utah, which in turn shipped them to a Navy depot at Hawthorne, Nevada. There was no real reason for the stopover at the Army depot. The explanation that it simplified bookkeeping hardly justified the cost in time, manpower, and money. If the ammunition had been shipped directly from the plant to the Navy depot, $1,506 per car would have been saved in transportation cost and the Navy would also have been able to take advantage of the cheaper storage-in-transit through rate to the West Coast.[34] Convinced by figures such as these that the Army depot ought to be eliminated from the routing, the Distribution Unit very soon began shipping Navy ammunition directly from producing plants to Navy depots.[35]

Direct Shipments

The policy of making all possible shipments directly from the loading plant to the ultimate consignee promised to yield great savings in transportation cost and the expense of rehandling at depots. But it was not to be put into effect until the new program of issuing to the user an over-all obligation against stocks rather than a credit at a specified depot gave the Ammunition Supply Branch better control over shipments. Nor could the maximum number of direct shipments be made until closer co-ordination was achieved within the Branch. In August 1943 the Shipping and Issue Sections were combined under Maj. Stanley E. Mulliken and control of all shipments was placed under Captain Carlisle.[36]

During September 1943, 511 carloads of training ammunition were shipped directly from manufacturing plants to posts, camps, and stations; during October the figure rose to 671. Exact savings in dollars and man-hours were difficult to calculate, but a rough estimate indicated that over 100,000 man-hours were saved in September by eliminating the necessity to load and unload cars at depots, not taking into account the labor that would have been required to restencil or mark boxes, place dunnage in cars, and fill out papers. Another important economy was in the use of railroad rolling stock—estimated for September at approximately 3,066 car days and for October at 4,026 car days. Still further savings in crating material and labor were achieved by shipping uncrated ammunition directly from a plant to a post. In one instance the elimination of the crating operation saved approximately $70,000 on a single shipment of forty-five carloads of 105-mm. ammunition. In addition to the conservation of materials, manpower, and equipment, the new system speeded up operations; ammunition was made available in time to provide

[34] In November 1942 Ordnance and the Transportation Corps had made arrangements with the Association of American Railroads for storage-in-transit privileges. A shipment from a loading plant in Ohio, for example, could go to a depot in Pennsylvania and later to the New York Port of Embarkation at the same rate that would have been charged if the shipment had gone directly from the plant to the port. Hist, Ammo Supply Div, p. 66.

[35] PSP 64, p. 6.

[36] (1) Hist, Ammo Supply Div, p. 90; (2) Carlisle Rpt.

maximum training for troops before they moved out to combat theaters.[37]

Bypassing the depot was even more desirable in the case of ammunition destined for American troops overseas than it was for ammunition sent to training camps or the Navy, because speed in overseas shipments was of greater importance. No great harm was done if a shipment was a little late in arriving at a training camp or Navy depot; if it failed to make a port deadline it had to be shipped back at great expense and, far worse, was lost to the men who needed it most. But the time factor made port shipments more difficult. Shipping directly from plants to ports required not only tight control by the Ammunition Supply Branch but also close co-ordination among all agencies.

A new procedure set up in September 1943 made tighter control possible. Port-bound stocks were no longer obligated at any one depot but were shipped, on orders from Washington, from the depot nearest the port. Conferences with the Transportation Corps in the fall of 1943 resulted in better co-ordination. Agreements were made to cut down the number of days in the acceptance period at the port and to center responsibility more definitely on Transportation's Traffic Control Division. The Ordnance Department would now deal directly with that Division, rather than go through the subordinate Ocean Traffic Branch. Responsibilities were in general more clearly defined. The Chief of Ordnance was responsible for giving early information to the Traffic Control Division as to availability of items; the Traffic Control Division was responsible for determining the deadline date from the Port of Embarkation and for arranging transportation in such a way that the items arrived on time.[38]

At the same time, General Campbell began a program of educating the Industrial Service and loading plants in handling Field Service orders on a direct basis. Instructions went by telephone to the man at each plant who was responsible for routing the ammunition as it came off the production line. As the program got under way, plants were ordered to ship speedily, in the exact quantities specified, giving first priority to shipments to Ports of Embarkation, and to furnish the Chief of Ordnance with complete and accurate information. Major Carlisle's assistant, Capt. Joseph J. Calhoun, kept current records on daily production schedules, running times between plants and ports, holding capacities of plants, and so on. When he received a port clearance from the Transportation Corps on a Notice of Availability, he went through it and obligated all items possible on producing plants. The records on which he based his decisions were obtained by close liaison with the producing plants as well as the Transportation Corps and Industrial Service. He found at the producing plants an excellent spirit of co-operation. An important by-product of the new system was a boost to the morale of the workers when they saw their ammunition stenciled with an overseas marking and loaded into cars consigned to a port of embarkation. Of all ammunition shipped from plants between January 1944 and February 1945 the percentage shipped directly to users rose from 28.6 to 50.12. Direct port shipments climbed steadily,

[37] Ltr, CofOrd to ACofS G–4, 23 Nov 43, sub: Distribution of Ammo for Training, and Indorsements, OO 471/33664.

[38] (1) Ltr, CofOrd to Chief of Transportation, 23 Nov 43, sub: Port-Bound Ammo Shipments, and Indorsement, 7 Dec 43, OO 400.37/4145; (2) Calhoun Rpt; (3) Hist, Ammo Supply Div, pp. 83–85.

until by June 1945, 62.5 percent of all ammunition arriving at ports came directly from plants.[39]

From 1 August 1943 to 21 July 1945, 107,517 cars of ammunition were shipped directly to the consignee, at an estimated saving in car dunnage and transportation alone of $1,000 a car, or $107,517,000. Nor was this the only saving. Ordnance stock controllers estimated that, if all the ammunition shipped directly at the peak of operations had been placed in storage en route, it would have required at least twelve additional depots of the capacity of Wingate, which cost approximately three million dollars a year to operate, to say nothing of the cost of construction. Of incalculable value logistically was the economy in time, figured at ten days travel time per carload. In the fall of 1944 and spring of 1945, this saving was an important factor in theater planning in combat areas.[40]

Control of Excess Stocks in the Zone of Interior

As effective as the new system was in preventing long hauls between depots, training camps, and ports, it could not solve the problem of controlling excess stocks at posts, camps, and stations, a problem that assumed ever greater importance as troops began to move overseas. Returning stocks to the depots without adequate supervision from Washington could conceivably result in unnecessary crosshauls and backhauls, the type of waste that stock controllers had been trying to avoid. An especially troublesome aspect of the problem was the improper handling of odd lots of ammunition left behind by departing troops; there was also danger in allowing ammunition to pile up at camps that lacked adequate storage facilities. One way to prevent waste and to economize on storage was to provide better control of issues by the Office, Chief of Ordnance, so that no more ammunition was shipped to the station than could be used. Another was to be sure, by careful co-ordination with Ground Forces, that the ammunition was truly excess and was not needed by any neighboring installation.

With both objectives in mind, two Ordnance stock controllers, Lt. Col. Samuel L. Smith and Maj. Joseph Rollins, after consultation with representatives of the using arms and ASF, proposed a change in the method of issuing training ammunition. All forces would present their demands to the Post Ordnance Officer with the deadline date at which they had to have ammunition for their training programs. The Post Ordnance Officer would report every month to his area depot the amount of ammunition he had on hand, the issues for the last thirty days, and the amount he wanted shipped. He would furnish the desired time for arrival of the ammunition at the post and the rate at which he would be able to handle and store it. The area depot, reviewing the report, would have authority to ship directly from its stock all less-than-carload amounts and all items for which there was an urgent need. The report would then be forwarded to the Office, Chief of Ordnance, for supply of the larger quantities, which would be scheduled for ship-

[39] (1) Calhoun Rpt; (2) Carlisle Rpt; (3) Ltr, CofOrd to FDAP, 5 Oct 43, sub: Direct Shipments from Loading Plants, ex. 30, Hist, Ammo Supply Div.

[40] (1) Calhoun Rpt; (2) Smith Rpt; (3) Carlisle Rpt.

ment directly from loading plants whenever possible.[41]

Presented to G–4 early in 1944, the plan ran into serious objections from officers of the Army Ground Forces, who felt that it gave too much authority to the Post Ordnance Officer. By giving him control over station stocks of ammunition the plan would in effect give him control of training. The AGF counterproposal was to continue the system by which the Ground Forces commander ordered what he considered necessary, within the limits of the local storage and transportation capacity reported to him by the Ordnance and Transportation Officers.[42]

One basic difficulty in this system, admitted by AGF, was that the post authorities were allowed to keep ammunition for as long as ninety days before they determined whether or not they had an excess. The period was too long, and when excesses were finally reported to Ground Forces headquarters, the excess stocks might be shifted around to various commands for months. Meantime, troops were moving out of the camps continuously, often unexpectedly. Ammunition piled up, and the post authorities had no control over shipments coming in. By 1945, magazine areas were becoming dangerously overloaded.

An investigation by the Joint Army and Navy Storage Board made it plain that some action would have to be taken. Accordingly, an AGF representative met with representatives of the Ordnance Ammunition Supply Division and agreed upon a plan that was similar to the one Ordnance had proposed before, except that the Service Command rather than the Post Ordnance Officer would control excess stocks. At a later date ASF insisted that the job be given to the area depot rather than to the Service Command. As finally worked out, the plan provided that all requisitions would be channeled through the depot. They would be prepared on the tenth of each month for the requirements beginning the first of the next month. When the second month's requisition came in, any stocks that had not been used in the first 30-day period would apply against the ammunition required for the second 30-day period. At the end of sixty days, area depot officers were authorized to move excesses back to the depot. To the more important depots would be assigned two officers who would travel from post to post, assisting the Post Ordnance Officer to remove excesses or to plan for additional storage if necessary. They were like the "excess stock teams" used for general supplies.[43]

Under the constant supervision of Major Rollins the plan was tested at Red River Ordnance Depot, Texarkana, Texas. Two months after it went into effect, a check of station ammunition stocks indicated that they had been reduced by 46 percent. But AGF felt that the new procedures placed too great a restriction on the flexibility of its credits, and a compromise plan, proposed in July, was under consideration as the war ended.[44]

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[41] (1) Min, Conf of SC Ord Officers, 28 and 29 Jan 44, pp. 2–4; (2) Min, Ord-SC Conf, 8–9 May 44, pp. 1–2.

[42] Min, Ord-SC Supply and Maint Conf 16–17 Feb 45, p. 11, OHF.

[43] (1) Ltr, JANASB to SW and SecNav, 4 Oct 44, sub: Inspection of AGF Installations, 471 JANASB vol. II, G–4 files; (2) Ltr, Col William M. Cobb to JANASB 1 Nov 44, sub: Inspection of Ammo Storage at GF Stations, 471 JANASB, vol. III, G–4 files; (3) Ltr, CofOrd to CG ASF, 25 Jan 45, sub: Plan for Distribution of Training Ammo, and Indorsement, 30 Jan 45, OO 471/38578.

[44] (1) Ltr, CofOrd to CG ASF, 23 Feb 45, sub: Plan for Distribution of Training Ammo, and Indorsement 27 Feb 45, OO 471/38884; (2)

Long after V–J Day, training ammunition was still being issued on the wartime system of monthly credits based on allocations to the various services. Ordnance supply experts believed that the best plan for an orderly change-over to peacetime operation was a revision of AR 775–10 of 30 December 1943, which authorized the kind and amount of firing required for training. They recommended that for all services ammunition be issued on an allowance basis and that expenditure guides for each service, similar to those used by AGF beginning in 1944, be included in the program.[45]

Return of Excess Stocks from Theaters

A growing problem after 1943 was the safe and orderly return of excess stocks from overseas theaters. Such shipments had to be cleared with ASF for ground ammunition and AAF for air ammunition. With a few exceptions, War Department policy was to return only serviceable ammunition that was definitely known to be safe for shipping and handling. The quantities were enormous. Early in August 1944 when both ETOUSA and NATOUSA expressed a desire to return excesses there was an estimated total of 1,737,000 tons in both theaters, including an overage of fifty days of supply. Out of this amount there were available for distribution 1,570,000 tons, of which 1,085,000, ground and air, would go to other theaters. This left for return to the United States 485,000 tons, all of it ground ammunition.[46]

The first step was to select the lots of ammunition that would be retained in the theater, those that would be transferred to other theaters, and those that would be returned to the United States. Over this step the Ordnance Department had no real control, because it was the policy of G–4, General Staff, to permit overseas theaters to return any lots of ammunition they desired. But Ordnance could offer advice and guidance. Field Service prepared lists of all lots that had been shipped to ETOUSA and to NATOUSA, reviewed them carefully in co-operation with Industrial Service, and arranged the individual lots by caliber and type in the order of frequency of issue. These lists were sent to the two theaters to serve as a guide in the retention, transfer, or return of ammunition. Ordnance also offered technical assistance on the problem of safe and efficient handling of excess stocks. It urged G–4 to reconsider its policy of not requiring theaters to destroy unserviceable ammunition locally, and emphasized War Department regulations on the segregation, packing, marking, and safe storage of explosives and incendiary materials in outgoing shipments.[47]

Planning for the reception of excess stocks in the United States began early in 1944 on a directive from ASF stating

Ltr, CofOrd to CG ASF, 2 Jun 45, sub: Plan for Distribution of Training Ammo, and Indorsement 7 Jun 43, OO 471/40021; (3) Memo, Col William C. Young to Chief, Staff Rqmts Sec Admin Br Fld Serv OCO 7 Jan 46 with inclosures, final report of Maj Joseph Rollins Stock Control Branch Ammunition Supply Division Field Service for Tour of Duty, 15 July 1942 Through 3 January 1946, in Fld Serv Key Pers Rpts (hereafter cited as Rollins Rpt); (4) Smith Rpt; (5) History of Red River Ordnance Depot, vol. IV sec. I (1 Jan–31 Mar 45) pp. 386, 390–91; (6) WD Cir 269, 7 Sep 45.

[45] (1) Rollins Rpt; (2) Maj Daniel J. Strauss. Supplement to Historical Report. . . . 1 Jul 45 to 10 Feb 46, FS Key Pers Rpts.

[46] Hist, Ammo Supply Div, ex. 65.

[47] Hist, Ammo Supply Div, pp. 103–08 and ex. 65.

that ports should be used that were not actively engaged in handling outgoing shipments. Ordnance recommended Curtis Bay, near Baltimore; Nansemond, at Hampton Roads; San Jacinto, Texas; Boston; Charleston; New Orleans; Benicia, near San Francisco; Seattle; and Beaver Site at Portland, Oregon. But the Joint Working Committee Concerning Return of U.S. Army and U.S. Navy Ammunition From Overseas, appointed in June 1944, determined that the Navy would provide facilities and sorting service at or near ports on the West Coast and that the Army would handle East Coast terminals. The Army was to enlarge Nansemond and use Charleston for current and continued receipts and Curtis Bay when outgoing shipments stopped or decreased materially.[48]

From the ports, ammunition would be sent to loading plants for screening. This process would include segregating by caliber, type, and lot, and necessary renovation to make sure that only the highest quality ammunition was kept for long-term storage as War Reserve. The final step was storage in depots. As of August 1944, igloos and magazines in the United States were only two-thirds filled and could accommodate more than a million tons of returned stocks. An expected cutback in the current production of 600,000 tons per month would increase the amount of storage available.[49]

Beginning in the summer of 1944 the Ordnance Department worked out several ways of controlling the flood of stocks that was expected after the war was over in Europe. The Ammunition Supply Division established a system of identification markings for ammunition shipments. Stock controllers also contrived a system of facilitating shipments from port to plant or depot by using a single shipping order number. They devised this number by assigning a series to each port and combining it with the code number already assigned to each plant and depot. A shipment from New York, series 600, to Milan Ordnance Depot, number 25, would be coded 625.

Co-ordination between port and depot was furthered by a meeting in Washington in November 1944 of Port Ordnance Officers with representatives of the depots. Port Ordnance Officers were instructed to obtain shipping instructions from the Ammunition Supply Division and after shipment to mail a copy of the shipping order to the Philadelphia Ammunition Supply Office for record purposes. At PASO a Returned Ammunition Unit of two persons was established to keep records, and the establishment of a purpose code permitted analysis of returns from individual theaters and the reason for the return.[50] In general the ports were co-operative in obtaining shipping instructions from the Ordnance Department, though there were some cases of carelessness in reporting shipments, as well as some instances of improper identification and segregation. One Ordnance stock controller felt that segregation centers adjacent to ports would have saved considerable money in transportation and handling at both ports and depots.[51]

The effectiveness of the Ordnance Department's ammunition supply operations depended on two factors: knowing where the stocks were and what their condition was, and being able to deliver them to the right place at the right time. The main objectives were to meet deadlines for de-

[48] *Ibid.*
[49] Hist, Ammo Supply Div, ex. 65.
[50] (1) Rollins Rpt; (2) Strauss Rpt.
[51] Burroughs Rpt.

livery and to maintain an accurate record of all items received from production. In the opinion of Col. William C. Young, Chief of the Ammunition Supply Division from June 1942 to August 1946, the first objective was well met; the second was only partially met. The reasons for the failure to achieve completely accurate records were many. Some errors crept into accounting when ammunition had to be returned to production plants for reworking; others were caused by changes in procedures for gathering and recording data, faulty co-ordination between Industrial Service and Field Service, and lack of enough personnel for the necessary paper work. Complete adjustment of records was never possible. Yet partial reconciliation was achieved. By reducing the number of crosshauls and backhauls, and by developing effective techniques for making shipments directly from plants to ports, Ordnance ammunition supply experts contributed notably to the war effort.[52]

[52] (1) Final Rpt of Col William C. Young, 20 Aug 46, FS Key Pers Rpts; (2) PSP 64, exs. 79–84.

CHAPTER XXII

Maintenance

In the hot sun of a September day in 1921 the people of Columbia, South Carolina, witnessed the beginning of an interesting experiment in Army mechanization and mobility. The 51st Artillery Regiment (heavy) was setting out on a march from neighboring Camp Jackson to Camp Eustis, Virginia, six hundred miles away, the first long journey overland ever made by a heavy motorized artillery regiment under its own power.

The convoy was an impressive spectacle. Rumbling and clanking through the streets of Columbia were sixteen pieces of heavy ordnance: eight 8-inch howitzers and eight 155-mm. GPF (*Grande Puissance Filloux*) guns, each towed by a 10-ton tractor. There were twenty-one additional tractors—more than half of them 10-ton types—and 240 trucks carrying tentage, equipment of all kinds, machinery for repair work, and spare parts. Accompanying the artillerists was a detachment of Engineers to repair roads and bridges and an Ordnance company to keep the guns, howitzers, tractors, and trucks in running order. As the great procession ponderously moved north on the long journey, much of it over narrow dirt roads in a cloud of dust, farmers along the way stared and wondered. Some thought another war had broken out. Most of them had never before seen guns of such size or troops of the Regular Army.

At night, when the regiment halted near a small town, country people would gather around the Ordnance shop, attracted by the blaze of light and whir of machinery. In the middle of a cleared field stood an artillery repair truck—itself a complete machine shop—and from its generator electric lights on extension cords ran to each job. Near it were parked some of the thirteen Ordnance trucks in the convoy, containing tentage and baggage for the company, blacksmith's tools, light tools for truck repair, chain blocks and ropes, and spare parts. For the latter there was also a huge stock-bin trailer drawn by a 10-ton tractor. The spectators—marveling at a machine shop on wheels, a soldier working at an anvil, another skillfully using an acetylene torch—saw tractors with the whole transmission out or with the armor removed and engine totally dismantled. They freely expressed doubt that the regiment would be able to reach Camp Eustis before Christmas.

Exactly one month and ten days after leaving Camp Jackson the convoy rolled into Camp Eustis, on the afternoon of 22 October 1921, with all wheels turning, and all vehicles still in the line of march, not one having been abandoned. The Ordnance Department's maintenance experts in Washington, who had followed the progress of the march with even more interest than the farmers, were extremely



CONVOY OF ORDNANCE MAINTENANCE TRUCKS *on maneuvers shortly after World War I.*

gratified. The march had been in a sense a test of the ability of Field Service—an organization then less than three years old—to serve the using arms; and its successful conclusion had vindicated maintenance planning that had begun in World War I.[1]

Mobile repair shops, first improvised on the Mexican border in 1916, had been used by the AEF, but in France only the Field Artillery brigade had rated an Ordnance company. The Infantry depended on the small arms section of that company and, for first aid repairs, on small detachments of three or four men that were often called on to perform duties other than their specialty. In one case Ordnance men washed the trucks of the ammunition train because the train commander ordered them to do so.[2]

The first thoughtful organization of Ordnance maintenance specialists, trained and supplied by the Ordnance Department, came into being as a result of study by the board of officers appointed by the chief Ordnance officer of the AEF, Brig. Gen. John Rice, in France immediately after World War I.[3] In addition to fixed base shops in the rear of the army in the field, the planners envisaged two types of maintenance companies, the light maintenance company to accompany the division, and the heavy maintenance company at corps and army level. These performed to the limit of the capability of their equipment and the amount of time available all field repair that the individual infantryman or truck-driver could not do for

[1] Capt. James A. B. Gibson, CO 32nd Ordnance Company, "Ordnance Maintenance En Route," *Army Ordnance*, II, No. 11 (March–April 1922), 266–69.

[2] Interv, Crain, 17 Feb 54.

[3] See Ch. XVI, above.

himself.[4] The companies were placed directly under the commanding officer of the line organization. Also under the command of the line was the Ordnance officer attached to the staff of the camp, division, corps, and army commander. He exercised technical supervision over the maintenance troops, was the adviser on Ordnance matters to his commander, and in general was responsible for efficient Ordnance operations in the field.[5]

The maintenance responsibility of the Ordnance Department had two aspects. Maintenance engineering, closely allied with design and production, meant the analysis of new design with an eye to maintenance, the preparation of Modification Work Orders (MWO's) for the correction of defects, the determination of requirements for parts, tools, and equipment, the preparation of publications, and various kinds of planning. Maintenance operations meant technical help to the shops and troops that were under the command of the using arms, and the operation of arsenals and base shops under the direct orders of the Chief of Ordnance.[6]

Maintenance at the Arsenals

Following World War I, there had to be a general overhaul of the Ordnance matériel returned from France, about 75 percent of which was in such bad condition that it could not be issued to troops. This work was done at the arsenals. Rock Island Arsenal, for example, performed an enormous amount of work on artillery matériel, tanks, and tractors, with assistance from special shops organized at Camp Meade, Savanna Proving Ground, and Erie Proving Ground.[7] In 1924 the Ordnance Department spent $309,655 for maintaining in storage matériel worth about $500 million, exclusive of ammunition, a figure comparable to the $471,355 spent on matériel in the hands of troops. The life in storage of many weapons was almost unlimited.[8]

A continual arsenal task was modification of equipment. On the march from Camp Jackson to Camp Eustis in 1921 the Ordnance troops kept a detailed list of all classes of repairs made to tractors and other motor vehicles and submitted it to the Ordnance Maintenance Division in Washington. From such a list Ordnance engineers could tell which parts of the mechanism gave trouble, and often were able to correct malfunctions by a change in design. In that case, Field Service prepared Modification Work Orders that applied to all matériel of that particular kind. Experience in the field was also useful in preparing spare parts data. Tables showing parts consumption on a mileage basis were invaluable in estimating the

[4] (1) Harmon, "Ordnance Maintenance," *Army Ordnance,* I, No. 4 (January–March 1921), 167–73; (2) C. A. Schimelfenig, "Ordnance Service Stations," *Army Ordnance,* II, No. 11 (March–April 1922), 260–62.

[5] (1) *Manual of 1919,* pp. 14–31; (2) Fred A. McMahon, "Maintenance Activities at Camp Bragg," *Army Ordnance,* II, No. 11 (March–April 1922), 273–74; (3) Maj. Harry R. Kutz, "Corps Area and Department Ordnance Officers," *Army Ordnance,* II, No. 11 (March–April 1922), 279–84.

[6] History of the Maintenance Division, OCO–D, 1942–45, exs. to General History—Plan for the Rearrangement of Automotive Maint Activities, 17 Nov 42.

[7] Harmon, *op. cit.,* pp. 172–73.

[8] (1) Maj. Gen. Clarence C. Williams, "Annual Report of the Chief of Ordnance, Part II," *Army Ordnance,* V, No. 29 (March–April 1925), 729–34; (2) Survey of the Ord Dept, 20 Sep 29, Incl. 6, Survey of Depots and Excess Supplies, 320/377 NA.

number of parts that would be needed for a similar operation in the future.[9]

Ordnance planners were aware that overhaul at arsenals was expensive. Peacetime maintenance could be done more economically and efficiently by civilian mechanics in commercial repair shops. Many commanders preferred to have work done locally to save the cost of transporting the matériel to and from an arsenal and to avoid loss of the weapons for a long period. Yet the advantage of having arsenal maintenance facilities ready to back up corps area and field maintenance facilities in time of war outweighed considerations of economy or convenience.[10]

An example of the peacetime work of an Ordnance maintenance company stationed at an arsenal is afforded by the 33rd Ordnance Company (Heavy Maintenance), at Rock Island Arsenal, organized 11 April 1921 from the Ordnance detachment at the Arsenal. Its peacetime strength was 2 officers and about 110 enlisted men. The only company at the Arsenal, it was comfortably quartered in stone barracks with excellent recreational facilities, including a large ballroom; for its mess it maintained a garden and some fine Holstein cattle. The men of the company's Automotive, Artillery, and Small Arms Sections were experts in the repair and upkeep of their own types of matériel; those in the Service Section were machinists, welders, blacksmiths, saddlers, painters, carpenters, and electricians.

The company not only worked on the matériel stored at the Arsenal but furnished maintenance service to the Fifth, Sixth, and Seventh Corps Areas, at whose various stations thirty-seven men of the 33rd Ordnance Company were on detached duty throughout the year. During the summer training season the company took to the field, leaving only a handful of men at Rock Island. At the training camps of the three Corps Areas they checked matériel in the hands of troops; repaired, replaced, and issued all necessary Ordnance stores and equipment; and at the close of camp prepared the stores and equipment for winter storage. When the company moved into the field, its rolling equipment included thirty-four trucks, of which nine were for artillery repair, two for light repair, two for equipment repair, and six for spare parts; the rest contained baggage, a toolroom, a power saw, an office, and other cargo. There were thirteen trailers, seven carrying various types of maintenance tools and equipment, five carrying parts, and one containing a kitchen.[11]

Reorganization of Men and Equipment

The Ramsey Board appointed in December 1936 to study Ordnance manufacturing and storage facilities in the United States also reviewed Ordnance maintenance facilities "to determine whether in the main such facilities should be concentrated at a few of the manufacturing arsenals and depots or more widely divided

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[9] (1) Gibson, "Ordnance Maintenance En Route," *Army Ordnance*, II, No. 11, (March–April 1922), 268; (2) Ord FS Bull 5–1, 2 Jan 30, sub: Field Service Modification Work Orders Method; (3) Ord FS Bull 4–2, 11 Aug 41, sub: Spare Parts and Tools.

[10] (1) Report of Board of Officers to Prepare Secret Plan Embodying an Ideal Set-Up for Ordnance Manufacturing and Storage Facilities in the United States, 15 Apr 37 [hereafter cited as Ramsey Bd Rpt], OO 682/1499, copy in Site Bd Rpts, ex. 20; (2) History, Augusta Arsenal, I, Through December 1942, p. 198, OHF.

[11] George W. Outland, "The 33rd Ordnance Company, Rock Island Arsenal," *Army Ordnance*, V, No. 28 (January–February 1925), 658–60.

among field establishments as seems to be the tendency at present." [12] The members of the board decided that existing policies were generally sound and should be continued, but observed that maintenance companies attached to line organizations were prone to use more elaborate machine-tool equipment than was necessary, thus turning their organizations into semipermanent shops that could not be carried efficiently into the field.

The question came up again in the summer of 1937 following tests in Texas of the new "streamlined" Infantry division. The 3-truck Ordnance shop authorized in 1935, composed of 2-1/2-ton trucks, seemed to the using arms excessively heavy and bulky, and there was some talk of eliminating it. Ordnance officers disagreed. They considered machine-shop and welding equipment essential, for it was impossible to carry an inexhaustible supply of parts, even if they were available. Parts had to be improvised at times; frequently the parts on hand had to be machined or welded to fit them into the mechanism where they were needed. The answer to the problem of mobility was to simplify and reduce the equipment of the machine-shop and welding units. This effort, which continued throughout the thirties, was aided by such commercial developments as the power take-off that permitted the truck engine to power the generator. In addition to shop trucks, Ordnance companies in the prewar years carried two other types of automotive equipment: trucks for spare parts, and roving emergency trucks for repairing matériel in place whenever possible.[13]

Along with equipment, Ordnance studied the question of the number of men and amount of time required for maintenance in the 1937 tests. It was from these tests that plans grew for the new triangular division. The aim was to create a mobile, hard-hitting division with a minimum of noncombat troops. One means of reducing nontactical overhead was to draw more heavily than before on higher headquarters for logistical support.[14] Yet demands for maintenance were sure to increase, because more mobility meant more mechanization, and greater firepower meant wider use of automatic weapons.

If Ordnance personnel with the triangular division were reduced, the Ordnance organization at corps level, upon which the division would draw, would have to be strengthened. One means of making the most of available personnel had been observed in World War I by Col. James K. Crain, who was Ordnance Officer of the Eighth Corps Area from 1934 to 1939 and later became the first wartime Chief of Field Service. In France he had observed that the French Eleventh Corps put all ordnance companies of the corps in one place to serve as a pool to support all division and corps troops; in this way the workload was kept even and there were seldom any idle mechanics. This gave him the idea for an Ordnance battalion.[15]

The planners shaping the new division moved the Ordnance maintenance companies out of the division and placed them as corps troops to form a battalion under centralized control. Each division retained

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[12] Ramsey Bd Rpt.

[13] (1) Lt. Col. Donald Armstrong, "To Keep the Guns Firing: Equipment of the Modern Ordnance Maintenance Company," *Army Ordnance,* XX, No. 116 (September–October 1939), 84–88; (2) History of the Field Service Maintenance Division, vol. I, From July 1939 to December 1941 [hereafter cited as Hist, Maint Div, I], pp. 48–49, OHF.

[14] Greenfield, Palmer, and Wiley, *The Organization of Ground Combat Troops,* pp. 271–76.

[15] Interv, Crain, 17 Feb 54.

only a small Ordnance section composed of one officer and sixteen enlisted men. This new organization promised to promote efficiency as well as economy in manpower. By pooling Ordnance field personnel in as large an organization as was practicable, Ordnance planners believed that the full force of the maintenance organization could be exerted where maintenance was most needed. The load of spare parts of any company became a potential reserve for any other company; the mechanic who specialized in a certain type of maintenance became available to other companies. There would be greater economy in tools, since a single tool of a certain type might serve the entire battalion.[16]

The new Ordnance battalion, consisting of three medium-maintenance companies and one ammunition company, was attached to the IV Corps, and it was commanded by the Corps Ordnance Officer. Tested in the April–May 1940 exercises of the Third Army, it performed well. Continuing study of this new organization indicated that the battalions should be of several types. By February 1941 five types had been evolved: (1) Maintenance, attached to corps and consisting of three medium - maintenance companies; (2) Maintenance and Supply, attached to armies and consisting of two or more medium-maintenance companies, an Ordnance depot company, and sometimes a heavy-maintenance company; (3) Ammunition, attached to armies and consisting of two or more ammunition companies; (4) Armored, attached to general headquarters of the 1st and 2d Armored Divisions; and (5) Aviation, located at air bases.[17]

Ordnance officers who participated in the 1940–41 maneuvers studied several ways of using the battalion to best advantage. Some advocated specializing the companies, that is, having an artillery company, an automotive company, and so on. But this conflicted with the concept of the company as a balanced maintenance team to support a rapidly moving tactical unit. Planners tried the consolidated corps Ordnance shop, in which like sections of the different companies, such as artillery sections, were grouped together under the senior section officer. Friction developed between the different groups, and it was difficult for the men to work under a system that involved dual command, that of the company officer and the shop officer; also, there was confusion in going from shop formation to company formation for the march and back again. For these reasons, in the Carolina maneuvers of 1941 the companies operated their own sections. The consolidated-shop system did have the merit of combining the tools, parts, and manpower resources of the companies; some officers believed that this functional as opposed to tactical organization would be preferable under actual combat conditions.

In the 1941 maneuvers the Ordnance maintenance battalion worked satisfactorily. For Ordnance companies it provided a parent organization, the battalion headquarters, that knew and understood their problems and relieved them of difficult housekeeping problems. It made "a family

[16] (1) Speech, Brig Gen Edward E. MacMorland, Weapon Maintenance in Battle, OCO Maint Div, vol. 100, pp. 8–9, OHF; (2) Colby (Comdr, Ord Bn, Fourth Army Corps), "The New Ordnance Battalion: Maintenance and Supply in the Streamlined Division," *Army Ordnance*, XXI, No. 123 (November–December 1940), 208.

[17] *Ordnance Sergeant*, I, No. 2 (February 1941), 65–66, and No. 6 (June 1941), 254–56; II, No. 3 (September 1941) 170–71, and No. 4 (October 1941), 202–12.



TRUCKS OF NEWLY FORMED ORDNANCE BATTALION *at the April–May 1940 exercises of the Third Army.*

of a group of orphans." [18] The observers considered command of the battalion by the corps Ordnance officer to be a distinct advantage because it provided a close working arrangement between all Ordnance units and with the corps general staff.

The equipment of an Ordnance battalion was considerable: 3 artillery-repair trucks, 3 automotive-repair trucks, 32 emergency-repair trucks, 2 instrument-repair trucks, 3 major shop trucks, 5 small-arms repair trucks, 20 small-parts trucks, 3 tank-maintenance trucks, 3 tool-and-bench trucks, 5 welding trucks, nine 10-ton wrecking trucks, 2 sedans, 12 motorcycles, 1 water trailer carrying 250 gallons, 6 motor tricycles, 4 half-ton command trucks, one 1-1/2-ton cargo truck, forty nine 2-1/2-ton cargo trucks, and three 600-gallon gas-and-oil trucks. There were also 6 scout cars with armament, including light and heavy machine guns, submachine guns, and automatic pistols.[19]

In 1942, when the planning for offensive action made it plain that the most economical use would have to be made of all available manpower and every ship-ton, Army Ground Forces concluded that economy could best be achieved by a

[18] (1) Lt. Col. L. Monroe Bricker, Corps Ord Officer, IV Army Corps, "Ordnance in the Field: Maintenance and Supply in the IV Army Corps During Maneuvers," *Army Ordnance,* XXII, No. 132 (May–June 1942), 967; (2) Greenfield, Palmer, Wiley, *The Organization of Ground Combat Troops,* pp. 357–58.

[19] "Professional Digest," *Army Ordnance,* XXII, No. 129 (1941), 411. See also schematic drawing of the vehicles of Ordnance maintenance companies, *Army Ordnance,* XXI, No. 124 (January–February 1941) facing p. 364.

further process of streamlining and pooling. This time the streamlining—in the sense of limiting a unit organically to what it needed at all times and not just occasionally—was applied to the corps, which General McNair considered to be a tactical, combat unit; and the pooling, in the sense of massing units under higher headquarters for servicing of lower commands when needed, took place at army level. The idea was that the army was both a combat and an administrative agency, the corps a combat agency only, unless it was operating independently, in which case it would be reinforced to function as a small army. Thus, in the reorganization that took place in the summer of 1943, the maintenance battalions attached to IV, VIII, and X Corps in the United States became a part of the Third Army troops.[20]

Overseas a new type of Ordnance organization had already taken shape. In North Africa in the late fall of 1942 Col. Urban Niblo, Ordnance Officer of II Corps, organized provisionally an Ordnance Group consisting of several battalions. It was more flexible than a regiment, for battalions could be added to it or detached from it as the situation demanded. It was so successful that several groups for operations at army level became the accepted practice throughout the war. By April 1944 the Ordnance Group had a Table of Organization and Equipment. Going a step further, Niblo and others advocated an Ordnance brigade to control the groups, but this proposal failed to win approval.[21]

There was a brief experience with regimental organization. In 1941 General Crain foresaw the need for a new type of unit to operate the large supply bases that would be required overseas. When the General Staff called for recommendations for overseas units in early 1942, he recommended the organization of Ordnance regiments, and his plan was approved.[22] During 1942 four regiments, the 301st, 302d, 303d, and 304th, were activated, and the 305th was partially activated. Recruited with the aid of commercial organizations such as the National Automobile Dealers Association, they were known as affiliated units. These units were experimental; their recruitment, training, and use in the field presented problems that were never entirely solved.[23] ASF maintenance experts believed that more effective service was obtained from smaller and more flexible units. In the spring of 1943 the five Ordnance regiments were reorganized into individual, numerically designated Ordnance Base Armament Maintenance Battalions; the battalions of the original regiments became companies.[24]

[20] Greenfield, Palmer, Wiley, *The Organization of Ground Combat Troops*, pp. 364–71 and 375–76.

[21] (1) Mayo, The Ordnance Department: Ordnance Overseas; (2) Greenfield, Palmer, and Wiley, *The Organization of Ground Combat Troops*, pp. 357–59.

[22] Maj. Gen. James K. Crain, "Ordnance in the Field," *Ordnance*, XXXIX, No. 206 (September–October 1954), 329. General Crain also wanted an Ordnance brigade consisting of two regiments—one Ammunition, one Maintenance and Supply—but could not obtain General Staff approval for it.

[23] Green, Thomson, and Roots, *Planning Munitions for War*, ch. V; (2) Memo, CG ASF for CG SOS Through CofOrd, 9 May 42 and 1st Indorsement, 16 May 42, OO 320.2/1759; (3) Ltr, Maj Gen Levin Campbell to Senator D. Worth Clark, 11 Jul 42, OO 320.2/2129; (4) Memo, Brig Gen Julian S. Hatcher for Brig Gen James Kirk, 22 Sep 42, sub: Training of Ord Base Regiments, OO 322.1/414; (5) History, Troop Units Reports, 301st Ordnance Regiment, OHF.

[24] Ann Rpt ASF for FY 1943.

An important part of the reorganization for war that took place in the late 1930's was the effort to obtain better grades and ratings for Ordnance enlisted men. Pay had been so low that skilled mechanics to repair the increasingly complicated matériel could not be recruited. A General Staff survey in 1929 found Ordnance personnel inadequate for work in the field, and as late as FY 1938 approximately 90 percent of the maintenance funds allotted to Ordnance officers of corps areas, departments, and exempted stations went to pay the salaries of civilian mechanics.[25] As the Air Corps began to expand, it attracted many of the best Ordnance enlisted men. But in the summer of 1940 General Crain managed to get much more liberal Tables of Organization, and by 1941 Ordnance grades and ratings were second only to those of the Air Corps.[26]

The Echelon System

The Army assigned responsibility for maintenance in the field according to the skill and tools available at various levels. The individual soldier was responsible for the proper care of his rifle, truck, or other equipment and for such minor repairs as he was able to make; the company mechanic made the slightly more difficult repairs that he could accomplish with his limited tools. The work that the using organization did not have the tools or parts to do was turned over to Ordnance specialists in the field. The Ordnance men could perform a considerable amount of repair, but could not be so loaded down with tools and spare parts that they could not accompany the tactical unit to which they were assigned. Therefore, for everything beyond their capabilities—major overhaul or complete rebuild—the weapon or truck was sent to a base shop, manufacturing arsenal, or Ordnance depot.

Sometime in the 1930's the term echelon came into use to describe these levels of maintenance. The work performed by the line organization was first echelon; that done by the Ordnance maintenance companies was second echelon; and that in the rear was third echelon.[27] A study of maintenance problems in 1941 suggested the possibility that more echelons might be needed. The Motor Transport Service, before it was transferred from the Quartermaster Corps to Ordnance in midsummer of 1942, had four echelons: the first performed by the drivers; the second by company, battalion, and regimental mechanics, who made inspections and the necessary mechanical adjustments in time to prevent failures; the third by units trained to make minor repairs, replace engines, and supply parts; and the fourth by semimobile or fixed shops that took care of major repairs, general overhaul, reclamation, and supply.[28]

Ordnance maintenance planners devised a 5-echelon system. The two types of

[25] (1) Survey of the Ord Dept, 20 Sep 29, Incl. 13 to Ltr, SW to All Chiefs of Branches and Burs, 1 Aug 29, sub: Spec Survey of the Mil Establishment; (2) WD OCO Annual Summary, Ordnance Digest of Activities, Including a Summary of Principal Operations Fiscal Year 1938, OHF; (3) Lecture, Maj Gen Charles M. Wesson, Operations of the Ordnance Department, 12 Nov 38, Army War College, p. 14, OHF.

[26] (1) Crain, Diary, 27 Jun 40, OHF; (2) Interv with Maj Gen James K. Crain, 30 Jun 49, OHF.

[27] (1) Hist, FS Maint Div, vol. II, History From 7 December 1941 to December 1942 [hereafter referred to as Hist, Maint Div, II], p. 40; (2) Ramsey Bd Rpt, pp. 33–37; (3) 2d Indorsement, (Memo, SW for CofS, 8 Dec 36, sub: Location of Government Mfg Plants). CofOrd to TAG, 6 May 37, AG 381 National Defense, copy in Site Bd Rpts.

[28] Hertz Rpt.

simple maintenance performed by the using organization—the individual or the regiment, battalion, company, or detachment—were labeled first and second echelon. That accomplished by Ordnance troops was now divided into two categories, third echelon and fourth echelon. Third echelon, sometimes called medium maintenance, was done in mobile shops, in close support of using troops. Soldier mechanics at this level took care of the overflow from lower echelons, replaced assemblies such as recoil mechanisms, engines, and transmissions, and supplied parts to the lower echelons. Fourth echelon, commonly referred to as heavy maintenance when armament work was meant, was done in fixed and semifixed shops serving a specific geographic area. Its major function was the rebuilding of major items by using serviceable assemblies and subassemblies that were in stock or could be obtained by cannibalization. Fifth echelon maintenance, performed at an arsenal or base shop, was the highest level and consisted of completely reconditioning or rebuilding matériel, and, to a limited extent, manufacturing parts and assemblies. The work in the first and second echelon class was known as organization maintenance; that of the third, fourth, and fifth echelons was service maintenance.[29]

The echelon system required that the various repair operations be definitely allocated to certain persons in preestablished places; the guiding principle was that repair would be performed in the lowest echelon of maintenance consistent with the availability of suitable tools and necessary parts, the capabilities of personnel, the time available, and the tactical situation. Constant supervision was necessary to be sure that the work was done at the right echelon.

Every energetic shop commander of whatever echelon wanted to undertake all work employing existing skills of his men. This meant demands for tools, parts, and supplies beyond their tables of equipment and the capability of Field Service to supply. Sometimes a third echelon company, well dug-in at a permanent post, forgot that it would some day have to take the field and, consequently, accumulated more heavy items than it could transport.[30] Deviations from the echelon levels were permitted, but only in emergencies. A third echelon Ordnance company, for example, might perform first and second echelon work for exhausted combat troops or might provide fourth echelon maintenance for a new division whose station shop facilities were not ready for operation.[31]

ASF maintenance experts considered Ordnance too inflexible in its adherence to the echelon system. They felt that the field organization at the top would have been more effective if it had made more allowance for circumstances in which a heavy maintenance company, for example, might have to take on some of the work of a medium maintenance company. They also disliked the too-rigid compartmentation of fourth and fifth echelon work, arguing

[29] (1) AR 850–15, 6 Oct 42; (2) Hist, Maint Div, II, pp. 44–45; (3) Draft MS, George R. Powell, U.S. Army in World War II, Statistics: Maintenance, 16 Jan 50 [hereafter cited as Powell MS], p. 2, OHF; (3) ASF Staff School Presentation, Maintenance Policies and Procedures, 23–24 May 44 [hereafter cited as ASF Presentation], pp. 5–6, 28 in 337 Confs 1944, ASF Maint Div files.

[30] Ltr, MacMorland to Thomson, 10 Dec 54, OHF.

[31] (1) ASF Presentation, p. 33; (2) "Who Does What and Why and When? or, Those Exasperating Echelons of Maintenance," *The Ordnance Sergeant*, V (February 1943), 142.

that a good mechanic could do either; they maintained that, if a fourth echelon shop could do fifth echelon work efficiently, it ought to be permitted to do so.[32] There were also differences of opinion on the subject within Ordnance. General MacMorland believed that the lessons of the war had indicated that only three echelons were necessary—organizational, field, and base.[33] General Niblo believed that the five-echelon system was excellent and declared that, "No effort should be made to change this to such terms as organizational, field and base." [34]

Problems of Automotive Maintenance

The transfer to Ordnance of the Quartermaster Motor Transport Service brought a staggering maintenance task. In the peak war years 1944–45, the repair and overhaul of automotive equipment accounted for more than 75 percent of the total man-hours spent on the maintenance of Ordnance matériel.[35] More than a million transport vehicles were transferred to Ordnance in 1942. The magnitude of the maintenance problem is suggested by the fact that there were thirty-seven different makes of cars and trucks; and over three hundred different models.[36]

The automotive maintenance problem was of long standing. Shortly before Pearl Harbor, Secretary of War Stimson, in forwarding a report on motor transportation to the Chief of Staff, observed, "Our motor transport maintenance system ought to be the best in the world because our people are the best natural mechanicians"; but the report revealed that both the vehicles and the maintenance facilities were in bad condition.[37] In the eighteen months before Pearl Harbor, Army vehicles had increased from a few thousand of the simple, 2-wheel-drive type to more than two hundred thousand highly complicated 4-wheel- and 6-wheel-drive types. Because of the rapid expansion of the Army, these vehicles had been entrusted to young, often irresponsible drivers, commanded by inexperienced officers who sometimes did not even require that their drivers have operators' licenses. Few officers had adequate mechanical training or background in automotive shop work and parts supply, and this disadvantage, aggravated by lack of centralized control, accounted in large part for the poor condition of maintenance facilities.[38]

Ordnance planners looked at the new motor vehicle problems not only from the standpoint of maintenance operations, but also that of maintenance engineering. In the weeks following the acquisition of motor transport, poor co-ordination between the various branches of the Ordnance Department delayed the issuance of Modification Work Orders, the dissemination of technical publications, and the receipt of information on the development of new items. Often by the time maintenance information on new projects was received, it was too late to apply it, as the vehicle was already in production. The remedy was found in decentralization. In late September 1942 the Chief of Ordnance transferred the Technical Unit of the

[32] Interv with Maj Gen Frank A. Heileman, 1 Sep 54.

[33] Ltr, MacMorland to Thomson, 10 Dec 54.

[34] Ordnance Lessons Learned in the U.S.–U.K. –and MTOUSA by Brig Gen Urban Niblo, Incl 1 to Ltr, Niblo to CofOrd 27 May 46, sub: Personal Ord Lessons Learned . . . During World War II, OHF.

[35] Powell MS, pp. 9, 16, 28.

[36] Hist, Maint Div, II, p. 50.

[37] Memo, SW for CofS, 22 Nov 41, QM 451 E (Maint), copy in Hertz Rpt folder.

[38] Hertz Rpt.

Maintenance Branch, along with the rest of the Automotive Section, to the new Tank-Automotive Center in Detroit; and within a short time this decentralization made it possible to expedite MWO's and other actions requiring co-ordination.[39]

One of the earliest maintenance engineering tasks was that of preparing for combat landings. This entailed modification of existing vehicles so that they could ford deep water, and improvement of the design of new vehicles such as the amphibian truck (Dukw). The issuance of new or modified vehicles required a program for acquainting the users with their characteristics by sending teams of specialists into the field and publishing new Standard Nomenclature Lists.[40]

For repair work on automotive matériel in the field, the Ordnance Light Maintenance Company was made organic in the division. Most automotive repairs had to be made by the troops, for no Ordnance company, General McNair realized, could "even make a dent in the trucks of a division." [41] But the light maintenance company could often take care of the broken down vehicles that would otherwise have had to be sent rearward to army shops. This was a great advantage in combat, as it meant that the division kept control of its equipment. And it illustrated the tendency to push as many repairs as possible forward to line units.[42]

General McNair intended the maintenance company in an armored, motorized, cavalry, mountain, or airborne division to make the division self-sufficient for a short period of time, that of the infantry division to provide only a part of the necessary third echelon maintenance. The infantry division generally, and other divisions occasionally, would have to be reinforced by the services of nondivisional medium maintenance units under army (or corps) control. In combat, beginning in North Africa, it was usual for line divisions to be backed up by additional third echelon companies.[43]

The Preventive Maintenance Program

In the fall of 1941 a spot check of about one-third of the motor vehicles of five divisions, made by a group of mechanics under the control of The Inspector General, showed that 47 percent of the vehicles were improperly lubricated, 50 percent had distributors loose or dirty and points badly burned, 49 percent had loose steering gear housings, 53 percent had underinflated tires, 23 percent had improper wheel alignment, 36 percent had dry batteries, and 37 percent had tires that were badly worn, cupped, and improperly mounted. There was no reason to believe that this discovery did not represent average conditions throughout the Army; and it was plain that the conditions were mainly the fault of careless drivers.[44] The Quartermaster General was inclined to

[39] (1) OCO-D Hist, Maint Div, pt. 1, vol. 22, sec., Parts Requirements Unit; (2) OCO FS Maint Div, PSP 57, Maintenance Facilities, Personnel, Equipment and Supplies, Jun 45, p. 15, OHF; (3) Capt. H. Durst, III, Final Rpt, OCO-D Key Pers Rpts.

[40] (1) PSP 57, pp. 16–30; (2) ASF Presentation, pp. 1–11; (3) FS Ann Rpts, Jul 42, p. 9, OHF; (4) MS, C. W. Spooner, Fording and Floating Equipment (Record of Army Ordnance Research and Development) and booklet, The Adaptation of Standard Combat Vehicles to Amphibious Operations, both in OHF.

[41] Greenfield, Palmer, and Wiley, *The Organization of Ground Combat Troops*, p. 310.

[42] *Ibid.*

[43] (1) Ltr, McNair to CG's Second and Third Armies, and Others, 5 Dec 42, sub: Ord Maint, AGF files 400.402/-GNGDS; (2) Ltr, MacMorland to Thomson, 10 Dec 54.

[44] Hertz Rpt.

blame the unit commanders for not enforcing stricter maintenance discipline, and concluded: "When unit commanders realize that a motor vehicle is a fighting weapon, the greater part of motor transport problems will be solved." [45]

The Quartermaster Corps was sending to the troops preventive maintenance material, including a monthly publication called *Army Motors,* and on the recommendation of the Hertz Committee, appointed by the Undersecretary of War to study motor maintenance, had tested with some success a program for using civilian automotive experts as instructors in the field. But no standard procedures for preventive maintenance had been evolved by the War Department, and the civilian adviser program was scarcely out of the embryo stage.[46]

Preventive maintenance had long been a subject of concern to Ordnance Field Service[47] and it received concentrated attention after the assignment of motor vehicle responsibility. In August 1942 Field Service organized a Preventive Maintenance Section and placed under it a unit to handle the Civilian Automotive Advisor Program; a maintenance engineering unit was charged with the preparation of standard preventive maintenance procedures and with the publication of *Army Motors* and technical manuals.

The men directing the Civilian Automotive Advisor Program devoted their first efforts to recruiting better qualified advisers and then to giving them more thorough indoctrination in Army procedures than had before been possible. The unit also prepared a booklet to guide them and provided better supervision in the field. By July 1943 these civilians, whose numbers had increased from six hundred to about sixteen hundred, were working constantly with the troops on preventive maintenance and were instructing officers as well as enlisted men.[48]

The civilian advisers were recruited with the assistance of several hundred transportation and maintenance executives throughout the country, who located, interviewed, classified, and recommended applicants. Qualifications were rigid: the men had to have wide experience either as fleet superintendents, maintenance managers, shop foremen, service managers, or mechanics. There were several advantages to retaining them as civilians rather than commissioning them as officers. Under Civil Service their appointments could be effective immediately; age or slight physical disability was no barrier; and as civilians they did not have to accompany their assigned units into combat areas, but could be reassigned to train newly activated units.[49]

Automotive advisers were not at first authorized to accompany units leaving the United States, but the theater commanders began to request them in 1943, after the landings in North Africa. In March 1944 the War Department made

[45] OQMG, Comments on the Rpt on Motor Vehicle Maint by Hertz, Hertz Rpt folder.

[46] (1) Hertz Rpt; (2) OCO-D Hist, Maint Div, pt. 1, vol. 22, Summary of Activities of Preventive Maintenance Section (Prior to 1 January 1943) [hereafter cited as OCO-D Preventive Maint Summary], pp. 25–26.

[47] Capt. George H. Schoenbaum, "Lubrication: The Essence of Ordnance Operation and Maintenance," *Army Ordnance,* XXII, No. 129 (November-December 1941), 393.

[48] (1) OCO-D Preventive Maint Summary, pp. 25–28; (2) Ann Rpt FS FY 1943, p. 13; (2) *Report on the Army July 1, 1939 to June 30, 1943: Biennial Reports of General George C. Marshall, Chief of Staff of the United States Army to the Secretary of War* (Washington, 1943), p. 108.

[49] Hist. Maint Div, II, pp. 66–68.

them available for overseas duty upon request of the theater commanders, but proportionately few went overseas. As of 11 September 1945 there were 61 in the ETO, 34 in the Pacific Ocean Area, 2 in the African Middle East Theater, and 1 in India-Burma.[50] Ordnance officers connected with the program felt that the central authority to co-ordinate and supervise it, which was given to the Chief of Ordnance in October 1943, might better have been issued at the beginning.[51] The program was delayed because of inability to obtain qualified men, but Maintenance Division experts felt that it was of "immeasurable value" in the earlier stages of the war. After Ordnance had had time to train its own people in automotive problems, the need for civilian advisers lessened.[52]

Ordnance took other steps to promote preventive maintenance. In November 1942 maintenance planners requested AAF and AGF officers to join them in forming a Preventive Maintenance Board to act as a clearing house for procedure and techniques, to co-ordinate training, and to standardize forms. At the same time General Campbell requested the aid of the Society of Automotive Engineers, which had within its organization a group of experts conducting research on maintenance problems. This group, together with representatives from Ordnance, formed the Ordnance Vehicle Maintenance Committee to study and do research on specific problems of military maintenance.[53] But reports by ASF observers during maneuvers in the fall of 1942 and spring of 1943 indicated that an intensive training program at troop level was essential.[54]

In the fall of 1943 shortage of manpower, demands of the Navy and AAF, and limitations on the supply of critical materials and components created serious over-all maintenance problems and special problems of meeting the need for components such as ball and roller bearings, plain bearings, and electrical equipment and instruments. General Campbell recommended to General Somervell that even stronger emphasis be placed on preventive maintenance along with the reclamation of critical automotive components when unserviceable, and strict control of the supply of critical items. ASF accordingly began, in close liaison with Ordnance, a special program of education to alert users and repairers of vehicles to the importance of conservation. This involved the use of posters, cartoons, magazine articles, and other kinds of publications.[55]

Ordnance's Preventive Maintenance Branch improved the format of *Army Motors* and stepped up the circulation. A peak of 211,000 was reached in August 1945. The percentage that went to the using arms is indicated by the figures for October 1945: 19,885 to Ordnance personnel and installations, and 174,392 to all other services, including the Marine Corps, Navy, Seabees, and Coast Guard.[56]

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[50] Final Reports of Lt E. D. Scholey, 19 Oct 45, and Lt Col Monroe F. Weill, 8 Oct 45, both in OCO-D Key Pers Rpts.

[51] Scholey Rpt.

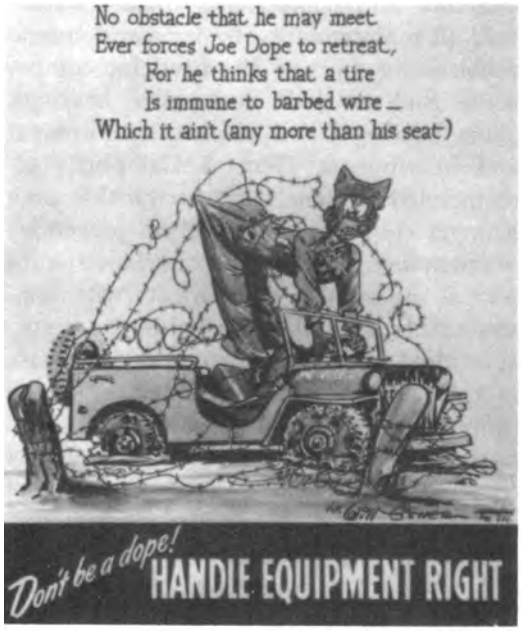
[52] (1) Weill Rpt; (2) Hist, Maint Div, II, p. 109; (3) Ann Rpt FS FY 1944, p. 12.

[53] (1) Ann Rpt FS FY 1944, pp. 64–65 and 69–70; (2) Ltr, Maj Gen Levin Campbell, to A. W. Herrington, President, SAE, 26 Nov 42, OO 334.8 15708; (3) FS Office Memo 86, 11 Dec 42.

[54] Ltr, CG ASF to CofOrd and Others, 16 Apr 43, sub: Lack of Preventive Maint, ASF Maint Div files, 400.402 Preventive Maint 1943.

[55] Memo, Campbell for Lt Gen Brehon Somervell, 2 Sep 43, sub: Conservation of Automotive Equipment, and Indorsement 1 Oct 43, ASF Maint Div files, 451 Vehicles, Sep–Dec 43.

[56] Weill Rpt.





In addition to the magazine, the Branch disseminated thousands of posters to the troops, a new design every two weeks. Most effective were those featuring "Joe Dope" who did everything wrong. Cartoonist Will Eisner, a private at Aberdeen Proving Ground, drew the amusing pictures. The text consisted of catchy rhymes such as:

> At maneuvers Joe Dope took a tank
> Hell bent o'er a 30-foot bank.
> Uncle Sam, you can guess,
> Now can boast one tank less—
> As for Joe, he's a permanent blank![57]

These educational efforts were helpful, but early reports from overseas indicated that nothing could take the place of maintenance discipline. A General Staff officer in NATOUSA in April 1943 observed that "Driver maintenance was universally bad. Service units reported that almost without exception vehicles presented for repair (excluding those in accidents) were the result of driver neglect." [58] A survey group from the Inspector General's office reported from North Africa that Ordnance officers were unanimous in declaring that basically the American soldier was extremely wasteful and undisciplined where maintenance was concerned. He seemed inherently extravagant and irresponsible. If an American driver had trouble with his carburetor he immediately demanded a new one, even though the only trouble was the malfunction of one small part. Vehicles left along

[57] Hist, Maint Div, II, pp. 42, 110, and ex. 33. An ASF-sponsored Army Preventive Maintenance Week to be proclaimed by the President was turned down by the CG ASF as being merely "an advertising scheme" of little value. Memo, Maj Gen LeRoy Lutes for ASF Director Opns, 1 Oct 43, sub: Army Preventive Maint Week, ASF Maint Div files 400.402.

[58] Memo, Col Floyd C. Devenbeck, Chief Policy Br, for Chief Preventive Maint Br, 5 Aug 43, sub: Overseas Maint Deficiencies, ASF Maint Div files, 400.4 Maint.

the roadside unguarded were cannibalized by almost every passer-by.[59] Failure of the users to grease the clutch-release bearing in the half-tracks of an armored division caused loss of the vehicles at critical times; failure of tank crews to lock the 75-mm. guns on medium tanks during a march damaged the turret rotating mechanisms and deadlined thirty-five to forty badly needed tanks. In the latter case the Commanding General fined those responsible $50 each—and the failures fell to zero.[60]

This was an extreme case, but it did show that at least one officer understood maintenance discipline as well as combat discipline. Some officers did not themselves appreciate the importance of proper preventive maintenance. In one theater a supply train carrying ammunition, rations, fuel, and lubricants to a regiment about to launch an offensive literally fell apart, with more than 50 percent of the trucks on deadline, not only because of disregard of maintenance by the drivers but also because the corps permitted the trucks to run twenty-four hours a day for weeks without any time out for upkeep. Better indoctrination of field and staff officers was indicated. One way of doing it was developed by the 26th Infantry Division. Each staff and field officer was given a two weeks' refresher course, one hour a night; and a different staff officer was assigned each day as motor officer of the day to keep a close check on all equipment. In seven months this program brought deadlined vehicles down to one-tenth of one percent. Frequent and formal command inspection by high-ranking officers, in the course of which they checked the preventive maintenance procedures of unit commanders, and other techniques of control, were developed by Ordnance and ASF experts.[61] There was ample recognition of the fact that maintenance would continue as a Field Service problem in direct ratio to the degree to which preventive maintenance was accepted as a responsibility of the command to which Ordnance equipment was assigned.[62]

A year after the transfer of trucks to Ordnance, The Inspector General's deadline report showed a progressive decrease in deadline percentages. In the opinion of General Campbell, this result was achieved by emphasis on preventive maintenance, and by the increasing co-operation of field commanders in the enforcement of maintenance discipline.[63] It was a sign that the Army had passed through the first hectic stage of mobilization and training and was settling down to smoother, more efficient operation.

Maintenance Shops

One of the first problems faced by Ordnance after taking over motor transport

[59] Memo, Brig Gen Frank A. Heileman, Deputy Director of Opns, ASF, for Director Stock Contl Div, 24 Aug 43, sub: Survey of Organizations, Admin, Supply and Procedures of the North African Theater of Opns, ASF Maint Div files, 400.4 Maint.

[60] ASF Presentation, pp. 33–34.

[61] (1) ASF Presentation, pp. 28–34; (2) Ltr, CofOrd to CG AGF, thru CG ASF and ACofS G–4, 4 Oct 43, sub: Preventive Maint Training Program, and Indorsement 15 Oct 43, OO 353/4736; (3) Memo, Lt Col Thomas B. Evans for Chief, Preventive Maint Br ASF, 4 Aug 43, sub: Improvement of Preventive Maint, ASF Maint Div files, 400.402 Preventive Maint 1943; (4) Ltr, Col William S. Conrow to Lt Col Walter C. Thee, 25 Sep 44, sub: Preventive Maint of Vehicles, ASF Maint Div files, 451 Maint Neglect, Jun–Nov 44.

[62] Ann Rpt of FS for FY 1944, p. 8.

[63] Memo. Maj Gen Levin Campbell, for CG ASF, 14 Aug 43, sub: Transfer of Fifth Echelon Automotive Shops to SC's. OO 020/776.

vehicles was that of combining the various repair shops for automotive and armament matériel. For both types of matériel, third echelon maintenance was accomplished in the United States at posts, camps, and stations. For automotive matériel, fourth echelon maintenance was done in Ordnance Service Command Shops that served districts covering a radius of from one hundred to one hundred fifty miles containing eight thousand to ten thousand vehicles. These Ordnance Service Command Shops performed heavy maintenance, supplied parts to lower echelons, handled tire inspection and reclamation, and evacuated major units to base shops for overhaul. Sometimes located at posts, but often in cities, they usually consisted of seven buildings—two for shop operations, two for storing parts, two for inspection, reclamation, and salvage operations, and one for administration. They employed from 240 to 275 persons.[64] Fifth echelon maintenance for automotive matériel was done at base shops formerly under the Quartermaster but transferred to Ordnance; for armament, the work was done at Ordnance arsenals and depots.

There were advantages to combining the automotive and armament shops. A shop that repaired tanks and guns as well as trucks could, for example, use one paint shop, one reclamation section, one tire section, and one safety and security officer instead of the two or three that would be required if the facilities were operated separately; spare parts could be concentrated instead of scattered; and labor could be shifted from one shop to another to meet peak loads of work. Faulty distribution of the maintenance load, caused by rapid expansion in all echelons and tardy activation of the higher echelon establishments, was a serious problem. But, although some progress was made toward consolidation, it was not sufficient to provide the answer to these problems. Most Service Commanders considered consolidation impractical, mainly because the physical facilities were separated.[65]

The Chief of Ordnance could only offer advice and guidance in the formulation of any plan, for the Service Commander had responsibility. In July 1942 third and fourth echelon maintenance had passed from the old Corps Areas to the newly formed Service Commands; the geographical boundaries were about the same, but the Service Commands, as field agencies of ASF, had tighter control. Reporting on maintenance conditions in the fall of 1942, The Inspector General was inclined to believe that the Service Commander had too much control over heavy maintenance for vehicles, and that one of the basic causes for the unsatisfactory condition of vehicle repair was separation of the two functions of maintenance and supply. The Ordnance Service Command Shops, serving the motor districts, obtained supplies from motor bases controlled by the Chief of Ordnance. While a parts representative of the base generally operated in each dis-

[64] Min, Conf of CG's, SC's. . . , 18 Dec 42, New Orleans, La., p. 18, ASF Contl Div files, dr G104.

[65] (1) Memo, Col James L. Keasler for a Col Campbell, 18 Aug 42, sub: Ord and QM Maint, in binder, Hist, Maint Div OCO–D 1942–45, exs. to Gen Hist; (2) Ltr, CofOrd to CG First SC, 12 Dec 42, sub: Ord Maint, and Indorsement, 5 Feb 43, OO 400.5/2644; (3) Ltr, CofOrd to CG Second SC, 12 Dec 42, sub: Ord Maint, and Indorsement, 23 Dec 42, OO 400.5/2645; (4) Ltr, CofOrd to CG Third SC, 12 Dec 42, sub: Ord Maint, and Indorsements, 25 Feb 43, 8 Apr 43, OO 400.5/2654; (5) Ltr, CofOrd to CG Fifth SC, 12 Dec 42, sub: Ord Maint, and Indorsement, 7 Jan 43, OO 400.5/2648; (6) Ltr, CofOrd to CG Seventh SC, 12 Dec 42, sub: Ord Maint, and Indorsement, 10 Feb 43, OO 400.5/2653.

trict to control stock levels, his efficiency was affected by the fact that he was there only on sufferance of the commanding general of the Service Command.

Because of the close correlation of parts and maintenance, The Inspector General concluded that the districts ought to operate as sub-bases under the control of the base commanders. To the objection that this system would concentrate too much control in the Office, Chief of Ordnance, the answer was that vehicle supply ought not to be different from supply of other matériel, which was requisitioned by the post from the area depot; and that fourth echelon maintenance pertained more to supply than to maintenance, because Army Regulation 850–15 prescribed that when vehicles required fourth echelon maintenance they should be turned in and other vehicles issued in their place.[66]

General Somervell, constantly opposing the "separatist" tradition of field administration in the technical services,[67] did not favor turning over control of the Ordnance Service Command Shops to the Ordnance Department; on the contrary, he wished to strengthen the Service Commands as much as possible and to give them even greater control of ASF field problems. Yet better integration of automotive maintenance had become necessary. The quality of the work performed in the fifth echelon shops was excellent, and the shops were of great assistance to the Ordnance training program for mechanics; but as of midsummer 1943 the shops were starved for work, operating at about one fourth of their capacity. There were two main reasons for this situation: (1) much of the Army's matériel was new and had not reached the stage of major overhaul; and (2) there was a natural desire on the part of fourth echelon shop commanders to do as much of their own overhaul work as possible.[68]

As one solution to the problem, the Chief of Ordnance considered contract operation of the shops, but he finally concluded that they ought to be a Government operation.[69] At a conference, ASF and Ordnance representatives agreed to continue the shops under Government operation but to transfer them from Ordnance to the Service Commands, with the understanding that the Chief of Ordnance retained technical direction through publications and letters of instruction.[70] The details of the transfer, including decisions on a definition of technical control, were worked out during August 1943. The ASF and Ordnance representatives finally agreed that technical control of the shops would consist of instructions covering the utilization of equipment, tools, shop methods, shop layouts, and procedures to insure uniform quality.[71]

[66] Memo, Brig Gen Philip E. Brown, Deputy, TIG for CG SOS, 11 Jan 43, sub: Maint Inspection for Period 1 Oct–31 Dec 42, ASF Maint Div files, 400.4 Maint.

[67] Millett, *The Organization and Role of the Army Service Forces*, p. 321.

[68] Memo, CofOrd for CG ASF, 14 Aug 43, sub: Transfer of Fifth Echelon Automotive Shops to SC's, OO 020/776, copy in Hist, FS Maint Div, vol. III, pt. 1, History From 1 January 1943 to 31 March 1944 [hereafter cited as Hist, Maint Div, III], ex. 7, OHF.

[69] *Ibid.*

[70] Memo for Red, ASF Maint Div files, 635 Shops (Gen) 1943. General MacMorland considered release of the shops to the Service Commands "no great sacrifice." Ltr. MacMorland to Thomson, 10 Dec 54.

[71] Memo, Heileman, Deputy Director Opns, ASF, for CG, ASF, 27 Aug 43, sub: Transfer of Fifth Echelon Automotive Shops to SC's, and Memo Routing Slip, Heileman for Maint Div (Col Conrow), both in ASF Maint Div files, folder 635 Shops (Gen) 1943. See also ASF Cir 76, 11 Sep 43, sec. II, Transfer to SC's of Fifth Echelon Automotive Maint Activities.

Effective 1 November 1943 three of the six Ordnance Base Shops for automotive work were turned over to Service Commands- Whittemore to the First Service Command, Atlanta to the Fourth Service Command, and Mount Rainier to the Ninth Service Command. Stockton was closed and Normoyle was consolidated with Red River Ordnance Base Shop, which Ordnance retained as a reserve plant for rebuilding unit assemblies, and for doing such overflow work as might have to be evacuated from the Service Commands.[72] Service Commands had full responsibility for maintenance through the fifth echelon but had the privilege of referring to the Ordnance Department all fifth echelon rebuilding of engines beyond the capacities of their shops. For assemblies other than engines, they could contract overflow work to local commercial shops. Any work not handled by those two methods was referred to Ordnance for transfer between Service Commands, for commercial contracts, or for overhaul at Red River.[73]

For armament the Ordnance Department had full responsibility for all fifth echelon work. For tanks and combat vehicles it had responsibility for such fourth echelon maintenance as could not be handled in Service Command shops or by maintenance companies of Army Ground Forces. For small arms, artillery, fire control instruments, and all tools, third and fourth echelon responsibility rested with post, camp, and station shops (Service Commands) and maintenance troop units (AGF, ASF, AAF).[74]

The co-operation of the Service Commands with Ordnance was "a source of gratification" to General MacMorland. After the war, recalling a series of meetings at which ASF, Service Command G-4's, and Service Command Ordnance Officers collaborated in the solution of technical problems, supply interchanges, and the equalization of work loads, he recorded that all the Service Commands "were imbued with the idea of winning the war and appreciated the real efforts we were making to provide guidance in maintenance problems." [75]

Combined Shops

Consolidation of Post Ordnance Shops with the Ordnance Service Command Shops that were located on posts was early recommended by Ordnance maintenance experts as being economical in tools, equipment, parts, and personnel.[76] By the spring of 1943 the using services were convinced that the dual channels and dual procedures involved in having at the same post one Ordnance shop commanded by the Post Commander and another commanded by the Commanding General of the Service Command were confusing and wasteful. The Commanding General of ASF agreed; but he was already considering a much more inclusive type of consolidation.[77] This was a combined shop for repairing matériel of all types, whether Quartermaster, Ordnance, Engineer, or

[72] Ann Rpt of FS for FY 1944, p. 9.

[73] (1) Memo, Brig Gen Edward MacMorland for CofOrd, 1 Mar 44, sub: Ord Maint Responsibilities, Hist, Maint Div, III, ex. 2; (2) Ltr, Maj Gen Edward MacMorland to Thomson, 10 Dec 54.

[74] Memo, Brig Gen Edward MacMorland for CofOrd, 1 Mar 44, sub: Ord Maint Responsibilities, Hist, Maint Div, III, ex. 2.

[75] Ltr, MacMorland to Thomson, 10 Dec 54.

[76] Presentation by Brig Gen James Kirk, in Min, Conf of CG's, SC's. . . , 18 Dec 42, pp. 30-31.

[77] Ltr, CG Armored Force to CG ASF, 31 Mar 43, sub: Automotive Maint, and Indorsements, 10 Apr 43, 16 Apr 43, 3 May 43, and 25 May 43, AGF 400.402 (3-31-43), copy in ASF Maint Div files, 451 Vehicles, Mar-Aug 43.

other technical service. It was like the system used by the British, who turned over all shop operations to their Royal Electrical and Mechanical Engineers (REME). It would include an automotive shop, an armament and instrument shop, a clothing and equipment shop, an electrical equipment shop, a machine shop, and a paint shop.

A survey by the ASF Maintenance Division had convinced ASF planners that the whole shop system in the Zone of the Interior was haphazard and wasteful. Of the 656 shops in operation as of 2 June 1943, 526 were under the supervision of the service commands, 89 were under the technical services, 27 under the port commands, and 14 under the defense commands. All had been established to meet the immediate requirements of each command or technical service, without coordination or any over-all policy, and there was inevitably duplication of effort and inefficient use of men and tools. ASF planners felt that shop facilities represented one of the most important fields of maintenance activity in which improvement could be effected. Accordingly, in May 1943, they drew up a plan to provide for the receipt, inspection, and repair of all Army matériel of all technical services by a shop, or group of shops, co-ordinated under the supervision of a maintenance shop officer for operation.[78]

Technical supervision of each shop in the group was to be assigned to the technical service having major interest. At Fort Knox, where the plan was tested in July 1943, the armament and instrument shop, the automotive shop, the machine shop, and the paint shop were under the Ordnance Department, the clothing and equipment shop under the Quartermaster Corps, and the electrical equipment shop under the Signal Corps. During the experiment representatives of the Service Commands and technical services visited Fort Knox, at General Somervell's direction, and submitted comments and recommendations. General MacMorland, who attended for the Chief of Ordnance, thought the combined shop operations as exemplified at Fort Knox would give satisfactory results at large posts, camps, and stations; that the consolidation seemed to have resulted in a reduction of personnel; and that the overhead would not be excessive. He recommended that the plan be tested at one large post in each service command before being adopted.[79] Tested throughout the service commands in model shops and redrafted in accordance with suggestions by service command and technical service officers, the combined shop plan was placed in effect 7 September 1943 at all posts, camps, and stations (except Class IV) in the United States.[80]

The integration was accomplished, but without enthusiasm on the part of either the service commands or the technical services; in fact, "resentment and objec-

[78] (1) Monograph, Maintenance Problems, A History of the Maintenance Division Headquarters, Army Service Forces, Apr 43–1 Sep 45 [hereafter cited as Hist, ASF Maint Div], pp. 126–30, OCMH; (2) ICAF Rpt 28, Maintenance Operations of the War Department, Apr 46 [hereafter cited as ICAF Rpt 28], 28–29, ICAF Library.

[79] (1) ICAF Rpt 28, p. 30; (2) Memo, Lt Gen Brehon Somervell for TQMG and Others, 31 Jul 43, sub: Combined Maint Shops at Posts, Camps, and Stations; (3) Ltr, Maj Gen Richard Donovan to CG ASF, 19 Aug 43, sub: Consolidation of Maint Activities at Posts, Camps, and Stations, both in ASF Maint Div files, 635 (W210–25–43), ASF; (4) Memo, CofOrd for CG ASF, 4 Aug 43, sub: Combined Maint Shops at Posts, Camps, and Stations, ASF Maint Div files, folder 635 Shops (Gen) 1943.

[80] (1) Ltr, Somervell to CG First SC and others, 7 Sep 43, sub: Combined Maint Shops; (2) WD Memo W210–25–43, 7 Sep 43.

tion," it seemed to the ASF historian, persisted throughout the life of the combined shop system. The technical services maintained that, since they were responsible for the development, procurement, and provision of spare parts for equipment, they ought also to have responsibility for maintenance. They feared that, in combined shops, operating standards would be lowered and that men belonging to one technical service would neglect the equipment of another.[81] The Ordnance position was that the same authority that controlled the supply of parts, tools, and supplies ought also to control shop operations, as was the case with their own Field Service; they had observed that the fault in the British system was that REME did not control supply. And General MacMorland "never had much patience" with the idea that Ordnance would favor its own operations to the detriment of the other technical services. In North Africa he had visited an Ordnance medium maintenance company which was busy making repairs to all types of equipment, mainly Medical Department items.[82]

Service Commanders pointed out some of the practical difficulties in operating combined shops. One could see little need for additional organization with the inevitable increase in personnel. The commanding general of the Eighth Service Command pointed out the great disparity between the amount of Ordnance maintenance and that of any other technical service. At the Camp Hood shops, for example, there were 417 Ordnance shop employees as compared with 68 for Quartermaster and 13 for Signal. At Fort Knox, four out of the six shops were under Ordnance supervision, and Ordnance had 75 percent of the personnel and 90 percent of the shop equipment. The real maintenance problem, he believed, was an Ordnance problem; the solution was to concentrate on economies in Ordnance maintenance.[83]

Some idea of the size of the Ordnance operation as compared with that of the other services is indicated by a breakdown of the 89 shops operated by the technical services before the combined shop plan went into effect: 51 were Ordnance, 12 were Engineers, 11 were Signal, 8 were Transportation, 5 were Quartermaster, and 1 each was operated by the Chemical Warfare Service and the Medical Department. Of the 526 shops operated by the service commands, 288 were Ordnance, 163 were Quartermaster, 37 were Signal, 28 were Engineers, and 10 were Transportation. Of the 14 shops operated by the defense commands, 13 were Ordnance and 1 was Signal; of the 27 operated by the port commands, 21 were Ordnance and 6 were Signal.[84] Ordnance was unsympathetic to combined shops, and opposition to them in other quarters, extending to The Inspector General's representatives, could not be overcome, in spite of the belief at ASF headquarters that the combined shops were a satisfactory and economical operation.[85] In July 1945 the War

[81] Hist, ASF Maint Div, pp. 132–33.

[82] Ltr, MacMorland to Thomson, 10 Dec 54.

[83] (1) Ltr, Somervell to CG Third SC, 28 Jul 43, sub: Consolidation of Maint Activities at Posts, Camps, or Stations, and Indorsement, 24 Aug 43, ASF Maint Div files, 635 (W210–25–43); (2) Ltr, Donovan to CG ASF, 19 Aug 43, sub: Consolidation of Maint Activities at Posts, Camps, or Stations, 19 Aug 43.

[84] Hist, ASF Maint Div, p. 128 and ex. A.

[85] (1) *Ibid.*, p. 133; (2) Interv with Heileman, 1 Sep 54; (3) Memo, Conrow, Director Maint Div, ASF, for Director of Supply ASF, 10 Jun 44, Sub: Rumors Tending to Undermine Morale within Combined Shops at Posts, Camps and Stations, and Memo for rcd, ASF Maint Div files, 635 Shops Jun–Dec 1944.

Department approved a new plan by which combined shops could be discontinued at the option of the commanding generals of the service commands and the shops could revert back to the technical services. They were retained in only two service commands out of nine, the Second and Third.[86]

The Reclamation Program of 1944

Because of confusion about the meaning of the word reclamation, the Army Service Forces in a circular dated 6 December 1943 defined it as "the process of restoring to usefulness condemned, discarded, abandoned, or damaged property, or parts, or components thereof, by repair, refabrication or renovation." By December 1943 the subject had become important enough to warrant a definition, a circular, and a program. Troops departing for the invasion of Europe left mountains of damaged weapons and vehicles at posts, camps, and stations; at the same time a trickle of unserviceable but repairable matériel was coming back from overseas.

The need for a definite reclamation program was centered in the spare parts problem. Early in 1944 inability to produce enough new trucks to meet the enormous demands of the European theater made it necessary to repair or rebuild used trucks for shipment overseas.[87] Repair and rebuild were responsibilities of the Service Commands, but Ordnance had technical supervision of the work. This involved close liaison with Service Commanders to determine the locations and quantities of unserviceable vehicles and to distribute the work among Service Command shops. Ordnance inspectors discovered that many of the vehicles designated as "ready for issue" by Service Command shops required further repair.[88]

Ordnance was also responsible for the supply of spare parts, engines, assemblies, tools, and other equipment required for the task of overhaul. To augment this supply, returned matériel centers were set up at Twin Cities Ordnance Plant in Minneapolis, at the Salt Lake Branch of Ogden Ordnance Depot, and at the Cressona Ordnance Plant in Pennsylvania. There were eventually five such plants, and by August 1945 more than 200,000 tons of equipment were being processed each month. In the reclamation of tires, production rose from 69,000 per month in 1944 to 202,000 in the month of January 1945.[89]

In spite of critical spare parts shortages and a manpower shortage caused by the shipment overseas of base shop personnel, Service Command shops and Ordnance shops were maintaining by early 1944 an excellent production rate on the overhaul of general purpose vehicles. This was

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[86] (1) Hist, ASF Maint Div, pp. 142-45; (2) WD Cir 207, 7 Jul 45.

[87] (1) Hist, ASF Maint Div, pp. 25, 29; (2) Ltr, Lt Gen Somervell to CofOrd and others, 18 Dec 43, sub: Repair of Unserviceable Wheeled Vehicles, ASF Maint Div files, 451 Vehicles, Sep–Dec 43; (3) Memo, Conrow, Director Maint Div ASF, for the Director of Supply, ASF, 17 Feb 44, sub: Repair of Unserviceable Vehicles for Overseas Shipment, ASF Maint Div files, 451 Vehicles, Jan–Mar 44.

[88] (1) Monograph No. 8, p. 82; (2) Col B. Ourisman, Final Rpt, 4 Oct 45, OCO–D Key Pers Rpts; (3) Min, Ord–SC Conf, Maint, Storage, Stock Contl and Reclamation, 8–9 May 44, p. 43, OHF.

[89] (1) Maintenance Division Annual Report for 1945. Hist OCO–D, FY ending 30 Jun 45 [hereafter cited as Ann Rpt Maint Div 1945]; (2) Ourisman Rpt; (3) A. D. Rathbone, IV, "Junk Goes Back To War," reprint from *Liberty* magazine, 10 Feb 45, OHF.

achieved by recruiting civilians on a large scale and working overtime—often on a two-shift and even three-shift basis. Beginning in January 1944, the preparation of transport vehicles for shipment overseas was the No. 1 priority job for Service Command shops.[90]

Late in 1943 Ordnance maintenance experts had to turn their attention to tanks, motor carriages, armored cars, and tracked vehicles. The need to supply overseas theaters could not be met from new production, for there had been a cutback. It could be met only by overhauling combat vehicles that had been used in training. But these were generally in poor condition, for the troops had neither the skill, the tools, nor the time to keep their equipment in good repair. Though the Chief of Ordnance recommended factory overhaul, ASF preferred Service Command Shops. The program originally provided that preference be given first to Service Command Shops, second to Ordnance Department Shops if a major overhaul was necessary, and third to commercial shops for an operation that amounted to remanufacture.[91]

But by midsummer of 1944 it became evident that thousands of combat vehicles would have to be overhauled to meet overseas requirements, and that the work could not be done by Ordnance arsenals or by Service Command shops already burdened with the tremendous job of overhauling transport vehicles.[92] Before the year was out Ordnance came to rely more and more upon contracts with commercial facilities.[93] During 1944 and 1945, out of a total of 1,248,557 transport vehicles repaired or overhauled, 74,268 were repaired at commercial shops. For the same period, out of a total of 79,653 combat vehicles repaired or overhauled, 12,476 were overhauled at commercial establishments.[94] The shift to dependence on commercial facilities for combat vehicle repair in 1945 is revealed by the fact that private organizations accounted for only 7 percent of the light tanks rebuilt in 1944, and handled 65 percent of those rebuilt in the first five months of 1945.[95]

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[90] (1) Memo, Conrow, Director Maint Div ASF, for Director of Supply ASF, 26 Feb 44, sub: Repair of Gen Purpose Vehicles for Overseas Shipment; (2) Memo for Rcd, 3 Mar 44, sub: Conf—Heileman, MacMorland, Conrow, and Col Alfred Johnson, Factory Overhaul Gen Purpose Vehicles and Combat Vehicles. Both in ASF Maint Div files, 451 Vehicles, Jan–Mar 44; (3) See also Ann Rpt Maint Div, p. 8.

[91] (1) Memo, Brig Gen John Christmas, Asst Chief OCO-D, for CofOrd, 22 Oct 43, sub: Factory Overhaul and Modernization of Tanks and Other Combat Vehicles, and Indorsements, 14 Nov, 13 Dec 43, 1 Jan 44, OO 470.8/464 Tank; (2) Memo, CG ASF for CofOrd, 6 Mar 44, sub: Factory Overhaul and Modification of Ord Matériel, OO 470.8/854 Misc.; (3) ODO 72 –44, 24 May 44, sub: Rehabilitation of Combat Vehicles.

[92] (1) Memo, Brig Gen Edward MacMorland, Chief Stock Contl Div, for CG OCO-D, 12 Jul 44, sub: Overhaul of Tank and Combat Vehicles, OO 451/2820; (2) Memo, CG ASF for CofOrd, 29 Jul 44, sub: Remanufacture of Tanks, OO 470.8/1361 Tank; (3) Memo, Brig Gen Elbert L. Ford, Chief Maint Div, for CG OCO-D, 30 Aug 44, sub: Remanufacturing Program, OO 451/2992; (4) OCO-D Historical Summary, Maint Div, pp. 13–14.

[93] (1) Hist, ASF Maint Div, p. 66; (2) Memo, Conrow for Director of Supply ASF, 16 Nov 44, sub: Additional Automotive Repair Facilities, in ASF Maint Div files, 451 Vehicles, Nov–Dec 44; (3) Memo, CG, ASF for CofOrd, 11 Feb 44, sub: Overhaul and Modernization of Motor Vehicles other than Combat Vehicles, and 1st Indorsement, CofOrd to CG ASF, 14 Feb 44, OO 451/2334; 2d Indorsement (Memo) Brig Gen Ford to CG OCO-D, 13 Dec 44, sub: Status of Rehabilitated Combat Vehicles, Misc. Correspondence re Rehabilitation Program; (4) See also Ch. XI, above.

[94] Powell MS, pp. 9, 13.

[95] Monograph No. 8, p. 83.

Trends in Maintenance Engineering

The experience of World War II led many Field Service officers to believe that some maintenance problems could have been solved by closer co-ordination within Ordnance and with the using arms. Too frequently, some experts felt, designers did not give enough consideration to maintenance problems, so that when the matériel reached the field extensive modifications were necessary. These observers were convinced that if designers gave more attention to easy removal of parts for repair and replacement the problems of field maintenance would be greatly simplified. Closer co-ordination in the preparation of Essential Extra Parts Lists (EEPL's) was also needed, as well as better and faster methods of getting maintenance publications out to the field and obtaining better information from the battlefields.[96] Late in 1943 ASF experts stressed the importance of using field experience data to determine maintenance factors, estimating that approximately 80 percent of production for 1944 and 100 percent for 1945 would be determined in that way.[97]

Improvements in maintenance were noted after 1943 when the Chief of Ordnance established maintenance suboffices at Rock Island Arsenal, Frankford Arsenal, and the Detroit Tank Arsenal. At these centers of technical information, maintenance experts studied drawings or, if drawings were not available, went to manufacturing plants and looked over the shoulders of draftsmen.[98] In addition to analyzing the designs of new matériel with an eye to improved maintainability, the suboffices also studied methods and procedures for preventive maintenance, analyzed performance of matériel in the field, issued Modification Work Orders to correct safety and functional faults, and prepared Products Correction Reports.[99] To secure firsthand information from the field, the suboffices sent out maintenance teams, first to troops in training in the United States, and later to theaters all over the world. These specialists gave instruction on the maintenance of new equipment and brought back data on previously unreported malfunctions of various types of Ordnance matériel.[100]

Among the most important engineering contributions to the preventive maintenance program were the preparation of lubrication guides for use in the field and the standardization of fuels and lubricants. Because each agency responsible for the development of weapons and vehicles in the rearmament program of 1939–40 issued its own instructions governing the use of fuels and lubricants, there were, by late 1940, more than 250 types required for Ordnance equipment. At that time the Ordnance Department began a program to reduce the number of types, and by March 1943 had succeeded in cutting down the number to 37. Another effort toward standardization was directed at lubrication fittings and grease guns.[101]

A continuing task of maintenance engineers was the analysis of reports on malfunction and failure of all types of Ord-

[96] (1) FS Ann Rpt, Jul 43, p. 10, OHF; (2) Capt Arthur G. Alen, Final Rpt, 21 Sep 45, FS Key Pers Rpts; (3) Ourisman Rpt.

[97] Memo, Maj Gen Wilhelm Styer, for CofOrd and others, 13 Sep 43, sub: Determination of Maint Factors, copy in G–4 files.

[98] (1) FS Ann Rpts, Jul 43, p. 10; (2) Monograph No. 8, p. 78; (3) PSP 57, pp. 110–12.

[99] (1) Lt Col Harry H. Needham, Final Rpt, 5 Aug 46, FS Key Pers Rpts; (2) Ann Rpt Maint Div, 1945, pp. 3–4.

[100] PSP 57, pp. 109–10.

[101] (1) *Ibid.;* (2) Monograph No. 8, pp. 78–80; (3) Hist, ASF Maint Div, pp. 259–60; (4) Alen Rpt, 21 Sep 45.

nance matériel; the conducting of tests to correct faults; and the issuance of Modification Work Orders (MWO's) to the field so that equipment could be made safer or more efficient on the spot. Men who worked closely on the very important MWO program felt that the greatest danger was the tendency to publish too many work orders. MWO's took up the time of the using troops, and it was extremely difficult if not impossible to control the parts involved and to have a central control on the modification performed.

An example of the parts difficulty is revealed in a letter General Campbell wrote to General Hughes, Deputy Theater Commander of NATOUSA, about the M6 heavy tractor for towing heavy guns: "It is a new design and, like all designs, when it reaches production and use in the field the bugs will begin to appear. Then we will make a series of changes to correct the bugs and in the meantime our spare parts will not be applicable to the latest tractor and then our troubles, as usual, will start." [102] In the last year of the war, OCO–D's Maintenance Division made a study of all work orders issued and in process, and those not considered absolutely essential to the safety of the user or the functioning of the matériel were canceled.[103]

A searching examination into all phases of maintenance after the war convinced many Ordnance specialists that tighter control and more emphasis on standardizing good maintenance practices were needed. On hardly any other aspect of Ordnance operations had there been more diverse views. There was need for careful evaluation of various theories on such matters, for example, as to whether it was cheaper in many cases to replace a damaged major item rather than to attempt to repair it, and whether it was not better to cannibalize for parts that were rarely needed, rather than attempt to supply spare parts to make any and all repairs. Acquainting maintenance engineers more thoroughly with design and production aspects of Ordnance seemed to be indicated. One tank expert at Detroit believed that obtaining men sufficiently informed in all phases of development, engineering, production, and maintenance of new matériel was one of the major problems of the war. There was a general feeling that the Ordnance Department ought to consider establishing in peacetime a more definite maintenance policy.[104]

Yet flexibility was essential, as was an open mind toward new techniques such as the spare parts ships suggested by General Campbell, the floating depots proposed in the Central Pacific area, and the plan for a maintenance-and-manufacturing center for a theater of operations worked out by Field Service's Maintenance Division.[105] Above all, good maintenance engineering depended greatly on the freest possible flow of technical information, in both directions, between the technician in the office and the soldier in the field.

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[102] Ltr, Maj Gen Levin Campbell, to Maj Gen Everett Hughes, 13 Dec 43, Gen Campbell's Personal Correspondence (Overseas Material).

[103] (1) Needham Rpt; (2) OCO–D Maint Div Ann Rpt 1945, p. 3.

[104] (1) Lt Col Louis M. Ballard, Final Rpt, 22 May 45, OCO–D Key Pers Rpts; (2) MS, Wilfred G. Burgan, The Spare Parts Problem and a Plan. Mar 48, OHF; (3) Maj William L. Drennen, Final Rpt, OCO–D Key Pers Rpts.

[105] (1) Memo, Campbell, for Somervell, 15 Jan 44; (2) Memo, Col Robert A. Case, Director Stock Contl Div ASF, for Director of Supply, ASF, 24 Jan 44, sub: ASF Spare Parts Ships, both in ASF Maint Div Files, 451.9 Spare Parts Policy; (3) PSP 57, pp. 133–34; (4) MS, Lt Col Charles R. Petticrew, Ordnance Floating Depots, 10 Sep 45.

CHAPTER XXIII

Conclusion

Appraising the Record

In the months and years that followed the defeat of Germany and Japan, the wartime leaders of the Ordnance Department looked back upon their achievements with a keen sense of satisfaction. They felt they had made a significant, if not always fully appreciated, contribution to victory. General Harris was outspoken in his praise of the Ordnance record on procurement; General Crain and General Hatcher were equally emphatic about the Ordnance Department's success with storage, issue, and maintenance. General Campbell wrote a book to eulogize the "Industry-Ordnance Team" and to portray its war record as "an epic of industrial accomplishment which had never been equaled in the history of the world." No less laudatory was the volume on research and development that appeared in 1947 over General Barnes' signature, *Weapons of World War II*. In reviewing the advances in weapons made during the war General Barnes gave a special salute to science, allotting credit for "results far beyond our expectations" to "the Science-Industry-Ordnance team," thus introducing a term that was to gain wide currency in Ordnance circles after the war.

The farther one moved from the immediate staff of the Chief of Ordnance the more frequently one heard notes of criticism in the postwar years. General Burns, who viewed the Ordnance Department during the defense and war periods from the offices of the Assistant Secretary of War and the Lend-Lease Administrator, spoke highly of Ordnance procurement plans and operations, but in postwar interviews he expressed disappointment that Ordnance leaders had not been sufficiently "international-minded" to appreciate the needs of allied nations. Officers who had served in ASF headquarters went much further in their criticism. They conceded that in many areas Ordnance had done an excellent job, but they complained that most influential Ordnance officers resented staff supervision and did not make good team players. Combat commanders overseas usually spoke well of the Ordnance equipment and support they received, but they sometimes voiced criticisms. Some complained that American tanks were no match for the enemy's; others denounced the Ordnance failure to provide combat troops with the ammunition they needed; still others castigated Ordnance for failing to provide enough spare parts for maintenance. General Niblo, an Ordnance officer with long experience overseas, found many points at which Ordnance service in the field needed improvement.[1]

[1] The activities of Ordnance units overseas form the theme of the volume by Lida Mayo, The Ordnance Department: Ordnance Overseas, a volume in preparation in the series UNITED STATES ARMY IN WORLD WAR II.

In any attempt to review and evaluate the Ordnance record on the procurement and supply fronts, one fact stands out clearly and serves as a point of departure: much of what the Ordnance Department did in World War II was an outgrowth of its experience in World War I. Most of the senior officers of the Department in World War II were men who still remembered their own successes and failures in World War I. Major elements of the Ordnance organization had been created during or immediately after World War I. The Field Service Division, for example, was a direct outgrowth of World War I, and its chief in the 1940–42 period, General Crain, brought to his office valuable experience gained as a young officer with the AEF. The Ordnance district offices had first been established in 1918 to relieve the congestion that hampered procurement officials in Washington. Though closed for a time after the Armistice, they were soon reopened on a skeleton basis in the early 1920's and became permanent elements of the Ordnance Department. Within the limits of their meager budgets, the district offices—with their unusual combination of military and civilian leadership—kept in touch with industries capable of conversion to munitions manufacture. They were not strong in 1940–41 when the need again arose for placing huge contracts with industry, but they were in existence and were rapidly expanded.

Outside the official hierarchy, but of great importance to it, was the Army Ordnance Association, also an outgrowth of World War I. Founded in 1919 as a voluntary association of American citizens (headed by Benedict Crowell, wartime Director of Munitions) to promote "industrial preparedness for war as being one of the Nation's strongest guarantees of peace," it provided influential civilian backing for Ordnance interests. Through the meetings of its many local posts and special committees, and through its magazine, *Army Ordnance,* it helped foster an interest in industrial preparedness and in the training of Ordnance reserve officers.

The manufacturing arsenals of the Ordnance Department antedated World War I by many years, Springfield Armory tracing its history back to the days when George Washington was President. Though starved for funds during the 1920's and 1930's, they managed to preserve some munitions manufacturing capacity for a nation that vainly hoped it would never again have to resort to war. Because the Ordnance budget was so low during the interwar years the arsenals were unable to replace equipment that wore out or became obsolete; they soon fell behind the rapidly advancing American technology. When the nation began to rearm in 1940–41, the arsenals were far from modern and their staffs were depleted. They nevertheless proved their value as the "Regular Army of production," carrying the load almost single-handedly while civilian industry was tooling up to make guns, ammunition, and tanks. For many months during the so-called defense period before Pearl Harbor, Frankford Arsenal was the sole source of small arms ammunition for the U.S. Army, and Springfield Armory was the only producer of the new M1 rifle. Meanwhile, the arsenals helped in another way: they opened their doors to engineers from industry and made available to them Ordnance drawings, specifications, and descriptions of manufacture. It is impossible to calculate to what extent the process of rearmament would have been delayed had there been no arsenals, but there certainly would have been some

delay. During an assessment of the value of the arsenals the question may well arise as to how the war might have turned out if the June 1944 invasion of the continent had been held up even for six months and Germany had meanwhile pushed forward with its atomic research and its development of V–2 weapons.

Along with developments based on the past came new factors that sprang from the experience of World War II itself. Most notable, perhaps, was the emergence of the Technical Division (later named Research and Development Division) as a major organizational element on a par with the Industrial Division and Field Service Division. Under the energetic leadership of General Barnes, it gave recognition to the increasing importance of science and technology in the development of modern weapons. At the other end of the development-procurement-supply chain were the greatly expanded activities of Field Service with scores of new storage depots, a vast bookkeeping operation, and complex problems of organization and management. Other new developments on the organizational side were the steady trend toward decentralization, the delegation of more and more responsibility to the arsenals and district offices, and the creation of new field agencies such as OCO–Detroit and the St. Louis office of the Field Director of Ammunition Plants. There were two factors working toward decentralization: one was the vast size of the Ordnance task, demanding that it be broken up into small pieces; the other was the congestion and lack of office space in Washington. Even after completion of the Pentagon in 1942, office space in the Washington area remained at a premium, and the need to check the trend toward concentrating authority at the seat of government became daily more urgent.

Impetus for the one most important decentralizing move came with the transfer from the Quartermaster Corps to Ordnance of responsibility for motor transport vehicles in 1942. No other organizational change during the war had such great impact on Ordnance. The transfer affected some four thousand contracts valued at $3 billion. It brought into the Ordnance supply system a great variety of civilian-type vehicles, enormously complicated the task of supplying spare parts for maintenance, and made Ordnance procurement equal in dollar value to the procurement of all the other technical services combined. The acquisition of new storage space made the Ordnance Department the largest warehouse operator in the world.

To keep the decentralization picture in perspective it should be noted that Ordnance had adopted a policy of decentralized operations long before 1942. The storage depots and the six "old line" manufacturing arsenals—Springfield, Watertown, Watervliet, Frankford, Picatinny, and Rock Island—were historic examples of decentralized operations under centralized supervision. After the procurement district offices built up their staffs in 1940–41 and assumed authority to make contracts, they, too, represented a major delegation of authority by the Chief of Ordnance. They placed a large measure of procurement authority in the major industrial areas of the nation, close to the industrial firms that were to sign Ordnance contracts.

The other side of the organizational coin was represented by the new Army Service Forces, created early in 1942 to provide for all the technical services more supervision and control than that to which they had formerly been accustomed. In

both procurement and supply ASF and its commanding general, Brehon Somervell, exerted a good deal of influence on the Ordnance Department. The decision, for example, to transfer trucks from the Quartermaster Corps to Ordnance was essentially a Somervell decision. On the supply side, it was ASF that directed the redistribution of depot space in 1943 and in 1944 established new and lower stock levels. In fact, of the many Ordnance activities, there was scarcely any major aspect that was not touched by ASF in one way or another. It was almost inevitable that friction should result from the sudden imposition of unwonted controls. Ordnance leaders were, to some extent, set in their ways and reluctant to change; they were also able, strong-minded men with long years of experience. They resented supervision by management experts who, in their opinion, had little or no technical knowledge of the procurement and supply of munitions. Yet one of the worst mistakes made by Ordnance itself early in the war period was placing too much faith in civilian supply experts unfamiliar with military procedures.

Ordnance procurement officers took special pride in their prewar planning; they felt that it had contributed greatly to the success of the Nation's rearmament, especially in the 1940–41 period. General Wesson, General Harris, and their associates were convinced that maintenance of the arsenals and district offices in time of peace paid big dividends in 1940 and 1941. Ordnance leaders steadfastly maintained that surveys of industry, accepted schedules of production, educational orders, and production studies proved their value at the start of the rearmament drive by saving the all-important commodity, time. In spite of objections raised by some observers that the prewar plans were valueless because not followed to the letter, the evidence suggests that the planning was well conceived and proved more helpful in Ordnance than in the other technical services. Had the planners been given more public support and more funds to work with, the results of their efforts would have been even more apparent.

One of the hardest things for General Wesson and his staff to accept in the 1940–41 period was the low priority assigned to Ordnance procurement. In an economy where priority ratings were more important than money, the Ordnance Department found that it had to take third place, ranking below both the Navy and the Army Air Forces. "We were so far ahead of the rest of them in our advance planning," some Ordnance officers commented, half in jest, "they had to hold us back to let the others catch up." Because the nation's strategic position in the 1940–42 period led to emphasis on air power and sea power, the Ordnance procurement effort, being geared mainly to supply of the ground army, had to take a back seat. Its rate of progress was thus inescapably slowed.

A notable Ordnance procurement innovation in World War II was the widespread use of government-owned, contractor-operated (GOCO) facilities. Plants and works of this type were needed chiefly to make powder and explosives and to load ammunition. As there were no civilian plants that could readily be converted to these purposes, nor any appreciable opportunity for commercial profit in the peacetime manufacture of military ammunition, such plants had to be built by the government if they were to be built at all. Broadly speaking, the experiment with GOCO facilities was highly success-

ful. Ordnance managed to recruit competent firms to operate the plants; it strictly enforced safety regulations with excellent results; it achieved quantity production, a high level of quality, and steadily decreasing costs. The main criticism of the GOCO contracts was that they were sometimes too liberal in permitting contractors to make profits that were out of proportion to services rendered.

The chief blot on the artillery ammunition record was the failure to provide enough heavy artillery ammunition for the invasion of Europe. It was not a failure on the production front but a mistake in planning. During the early months of the war, top Army planning agencies decided to put their faith in light and medium artillery, and aerial bombing. To a large extent their faith was justified. But heavy artillery was needed, too, and, when an urgent demand for big guns and ammunition came in 1944, Ordnance was unable to produce them overnight. Ordnance officers who had for many years been heavy artillery advocates were keenly disappointed that the demand for it came late in the war and had to be handled on a "blitz" basis. With heavy tanks and heavy-heavy trucks the story was much the same.

These examples illustrate the importance of sound strategic planning and accurate forecasting of future requirements. On this point, all Ordnance leaders were in agreement at the end of World War II. Some considered requirements as the Number One problem of the Ordnance Department; others rated it somewhat lower; but all recognized its great importance. They also recoganized that it was an extremely difficult problem to deal with. No matter how imaginative and farsighted the planners might be, there were always unforeseen twists and turns in the course of events. The Army high command, Ordnance leaders said in effect, with help and advice from Ordnance, must plan ahead, determine long-range production goals, and then stick with them. Given time and money, they said, there was nothing they could not produce—but the manufacture of fighting equipment would take both time and money and must be planned for long in advance. Changes in the plan could and must be made to keep production in step with battlefield needs, but changes must be held to a minimum and approved only after careful study of all factors in the situation.

Among the mistaken overestimates of requirements, the Ordnance Department objected most strongly to those for small arms ammunition and tanks. The goals set for both early in 1942, while the shock of Pearl Harbor was still fresh and British needs were being dramatically revealed by Churchill and his advisers at White House conferences, soon proved to be completely unrealistic. As Ordnance leaders warned at the time, some of the productive capacity built at great expense during 1942 proved to be unnecessary even before the year was out.

The same was true of storage depots, but here it was Ordnance rather than the Army staff that set its sights too high. Given a relatively free hand in 1940–42, Ordnance built more depots than it needed. ASF then stepped in, redistributed the excess capacity, and allocated storage space on an Army-wide basis.

In striving for efficient operation of its vast supply and distribution system, Ordnance found that many factors had to be considered. Nearness of depots to manufacturing plants had to be weighed against nearness to ports of embarkation; the de-

sirability of vast desert tracts for safe, dry storage had to be balanced against the problem of labor shortage in such areas. The integration of the storage space acquired from the Motor Transport Service in 1942 called for a good deal of reshuffling, as did the ASF-directed redistribution of excess capacity in 1943. On top of all this, Ordnance was justly criticized for making too frequent changes in depot missions, with resultant expense and loss of efficiency during the periods of changeover. The Master Depot System of 1943 was an ambitious plan to put Ordnance storage operations on a sound basis, but it worked no miracles.

Of all the many categories of Ordnance items, spare parts for vehicles caused the most trouble, in both procurement and distribution. The trouble originated with the Quartermaster Corps' losing battle during the 1930's to standardize Army trucks. The transfer of transport vehicles to the Ordnance Department in the latter half of 1942 made it necessary for Ordnance suddenly to assimilate a vast number of unfamiliar items. Before that time nearly everything procured by Ordnance had been a military item designed under Ordnance supervision exclusively for military use. With the exception of tanks and a few special articles such as new fire control devices, Ordnance had many years of experience on which to base its estimates for replacement parts. As a result, the wartime supply of spare parts for weapons —"shooting ordnance"—was usually adequate. But with military trucks the situation was much different. In the first place, trucks were basically civilian vehicles converted to military service; they were manufactured in many different makes and models with a bewildering variety of parts and parts numbers. Second, the Army had only limited experience in the field maintenance of a truck fleet.

To one not familiar with the complexities of automotive spare parts, the assigning of a name and number to each part as a means of identification would seem to be a fairly simple task. But in World War II it was far from simple, partly because of the vast number of parts made by many different manufacturers — some interchangeable, some not—and partly because Ordnance was in the throes of adapting its parts numbering system to electrical accounting machines at the time the truck transfer brought in some hundred thousand additional parts. The "Numbers Racket," as Ordnancemen dubbed this problem, caused endless trouble and was still not solved at the end of the war. Some vehicle parts masqueraded under many "aliases" as well as under their basic names and numbers. As a result, vitally needed spare parts could sometimes not be found because, for lack of a good numbering system, they were "lost." The one most effective step toward solving the problem was the compilation of many volumes of interchangeability data known collectively as ORD 15, supplemented by ORD 14 for combat vehicles and ORD 5 for tools.

On the procurement side, Ordnance recognized early in the defense period that production of spare parts had to be given just as high a priority as production of complete items. The principle was sound enough but it was not easy to apply, particularly as the procurement people did not see eye-to-eye with the supply people. Requirements for spare parts were based at the start on educated guesses and had to be adjusted later as field experience data became available for more accurate forecasting. How far to go in the direction

of supplying all types of parts for all types of equipment was another unresolved problem at the end of the war.

When it received responsibility for transport vehicles in September 1942, Ordnance was fortunate in one respect: the worst of the procurement crisis was over. The Quartermaster Corps had gone through a trying period since the summer of 1940, laying the groundwork for a large-scale truck procurement program; soon after Pearl Harbor steps had been taken to harness the automotive industry to the war effort. By the fall of 1942 three remarkably successful vehicles were either in production or ready for production—the 1/4-ton jeep, the 2-1/2-ton truck, and the 2-1/2-ton amphibious Dukw. The one serious lack was in heavy-heavy trucks, for which the using arms then foresaw no great need. Though total truck production was high all during the war, it nevertheless lagged behind schedule year after year, especially in the heavier types.

Among the most successful devices Ordnance developed to break bottlenecks, speed production, and promote cooperation among contractors in the automotive industry, and all other industries, were the many integration committees formed during the war. Fully protected from prosecution under the antitrust laws, these committees formed meeting grounds where representatives of all the firms making a certain product could discuss their manufacturing problems, exchange ideas, and arrange for temporary loans of materials, machinery, or production experts. Countless production problems were settled in committee meetings by the men best qualified to deal with them. Closely related to the integration committees were the machine-tool panels formed in the Ordnance districts to help remedy the lack of new machine tools by bringing to light the existence of used tools or recommending alternative types.

Stock control appeared as a new term in the military vocabulary during World War II. It described an activity that was, in essence, as old as war itself—the maintenance of an orderly flow of supplies to troops. But the magnitude of the supply task in World War II introduced the need for elaborate procedures to keep records on hundreds of thousands of separate items destined for shipment to troops in all parts of the world. Had Ordnance given more attention during the 1930's to adapting the Ordnance Provision System to sudden wartime expansion, or had it set up a training program for new Field Service employees in 1940, some of the delays and difficulties experienced in this area in World War II might have been avoided. The influence of ASF on Ordnance stock control methods came too late in the war to be of great value, but the experience pointed up lessons for the future.

The Ordnance Department, and the Army as a whole, learned much about maintenance during the war, particularly maintenance of trucks and tanks. Long before World War II a tradition of good maintenance practice had been well established in the Army, reaching from the soldier's daily care of his rifle to the proper upkeep of buildings and grounds. But the rapid expansion and mechanization of the Army during the 1940's, and the influx of millions of raw recruits led by inexperienced officers, brought neglect of equipment maintenance. A profligate and irresponsible spirit pervaded many units. Regardless of the administrative problems relating to echelons of maintenance and the control of repair shops, the one lesson

of the war that stood out above all others, from the maintenance point of view, was that troops must learn maintenance discipline as well as combat discipline. Illness and death caused by disease can cripple an army as effectively as wounds inflicted by shot and shell; vehicles with broken springs or burned out bearings caused by neglect or rough handling can halt an advance just as surely as damage from enemy action.

On the procurement front, the Ordnance Department, acting almost entirely on its own initiative, did some significant pioneering work in applying the techniques of statistical quality control to acceptance inspection. Here, as with so many other Ordnance activities, the seeds were sown during the 1920's and 1930's. Progress was slow during the prewar years, partly because the need for new inspection methods was not urgent and partly because few Ordnance officers were enthusiastic about statistical sampling techniques. But, with the coming of war production on a tremendous scale, the theories of Col. Leslie E. Simon and others were put to the test, in a few limited areas at first, and then with gradually widening usefulness. They helped make Ordnance inspection more efficient and rational, and shifted to the contractor more of the responsibility for quality production.

In its speedy termination of contracts Ordnance set a record of which it could well be proud. With the approval of the War Department, and in consonance with acts of Congress, it worked out—long before the war ended—enlightened plans for terminating and settling contracts without elaborate and time-consuming audits. Speedy contract termination not only promoted good will in the business community but also helped the nation make the difficult transition from war to peace without suffering a postwar depression.

Though Ordnance officers seldom mentioned it as anything remarkable, the Ordnance Department's record of honesty was certainly noteworthy. Ordnance procurement officers placed contracts for billions of dollars worth of war matériel with thousands of industrial firms, both large and small, without any taint of graft or corruption. In all the Congressional investigations of irregularities in wartime procurement, no evidence was uncovered to show that any Ordnance officer or civilian employee profited from double dealing. Ordnance procurement was sometimes criticized on the ground that it was too slow, too cumbersome, or too favorable to big business; but it could not be criticized for lack of integrity. The mistakes made appear to have been honest mistakes, not fraud. Most Ordnance leaders apparently saw nothing remarkable in this fact; they simply took it for granted as being the least that was expected of them.

Looking to the Future

Long before the war was over, General Campbell gave serious thought to the form the postwar organization of the Ordnance Department should take. As early as January 1944 he appointed a board of officers headed by General Harris to study the matter and prepare recommendations. General Campbell described his thinking on the matter as follows:

> As the outcome of the war became apparent I considered that it might well be of great value to the future of the Department and of value to the Army and the country if a Board composed of men who had been through the Ordnance job from the declaration of war, and who were to continue as an active part of the Department until the

War's end and possibly beyond that period, were to study and report upon the future organization of the Department and its personnel. I thought that the recommendations of these men, many of them of long experience, all of whom were engaged in the successful operation of the Department, would be of more value and would be better founded in fact than observations to be made after the war by officers returning from overseas who had not been connected in any way with the Industrial and Field Service front.[2]

During February the board's preliminary report was distributed for comment to six general officers, most of whom gave it their approval, and on 12 May the final Harris Board Report was placed on General Campbell's desk.[3]

This report recommended that the Ordnance headquarters consist of five major services closely comparable to the existing services and staff branches. The Military Service was to combine the Military Plans and Training Service with the Military Personnel Branch; the Administrative Service was to be made up of five existing staff branches—Legal, Fiscal, Plans and Requirements, Civilian Personnel, and Control. Both of these services were to report directly to the Chief of Ordnance, but the other three services, to be known as Research and Development, Procurement (formerly Industrial), and Supply and Maintenance (formerly Field Service), were to be responsible to a Deputy Chief of Ordnance for Matériel Services. The Board recommended creation of this position of Deputy Chief to relieve the Chief of Ordnance of the responsibility for supervising all the activities of the Department, and thus allow him more time to confer with chiefs of the using arms, with representatives of higher headquarters, and with committees of Congress, to study ways and means of strengthening the Department, and to consider the assignment and promotion of key personnel. It was also felt that the position of Deputy Chief would "tend to break down some of the present dividing lines" between the major operating divisions.[4]

The most important recommendation of the Harris Board was for the establishment of six decentralized Product Centers, each with full responsibility for design, procurement, storage, and maintenance of a certain class of matériel, and with jurisdiction over all arsenals, plants, and depots dealing with such matériel. "The finally accepted organization," the Board reported, "must be based upon product lines, with strong centralized control, and complete integration by product, from design to obsolescence." The six Ordnance establishments proposed by the Board as Product Centers were the following:

Springfield Armory	Small Arms and Small Arms Ammunition
Rock Island Arsenal	Artillery
Frankford Arsenal	Fire Control
Indiana Ordnance Works	Ammunition
Augusta Arsenal	Troop Equipment and Miscellaneous Supplies
Detroit Tank Arsenal	Tanks and Transport Vehicles

The recommendations of the Harris Board thus combined the functional and

[2] Ltr, Campbell to Thomson, 7 Sep 49, OHF. See also Memo CofOrd for CG, ASF, 13 Aug 43, sub: Prod, OO 400.12/9396, and Memo CG, ASF, for CofOrd, 21 Aug 43, sub: Prod, OO 400.12/9461.

[3] Report of the Committee on Post-War Organization of the Ordnance Department, 12 May 44, OHF. The Harris Board was appointed by Ordnance Special Order 14, 17 January 1944, and consisted of Generals Harris and Armstrong, Col. Philip R. Faymonville (vice General Safford, relieved), and Colonels Clarence E. Partridge, Reed, Raaen, and Gerson K. Heiss.

[4] Ltr, Boatwright, OCO-D, to Campbell, 22 Mar 44, OHF.

the product types of organization, but with far greater emphasis than had ever before been given to decentralization along product lines. The five services proposed for the Office of the Chief of Ordnance were functional in nature, but they were to be strictly limited to staff work and were not to engage in actual operations. The six Product Centers were to be the main operating divisions. Just as the Tank-Automotive Center had become a decentralized and semiautonomous organization specializing in the development, production, and distribution of one broad class of matériel, so each proposed Product Center was to become a decentralized headquarters specializing in one class of ordnance.

The broad principles of the Product Center idea were accepted by many Ordnance officers during the 1944–45 period, but there were differences of opinion as to how the six proposed Centers should be administered. In March 1944, for example, when General Hayes was asked to comment on the Harris Board's preliminary report, he declared: "I think that the Product Centers are a very fine idea, and they are probably essential to the further healthful development of the Ordnance Department. As shown on the chart, however, I am not sure exactly how they will work because they seem to have too many bosses, i.e., Chiefs of all Services except the Military Service. . . ." [5] General Barnes and Safford expressed similar views.

There was also disagreement as to the most desirable locations for the six proposed Product Centers. In September 1945 six committees were appointed to study this matter and make recommendations as to which Ordnance installations were best suited for use as Product Centers. These committees agreed with the recommendations of the Harris Board on only two Centers—Rock Island for artillery and the Detroit Tank Arsenal for tanks and other vehicles. For small arms they chose Frankford rather than Springfield, Picatinny rather than Indiana Ordnance Works for ammunition, Pottstown Depot rather than Frankford for fire control, and Raritan instead of Augusta Arsenal for troop equipment.[6]

In addition to its specific recommendations for organizational changes, the Harris Board laid down certain fundamental principles of organization to guide the future development of the Department. First and most fundamental was the principle that the technical services should continue to exist. "The successful prosecution of any war effort," the report stated, "can be obtained only by retaining the Technical Services as entities in the postwar organization of the War Department." The second principle was that the peacetime organization of the Department should be capable of handling the wartime mission simply by expansion, without a major organizational change. The third principle was that the Department should be organized along product lines, with decentralization of operations to Product Centers. The Harris Board also recommended that the Ordnance Districts be continued as the procurement agencies of the Department, that the existing Industry-Ordnance Team be maintained, and that the manufacturing arsenals "return to their pre-war role of keeping alive those phases of munitions art that do not have a commercial counterpart."

[5] Memo, Hayes to Campbell, 17 Mar 44, OHF.
[6] Memo, Christmas for Sayler, 2 Oct 45, sub: Product Organization of Ord Dept, OHF. Reports of the six committees are also in OHF.

The recommendations of the Harris Board take on added significance when they are compared with the trend of thinking within the Army Service Forces. The proposal that the Ordnance Department be organized along product lines ran directly counter to the prevailing opinion in the ASF that the technical services should be organized on a functional basis. During the preceding summer, General Somervell's staff had drafted a plan for the complete reorganization of the ASF, abolishing all of the technical services and merging their functions in various divisions within the ASF headquarters.[7] All research, development, and procurement activities of the technical services would have been centralized in one ASF division, all transportation in another, all supply in another, and so on. At the same time, the field establishments of all the technical services, including the Ordnance Districts, arsenals, and depots, would have been absorbed by the headquarters of the Service Commands in which they were geographically situated.

General Somervell and his staff vigorously pushed this reorganization proposal during the summer of 1943, but when it was finally referred to the Secretary of War in September he refused to approve it. As explained in his published memoirs, Stimson "was prepared in general to accept Somervell's judgment that his proposed changes would in the end increase the efficiency of the Service Forces, but it was a grave question whether the improvement would outweigh its concomitant disadvantages in the creation of bad feeling." [8] Stimson knew from experience "how deeply imbedded in sentiment the services of the Engineers, Ordnance, and Quartermaster are in the memories of all the people that belonged to them, and the tremendous uproar that would be created if we tried to destroy all that sentiment by wiping out the distinction of the services with their insignia, etc." Stimson also knew that the technical services had done outstanding work in organizing production for war and specifically noted the high quality of General Campbell's performance. He therefore opposed "stirring up a hornet's nest right in the middle of the war when things are going well."

The Harris Board was appointed just three months after this rejection of the ASF reorganization plan by the Secretary of War. The Board's conclusions were diametrically opposed to the ASF proposals, and represented the point of view held by most high-ranking Ordnance officers. As a result of wartime operational experience, leaders in the Ordnance Department had become convinced not only that the traditional product basis of the technical services should be preserved but also that the internal organization of each service should be along product lines.

General Campbell was in full agreement with the recommendations of the Harris Board, and in May 1945 directed a memorandum to the chiefs of his staff divisions announcing that the Harris Board report was to be the basis of all planning of postwar organization within the Depart-

[7] For a description of this plan, see Millett, *The Organization and Role of the Army Service Forces*, Chapter XXIV. Another similar proposal was advanced in 1944 by the ASF Control Division, but was not accepted by the Under Secretary of War. This plan would have retained the names of the technical services but would have assigned all procurement to Ordnance, all storage and distribution to Quartermaster, etc. Organization of the ASF in the Post-War Military Establishment, 15 Jul 44, ASF Contl Div files, 020.

[8] Stimson and Bundy, *On Active Service in Peace and War*, p. 452.

ment.[9] But he decided against any attempt to revamp the organization of the Department along such lines while the war was in progress. As a result, no major changes occurred before the surrender of Japan in August 1945. Even then there was no sudden reorganization, but only a reduction of staff, a gradual consolidation of administrative groups, and the elimination of specialized branches that were no longer needed.

After the war the Ordnance Department did not settle down immediately to a quiet life of peacetime routine. Too many startling new developments were in the air. In the closing months of 1945 it was widely felt that the atomic bombs that had blasted Hiroshima and Nagasaki had ushered in a new era in the history of war, or indeed in the history of mankind. The new forces miraculously unleashed from the nucleus of the atom made the power of TNT suddenly appear puny and outmoded. At the same time, the future possibilities of long-range rockets and guided missiles were taking definite shape. Even without the atomic bomb these new devices were in themselves sufficient to mark a major turning point in the long history of weapons. Some Ordnance men were momentarily stunned by the thought that rockets might some day render all existing artillery obsolete. Was the era of guns and howitzers that had opened about the time of the battle of Crécy in 1346 now about to end after six long and turbulent centuries? Were small arms and tanks to be of any military value in the future? In the face of the onrushing weapons revolution, would any of the arsenals save Redstone be able to hold their positions? If future wars were waged with long-range missiles carrying atomic warheads and lasted only thirty days, as some predicted, where was the value of procurement planning? Of what use were production plans or factories designed to swing into war production after from three to six months of conversion time? Would it ever again be possible to concentrate great quantities of supplies in huge depots of the World War II type, either at home or overseas? Would all the experience of that war have any relevance at all to the atomic war of the future?

These and many other questions went through the minds of the Ordnance officers and key civilians who remained in service after the war. There were no sure answers immediately forthcoming. It seemed to many Ordnance men that they had successfully concluded one war, with prodigious effort, only to find themselves confronted with a host of new, baffling, and yet challenging problems.

The situation was in some respects not unlike that following the Armistice of 1918 when the armored tank and the airplane appeared as dread new devices that threatened to change altogether the nature of war. People had said then, as they were saying in the fall of 1945, that war had become too terrible to contemplate and ought to be outlawed by international agreement. The older Ordnance leaders could remember the earlier years; their experience during the 1930's had left them with little faith in leagues of nations; they found it hard to comprehend the magnitude of the new weapons. The younger men paid little heed to philosophical principles; they turned their attention to the immediate problems at hand, began to pick up the scattered pieces left by the departing armies, and worked to master the techniques of the new science of war.

[9] Campbell. *The Industry-Ordnance Team,* p. 444.

Bibliographical Note

As a starting point for their research on this volume, the authors turned to the extensive collection of World War II records, both classified and unclassified, in the Historical Branch of the Executive Office, known as the Ordnance Historical Files (OHF). Here they found a comprehensive series of typewritten historical reports submitted quarterly during the war to the Historical Branch. These reports had been prepared by the division and staff offices in the Office Chief of Ordnance and by scores of Ordnance field installations, including arsenals, depots, district offices, proving grounds, plants and works, and decentralized headquarters such as OCO-Detroit and the Field Director of Ammunition Plants in St. Louis. They were made on a quarterly basis for the war years (1942–45); those from the older installations include introductory sections outlining the prewar history, some going back for more than one hundred years. In spite of their uneven quality, these reports were of inestimable value as records of major events and as accounts of the more important problems and achievements. Their appended documents, photographs, maps, charts, and statistical tables were particularly useful to the historians, as were some of the historical narratives prepared by contractors to supplement the histories of the Ordnance district offices.

Closely related to these periodic reports are many historical monographs—generally referred to as project papers or project supporting papers. These monographs had been prepared during the war, or soon after its close, by members of the Historical Branch or by specialists in other branches of the Office Chief of Ordnance. Each monograph covers a longer time span than do the individual quarterly reports and endeavors to treat a broad topic in analytical fashion.

The Ordnance Historical Files also include a useful set of personal narratives known as Key Personnel Reports. These reports had been written at the end of the war by Ordnance officers and civilians to describe their wartime experiences. Of comparable importance are the minutes of General Wesson's regular 11 o'clock conferences at which he discussed with his staff the major problems facing the Department during the 1940–42 period. For Field Service in the 1940–41 period, Col. James K. Crain's diary was invaluable. Of special importance for the chapter on motor transport vehicles was the collection of notes and documents assembled by Herbert R. Rifkind of the Historical Branch, Office of The Quartermaster General, and turned over to the Ordnance Historical Branch.

After exhausting the OHF material on a given subject the authors turned to a variety of other sources. Most important was the collection of retired Ordnance

records, dating back to 1940. At the time of research, these records were in the custody of Departmental Records Branch (DRB) of The Adjutant General's Office. Subsequent to their use for this volume, however, this collection of records was transferred to the custody of the Federal Records Center, Region 3, General Services Administration, in Alexandria, Virginia. These records—letters, memos, reports, conference minutes, and the like—were voluminous and were not always systematically arranged for ready reference. For pre-1940 Ordnance records the authors went to the National Archives. They also made intensive searches in the retired files of the Office of the Under Secretary of War, the Army Service Forces, the G-4 Division of the War Department General Staff, the Office of The Inspector General, the Transportation Corps, the former Motor Transport Service of the Quartermaster Corps, and the War Production Board. The series of volumes known as the Quartermaster Corps Historical Studies proved useful, and the hearings of Congressional committees were invaluable. The authors also consulted copies of lectures, committee reports, and research projects in the library of the Industrial College of the Armed Forces and in the General Reference Section of the Office, Chief of Military History. One of the most useful works for the purposes of the present volume, produced by the latter Office, was *The Army and Economic Mobilization,* by Dr. R. Elberton Smith, published in 1959.

Special mention needs to be made of *Army Ordnance* (now *Ordnance*), the bimonthly publication of the American Ordnance Association, whose pages included articles written by persons with firsthand knowledge. The Historical Branch possessed a complete set of this remarkable periodical beginning with the first issue of July–August 1920. There is scarcely a chapter in this volume that is not indebted in one way or another to material first published in *Army Ordnance.*

Final and most rewarding sources for the authors were interviews and correspondence with persons who held key positions during the war, whether in Ordnance or in other branches of the Army, and some industrial contractors, all of whom had intimate personal knowledge of events. This correspondence was carefully preserved, along with interview notes, and made a part of the Ordnance Historical Files.

Glossary

AA	Antiaircraft
AAF	Army Air Forces
ACF	American Car and Foundry Company
Acft	Aircraft
ACofAS	Assistant Chief of Air Staff
ACofS	Assistant Chief of Staff
ACofOrd	Assistant Chief of Ordnance
Actg	Acting
Admin	Administration
AEF	American Expeditionary Forces (1917–18)
AF	Air Force
AG	Adjutant General
AGF	Army Ground Forces
AGO	Adjutant General's Office
AIC	Ammunition Identification Code
Ammo	Ammunition
ANMB	Army and Navy Munitions Board
Ann	Annual
AOA	Army Ordnance Association
AP	Armor piercing
APC	Automotive Production Committee
APG	Aberdeen Proving Ground
API	Armor piercing incendiary
App.	Appendix
AR	Army Regulation
Arty	Artillery
ASF	Army Service Forces
ASP	Army Supply Program
Asst	Assistant
ASW	Assistant Secretary of War
AT	Antitank
BAR	Browning automatic rifle
Bd	Board
Br	Branch
Bull	Bulletin
Bur	Bureau
CG	Commanding general
Cir	Circular

Civ	Civilian
CO	Commanding officer
Co.	Company
CofAC	Chief of Air Corps
CofAS	Chief of Air Staff
CofEngrs	Chief of Engineers
CofFA	Chief of Field Artillery
CofInf	Chief of Infantry
CofOrd	Chief of Ordnance
CofS	Chief of Staff
Comdr	Commander
Comm.	Committee
Conf	Conference
Cong.	Congress
Contl	Control
Contr	Contract
CPFF	Cost-plus-fixed-fee
DCofS	Deputy Chief of Staff
Dept	Department
Dev	Development
Dir	Directive
Dist	District
Div	Division
DNT	Dinitrotoluene
Doc.	Document
Dr	Drawer
DRB	Departmental Records Branch
Dukw	2-1/2-ton amphibian truck
EAM	Electrical accounting machines
ECO	Engineering Change Orders
Ed.	Editor
Educ	Educational
EEPL	Essential Extra Parts List
Engr	Engineering
ETO	European Theater of Operations
ETOUSA	European Theater of Operations, U.S. Army
EUCOM	European Command
Ex.	Exhibit
Exec	Executive
ExecO	Executive Office
FA	Field Artillery
FDAP	Field Director of Ammunition Plants
FEPC	President's Committee on Fair Employment Practices
Fig.	Figure

Fisc	Fiscal
FM	Field Manual
FS	Field Service
FTC	Federal Trade Commission
FY	Fiscal year
G–3	Operations and Training Division of the War Department General Staff
G–4	Supply Division of the War Department General Staff
GAO	General Accounting Office
GE	General Electric
Gen	General
GF	Ground Forces
GHQ	General Headquarters
GMC	General Motors Corporation
GO	General Order
GOCO	Government-owned, contractor-operated
Gp	Group
GP	General Purpose
GPF	*Grande Puissance Filloux*
HE	High explosive
Hist	History
HP	Horsepower
Hq	Headquarters
H.R.	House of Representatives
H.S.	Mustard gas
IBM	International Business Machines Corporation
ICAF	Industrial College of the Armed Forces
Incl	Inclosure
Ind	Industrial
Inf	Infantry
Info	Information
Instr	Instruction
Intel	Intelligence
Interv	Interview
IOC	Introduction to the Ordnance Catalog
JANASB	Joint Army-Navy Ammunition Storage Board
JTR	Joint Termination Regulations
Ltr	Letter
Maint	Maintenance
MBCA	Munitions Board Cataloging Agency
Memo	Memorandum
MDL	Maximum Distribution Level
Mfg	Manufacturing
MG	Machine gun

Mil	Military
Min	Minutes
Misc	Miscellaneous
MS	Manuscript
Msg	Message
Mtg	Meeting
MTOUSA	Mediterranean Theater of Operations, U.S. Army
MTS	Motor Transport Service
MWO	Modification Work Order
NA	National Archives
NADA	National Automobile Dealers Association
Natl	National
NATO	North Atlantic Treaty Organization
NATOUSA	North African Theater of Operations, U.S. Army
N.d.	No date
NDAC	National Defense Advisory Commission
NDRC	National Defense Research Committee
No.	Number
NRA	National Rifle Association
OASW	Office of the Assistant Secretary of War
OC	Ordnance Committee
OCM	Ordnance Committee Minutes
OCMH	Office of the Chief of Military History
OCO	Office of the Chief of Ordnance
OCO–D	Office, Chief of Ordnance–Detroit
OD	Ordnance Department
ODO	Ordnance Department Order
OHF	Ordnance Historical Files
OO	Ordnance Office
OOM	Ordnance Office Message
OP	Ordnance plant
OPM	Office of Production Management
Opns	Operations
OPSI	Ordnance Publications for Supply Index
Ord	Ordnance
Orgn	Organization
OSRD	Office of Scientific Research and Development
OSW	Office of the Secretary of War
OUSW	Office of the Under Secretary of War
OWMR	Office War Manpower and Reconversion
Par.	Paragraph
PASO	Philadelphia Ammunition Supply Office
Pers	Personnel
PL	Public Law

Plng	Planning
PMP	Protective Mobilization Plan
POW	Prisoner of War
PP	Project Paper
PR	Procurement Regulations
Proc	Procurement
Prod	Production
PSP	Project Supporting Paper
PT	Point detonating
PWP	Preliminary work plan
QM	Quartermaster
QMC	Quartermaster Corps
QMG	Quartermaster General
QMR	Quartermaster Review
Rcd	Record
R&D	Research and Development
Rds	Rounds
RDX	Research Department Explosive (cyclonite)
Ref	Reference
Regt	Regiment
REME	Royal Electrical and Mechanical Engineers
Res	Resolution
Ret	Retired
Rev	Review
RP	Research Project
Rpt	Report
Rqmt	Requirement
S.	Senate
SA	Small arms
SAE	Society of Automotive Engineers
SC	Service command
Sec	Section
SecNav	Secretary of the Navy
Secy	Secretary
Serv	Service
Sess.	Session
SNL	Standard Nomenclature List
SO	Special Order
SOS	Services of Supply
SP	Self-propelled
Spec	Special
SR	Senate Resolution
Stat	Statistical
Stat.	Statutes

Sup	Supply
Supp.	Supplement
SW	Secretary of War
T–AC	Tank-Automotive Center
TAG	The Adjutant General
TCVD	Tank and Combat Vehicle Division
Tech	Technical
Telcon	Telephone conversation
Telg	Telegram
TIG	The Inspector General
TM	Training Manual
Tng	Training
TNT	Trinitrotoluene
T/OE	Tables of Organization and Equipment
TORCH	Allied invasion of North and Northwest Africa, 1942
TQMG	The Quartermaster General
U.K.	United Kingdom
USAF	United States Air Force
USSBS	United States Strategic Bombing Survey
USSR	Union of Socialist Soviet Republics
USW	Under Secretary of War
V–E	Victory in Europe
V–J	Victory in Japan
WD	War Department
WDAB	War Department Appropriations Bill
WDBO	War Department Budget Officer
WDGS	War Department General Staff
W.P.	White phosphorus
WPB	War Production Board
WPD	War Plans Division
ZI	Zone of Interior

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The following volumes have been published or are in press:

The War Department
- *Chief of Staff: Prewar Plans and Preparations*
- *Washington Command Post: The Operations Division*
- *Strategic Planning for Coalition Warfare: 1941–1942*
- *Strategic Planning for Coalition Warfare: 1943–1944*
- *Global Logistics and Strategy: 1940–1943*
- *Global Logistics and Strategy: 1943–1945*
- *The Army and Economic Mobilization*
- *The Army and Industrial Manpower*

The Army Ground Forces
- *The Organization of Ground Combat Troops*
- *The Procurement and Training of Ground Combat Troops*

The Army Service Forces
- *The Organization and Role of the Army Service Forces*

The Western Hemisphere
- *The Framework of Hemisphere Defense*
- *Guarding the United States and Its Outposts*

The War in the Pacific
- *The Fall of the Philippines*
- *Guadalcanal: The First Offensive*
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The Supreme Command
Logistical Support of the Armies, Volume I
Logistical Support of the Armies, Volume II

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The Persian Corridor and Aid to Russia

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Stilwell's Mission to China
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The Medical Department: Medical Service in the Mediterranean and Minor Theaters
The Ordnance Department: Planning Munitions for War
The Ordnance Department: Procurement and Supply
The Ordnance Department: On Beachhead and Battlefront
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The Quartermaster Corps: Operations in the War Against Japan
The Quartermaster Corps: Operations in the War Against Germany
The Signal Corps: The Emergency
The Signal Corps: The Test
The Signal Corps: The Outcome
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The Transportation Corps: Movements, Training, and Supply
The Transportation Corps: Operations Overseas

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Three Battles: Arnaville, Altuzzo, and Schmidt
The Women's Army Corps
Civil Affairs: Soldiers Become Governors
Buying Aircraft: Materiel Procurement for the Army Air Forces
The Employment of Negro Troops
Manhattan: The U.S. Army and the Atomic Bomb

Pictorial Record
The War Against Germany and Italy: Mediterranean and Adjacent Areas
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