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NOTES ON ANTI-AIRCRAFT GUNS

Compiled at the Army War College
From the Latest Available Information

APRIL, 1917

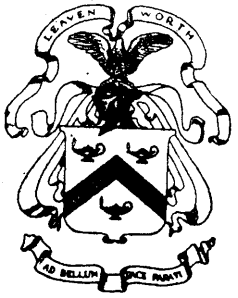
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WAR DEPARTMENT,
WASHINGTON, *April 28, 1917.*

The following Notes on Anti-Aircraft Guns are published for the information of all concerned.

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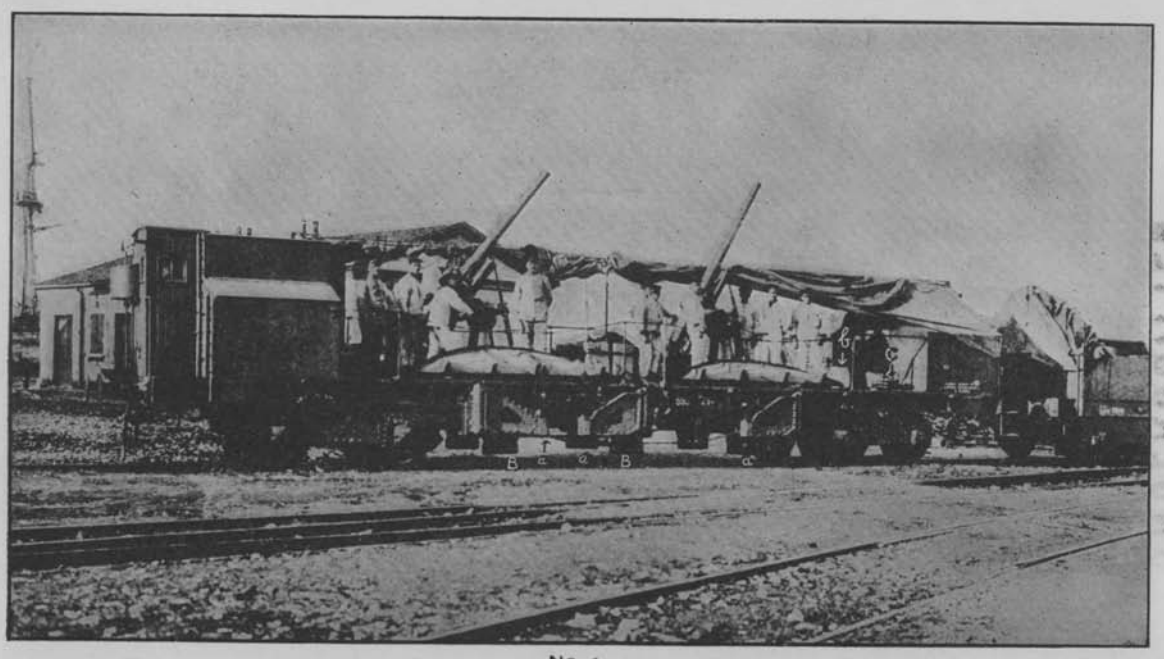
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No. 1.

ITALY.

The Italians use the 75 mm. (3-inch) Deport gun for anti-aircraft service. It has a maximum elevation of 85°, and fires 21 shots a minute. Shrapnel is considered inefficient; the high explosive shells, which are much preferred, carry either a time or a detonating fuse. The incendiary shell, used with a time fuse, throws out, upon exploding, a number of small balls containing a very efficient burning liquid. Six-gun batteries have been substituted for the formerly adopted two-gun battery.

The Italian Army in September, 1916, had 16 batteries (4 guns to a battery) of anti-aircraft guns mounted on automobiles. The gun, made by Ansaldo & Co., is of 102 mm. caliber. It is reported that the number of these guns has since been increased.

Illustration No. 1 shows an Italian flat car armed with two anti-aircraft guns. The three heavy brackets (B) are used to brace the car against recoil when the guns are fired. Before firing they are swung out at right angles to the car on the side away from the gun direction and a heavy, threaded, steel rod is screwed down through the band (a) until its lower end presses firmly against a truncated pyramidal block (b), which is placed on the ground to receive it. To facilitate rapid adjustment a detachable wheel (c) is attached to the top of the screw rod. It is believed that these braces are used only in the case of firing the heavier (6-inch) guns.

FRANCE.

The main reliance of the French for defense against aircraft is their 75 mm. gun, model of 1897, which fires 25 shots a minute and has a recoil mechanism so perfect that it can be fired continuously without relaying. This gun is shown in illustrations 2, 3, 4, and 5, but the reports show that the mountings have been modified. For anti-aircraft work this gun has been mounted in three different ways, as follows:

1. On an improvised fixed mount for the ordinary field carriage. The wheels of the carriage rest on a circular platform with a strong vertical pivot in the center. To obtain the high elevation necessary, the trail is sunk in a circular pit 32 inches below the level of the wheels. In order that the trail may not be driven into the ground, there is attached to it a chock, fitted with a traversing roller resting in the pit on a wooden traversing circle. To the pivot supporting the carriage is fixed a pivot collar which turns freely and carries four arms. To each of the two longitudinal arms is attached a tie-rod bolted at the other



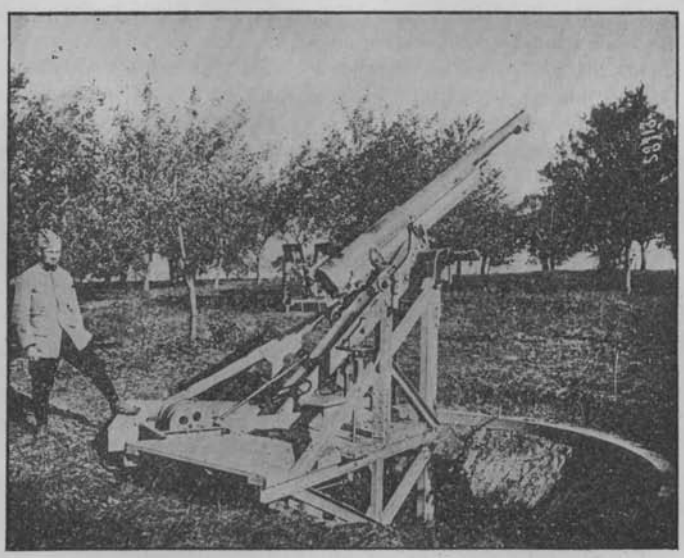
NO. 2.—FRENCH 75 MM. FIELD GUN ON FIXED MOUNTING FOR AERIAL DEFENSE OF PARIS.

end to the trail chock. These tie-rods resist the recoil of the carriage. To each of the two lateral arms is attached an elastic tie-rod fitted at the upper end with a bronze strap holding the axle of the carriage. The elastic tie-rods are equipped with spiral springs which steady the carriage. A pointing mechanism attached to the left-hand side of the trail includes a traversing wheel which actuates, by means of transmitting gears, the traversing chock roller.

The field of fire is 360°.

2. On a metallic demountable platform for the fixed defense of towns or with a modified substructure for use in the field. In the first case a concrete pit is prepared 4 meters in diameter and 1 meter deep. At the center of the pit is bolted a base plate with a socket in which turns the vertical pivot supporting the mounting.

The framework of this mounting is composed of two triangular trusses of riveted U beams in vertical planes, making an angle with each other of 30° and of two central brackets. To support the personnel, there rests on the trusses and the central brackets a flooring which is open between the brackets to provide space for the trail of the piece and for the winch used for pointing in elevation. The uprights of the two trusses are suitably cross braced, the lower brace being fixed to the pivot



NO. 3.—IMPROVISED ANTI-AIRCRAFT MOUNT FOR FRENCH 75 MM. FIELD GUN.

support. At the top these uprights are fitted with trunnion beds designed to receive the axle of the gun carriage from which the wheels, wheel brakes, and shields have been removed. The trail of the carriage is supported by a steel cable wound on the winch, which is operated by means of an elevating mechanism on the left-hand platform.

To facilitate the elevation and depression of the gun the carriage has a counterweight consisting of a cast-iron ball placed under the gun and supported from the axle of the carriage by a steel wire cable passing through a hole in the ball and held out

by means of a wooden outrigger, one end of which is placed in a recess of the counterweight while the other end is secured to the trail.

Each truss is fitted at the rear and under the flooring with a large cast-iron traversing roller, which travels on an iron traversing circle set in the exterior coping of the pit. By turning a handwheel connected to the right-hand roller, the entire framework can be made to rotate around the pivot.

Pointing in direction and pointing in elevation are distinct operations, done by separate men. For large movements in direction the mounting is pushed around by hand. The smaller movements are given by the before-mentioned traversing handwheel. The cannoneer pointing for direction is on a seat attached to the right-hand truss. In front of him, near the traversing handwheel on a sight bracket placed at the top of a column fastened to the truss, is the sight for direction, consisting of an ordinary telescopic sight provided with a deflection scale. The section commander computes the deflection from the travel of the target during the time of flight, drift, and wind. The cannoneer operating the sight is given the deflection, sets it off, traverses the carriage until the vertical cross hair is on the target, and then keeps the sight on the target.

Pointing in elevation is effected either by means of the handwheel operating the winch which revolves the entire carriage around its axle or by means of the elevating handwheel of the carriage which turns the gun on its cradle. Both handwheels are within reach of the cannoneer pointing for elevation, who stands on the left-hand platform. Elevations from 12° to 85° can be obtained.

The sight for elevation is an ordinary telescopic sight, the mounting of which is in gear with the range dial. The cannoneer at this sight keeps the horizontal wire of his sight on the target at all times by elevating or depressing the gun by means of the elevating handwheels. The range dial, about a foot to the left, is operated by another cannoneer. It consists of a small brass disk on which are curves corresponding to the different ranges. By moving the pointer along these curves to the range given, the necessary elevation is transmitted to the telescopic sight for elevation. Thus, when a change of range is announced, the gunner being already on the target, the cannoneer moves the pointer to the new range; this throws the gunner off the target, and he at once relays the piece.

The detachment consists of a chief of section and eight cannoneers viz, a pointer in elevation, a pointer in direction, a firer, a loader, a fuse setter, and three ammunition carriers.

For use in the field the substructure of this platform mount is simplified. The shape of the pit is that of a truncated cone; it is dug 1 meter deep, 1.8 meters in diameter at the bottom, and 4 meters in diameter at the top. A small parapet about 2 meters thick around the rim is formed of the excavated earth. The pivot socket is bolted to a bolster consisting of two layers



NO. 4.—ANTI-AIRCRAFT GUN ON AUTOMOBILE.

of wooden joists bolted together, and is centered in the traverse circle by 8 iron tie rods. The iron traverse circle is bolted to 12 blocks of wood.

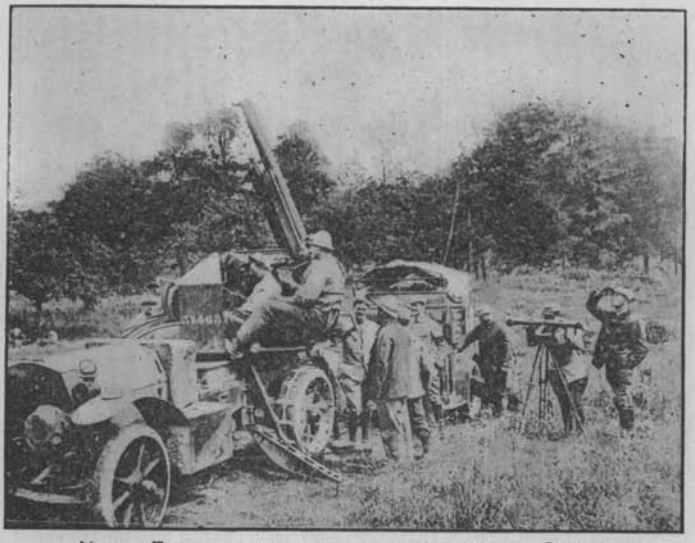
For transportation it is taken down in four parts, which can be carried in two wagons.

In mounting and dismounting the gun and carriage an assembling shears is used. The time taken is as follows: To dig ditch, 1½ hours; to mount platform, ½ hour; to mount gun, 5 minutes; to dismount the whole, 35 minutes.

3. On an automobile. To prepare for action the chassis is supported by four jack screws. In addition two side supports are lowered to the ground, to prevent overturning. The carriage permits angles of elevation from 0° to 70°. The hori-

zontal field of fire is limited to 240°, as the breach can not pass certain positions.

Until recently time shrapnel was used almost exclusively, but now the French are using high-explosive shells with time fuses. When shrapnel is used the entire percussion element is removed, for the protection of friendly troops, in case the time element of the fuse does not function. There is also a smoke-producing shell, filled with fuse composition, and the ogive is pierced with holes. It is primed with a time fuse, which communicates



NO. 5.—FRENCH OFFICIAL PHOTOGRAPH FROM THE SOMME.

flames to the interior charge, which escapes through the holes in the ogive. Thus it is possible to follow the projectile through its trajectory, which is of great assistance in anti-aircraft gunnery.

In addition to the 75 mm. gun, it is known that the French are using for aerial defense the 105 mm. gun, also the 37 mm. rapid-fire naval gun. In Paris some 37 mm. guns are on tripods, while one is in a cupola. No further information is on hand.

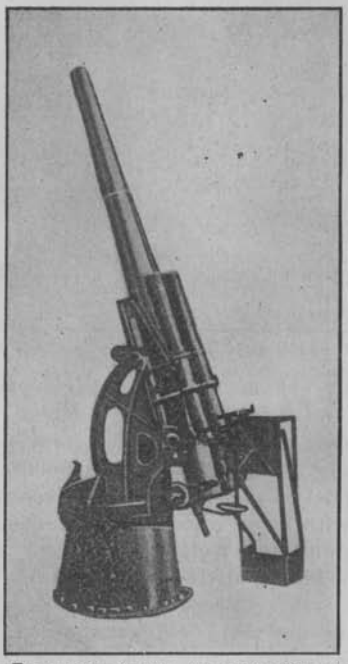
According to the latest information received on anti-aircraft guns on automobile mounts, the 75 mm. gun is used for firing a shrapnel weighing 7.4 kilograms (16¼ pounds) with a muzzle velocity of 525 meters per second (1,722 feet per second) and

a high-explosive shell weighing 5.315 kilograms (11⅞ pounds) with a muzzle velocity of 584 meters per second (1,815 feet per second). This fire appearing insufficient against aeroplanes flying at great altitudes there is now under consideration a 90 mm. anti-aircraft gun, with a muzzle velocity of approximately 750 meters per second (2,460 feet per second) for a shrapnel weighing 11 kilograms (24 pounds).

The use of the 75 mm. gun with a high muzzle velocity appears to be preferable to that of the 105 mm. with a reduced muzzle velocity.

GERMANY.

The German have used for anti-aircraft work numerous different types of guns, generally ranging in caliber from 50 mm.

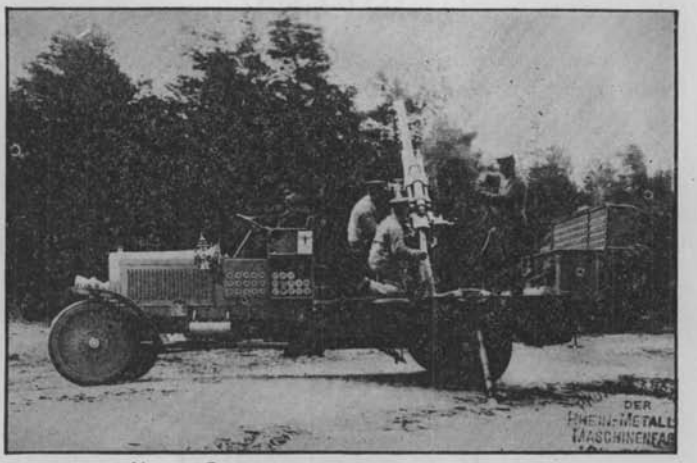


NO. 6.—EHRHARDT 65 MM. ANTI-BALLOON GUN L-35.

to 105 mm., though calibers as low as 37 mm. and as high as 120 mm. have been reported. Some of these guns had already

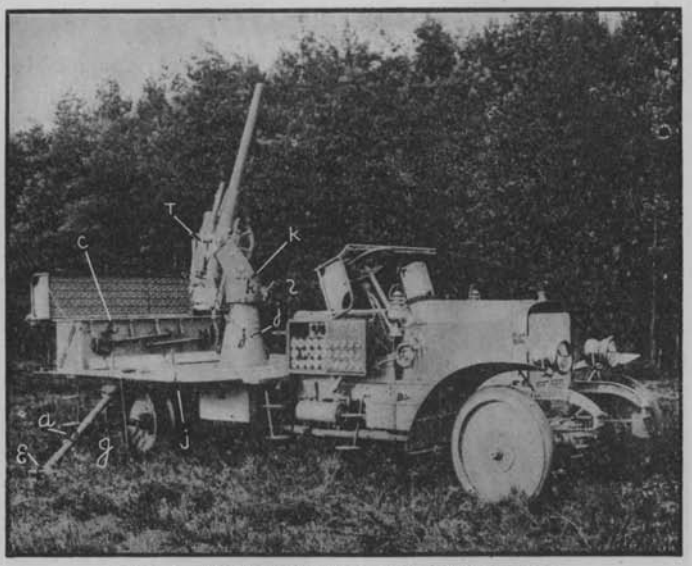
been developed before the war began, while others have since been brought out, the tendency being toward a constant increase in caliber, range, and muzzle velocity. The incomplete and sometimes more or less conflicting reports concerning some of these guns make it difficult to coordinate the data on hand, which for some guns are very meager.

The earliest German antiaircraft gun of which we have any information is the 65 mm. (2.56-inch) Ehrhardt anti-balloon gun developed several years before the war. This gun is 35 calibers long, fires with a muzzle velocity of 2,000 feet per sec-

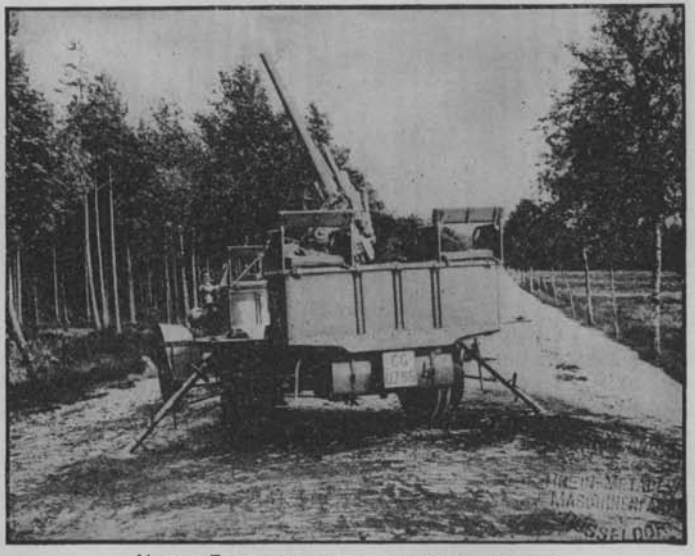


NO. 7.—EHRHARDT 65 MM. ANTI-BALLOON GUN.

ond, a 9.4-pound projectile, at a maximum elevation of 75° to a maximum height of 26,000 feet. The maximum range for time fuse is 5,960 yards, and for percussion fuse 7,760 yards. The gun has quick and slow movement in azimuth and all-around fire. It is mounted on a center-pivot cradle carriage on an automobile truck with broad wheels weighing about 7 tons (illustrations 6, 7, 8, and 9). Weight of gun and carriage is 1,900 pounds. With a level and two handwheels the upper carriage can be quickly leveled. The automobile has a wide gun platform with seats for the crew, ammunition chests for 130 rounds, and fuel tanks holding sufficient for 18 hours. In the firing position this platform is widened by dropping back its sides and is supported off the wheels by iron props resting on a broad metal base. The average speed is 50 kilometers (31



No. 8.—Ehrhardt 65 mm. anti-balloon gun.



No. 9.—Ehrhardt 65 mm. anti-balloon gun.

miles) an hour. In order to secure the necessary rapidity of fire, the breech mechanism has been provided with an apparatus for automatically opening and closing the wedge-shaped breechblock. A noteworthy feature of the gun is the automatic sight, which is so constructed that it is only necessary to set off the actual range in a straight line to the target whatever its altitude, found by means of a telemeter, and to bring the target on the cross hairs. The line of sight is capable of two movements, one which sets off the necessary angle between the

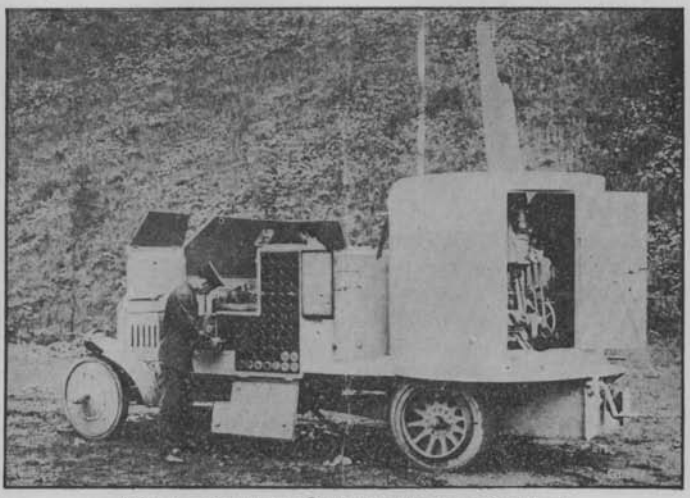


NO. 10.—KRUPP 71 MM. L-30 ANTI-BALLOON GUN.

axis of the bore and the line of sight when the target is in the horizontal and the other which corrects for the altitude of the target by automatically decreasing this angle to a theoretical zero at the zenith. There is also an automatic fuse time indicator. This is a brass plate with curves and a movable arm fixed in the trunnion opposite the sight. It is only necessary to set off the given range and lay the piece on the target, then the proper time can be read.

Another anti-aircraft gun developed by the Germans some years before the war is the 71 mm. (2.8-inch) Krupp anti-balloon gun (illustrations 10 and 11), firing 20 to 25 shots per minute.

This gun is 30 calibers long, fires with a muzzle velocity of 2,130 feet per second an 11-pound shell at a maximum elevation of 75° at a maximum height of 21,300 feet. Traverse, 360°. This gun is a barrel-recoil gun on a center-pivot carriage, mounted on an automobile which can also be armored. Weight of automobile without gun, 7,180 pounds; with gun, about 9,900 pounds; with armor and ammunition chest (carrying 122 rounds), about 15,400 pounds. Mean speed, 28 miles an hour. The gun has an automatic horizontal crank closure, rear trunnions and



NO. 11.—KRUPP 71 MM. L-30 ANTI-BALLOON GUN.

spring compensator, liquid brake, toothed-arc laying apparatus, and traversing apparatus which can be thrown out of gear for rapid movement.

It is also known that the Germans had before the war developed a 105 mm. (4.1-inch) anti-aircraft gun on center-pintle mount for fixed emplacements, with full automatic breech mechanism. Further details, however, are lacking.

A small-caliber anti-aircraft gun of high initial velocity was, according to one report, brought out by Krupp during the summer of 1915. This gun has a caliber of 53 mm. (2.09 inches) and a range of between 4,000 and 5,000 meters (13,120 feet and 16,400 feet). The initial range for firing being given the gun sights increase in range automatically 50 meters (164 feet), so

that the shells explode in series 50 meters apart. Three guns are usually placed in position together, and a zone of fire is thus established and maintained around the hostile aircraft. Several aeroplanes were brought down during that summer by this gun. No further data are available.

One report made during the summer of 1915 gives some information about the firing of a 77 mm. (3.03-inch) Krupp semiautomatic gun of about 35 calibers, mounted on a pedestal base upon a motor truck. The range finder, which was mounted on a tripod on the ground near the truck, was between 1½ and 2 meters long, and was of coincidence type, with internal and external readings. On the pedestal mount was a level, so that the mount could be leveled before firing. The sight consisted of a telescope with two eyepieces, one of low and one of high power, so close together that the eye could change readily from one to the other. In each eyepiece appeared a triangle, point up. The gun pointer brought the aeroplane within the triangle of the lower-power eyepiece, which was used as a finder, and then, shifting his eye to the high-power lens, he brought the aeroplane on the point of the triangle. The gun crew consisted of three men, one man to aim, one to load, and a third to bring the ammunition from the rack and adjust the fuses. Two officers were also present, one of whom managed the range finder, while the other gave the firing directions. Eighty-one shots at a French aeroplane at ranges increasing from 3,600 to 7,100 meters were witnessed. All shots were fired in groups, first of three and then of six shots. The mounts were clamped during the firing of each group. The interval between shots was 2½ seconds; the interval between groups varied, as each group was allowed to burst before the order to fire the next group was given. The shells burst with a thick white smoke. The powder used in the gun was absolutely smokeless, thus giving no clue to the location of the gun. The aeroplane was not hit.

A year later, namely, during the summer of 1916, a few data were received concerning an anti-aircraft coast battery of four 88-millimeter (3.46-inch) guns with semiautomatic breech mechanism on shielded pedestal mounts admitting of a maximum elevation of 75°. The guns were located at the corners of a square having a diagonal of about 100 meters. At the center of this square was the battery commander's station with self-contained horizontal base range-finding instrument, telephone connection with central to receive early notice of approaching

hostile aircraft, and megaphone for giving verbal orders to the gun crews.

According to a report submitted late in 1916, the Germans were then using four guns for anti-aircraft work, which, in the chronological order of their adoption by the Germany Army, were stated to be:

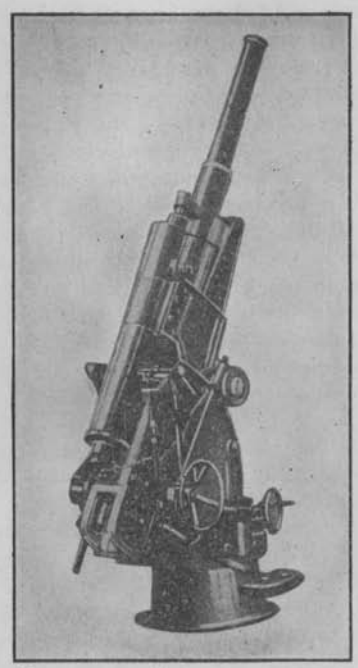
1. A 50-millimeter (1.96-inch) Ehrhardt gun 30 calibers long, firing a 1.25 kilogram (2.75 pounds) high-explosive shell with a muzzle velocity of 572 meters per second (1,877 feet per second). Sometimes a 2.4-kilogram (3.08 pounds) shrapnel shell is used. The maximum elevation is 70°. This gun, on a central pivot gun carriage with cradle, is mounted over the center of gravity of an armored car. The cradle contains a hydraulic brake and a spring recuperator. The sighting apparatus includes a muzzle sight and a mobile breech sight. The gun is pointed by means of a butt against the shoulder of the gunner. For this gun there are two models of motor car, differing only in their armor plating. The heavy model (plate of 7-millimeter nickel steel) can do 48 kilometers (30 miles) an hour on level ground and can climb gradients of 22°. The light model (4-millimeter nickel steel plate) can exceed 60 kilometers (37 miles) an hour. The latter car has a total weight of 3,200 kilograms (7,057 pounds) when carrying five men and material for 100 shots in the munition case at the back which also serves as a seat.

2. A 65-millimeter (2.56-inch) Krupp gun 35 calibers long, temporarily mounted on a 4-ton motor truck. No further details given.

3. A 75-millimeter (2.95-inch) Krupp gun, 35 calibers long (illustration 12). This gun has a muzzle energy of 110 meter tons, corresponding to a 5.5-kilogram projectile, and an initial velocity of 625 meters. With an elevation of 75° it can attain a maximum height of 6,300 meters (20,670 feet). Since January, 1915, it is mounted on a specially constructed motor truck with solid tires front and rear and weighing 3,920 kilograms (8,640 pounds). The motor develops about 75 horsepower and on a good track has developed a speed of 58 kilometers (36 miles) an hour.

4. A 105-millimeter Krupp gun, 35 calibers in length (illustration 13). This is the last gun developed. This special 105-millimeter gun fires an 18-kilogram shell with a muzzle velocity of 700 meters per second (2,300 feet per second) and at the maximum elevation of 75° reaches a height of 11,400 meters

(37,400 feet). The total weight of the gun is 3 tons (1,400 kilograms for the tube, 1,600 for the gun carriage). The gun was originally constructed for use on a field-gun carriage, but at the request of the German general staff the Mercedes workshop succeeded in constructing a motor truck for it which can easily make 40 kilometers (25 miles) an hour on good roads. The tires, solid front and rear, with a diameter of 1 meter, are of cast steel. The car is equipped with a 6-cylinder motor



NO. 12.—KRUPP 75 MM. L-35 FOR AUTOMOBILE MOUNT.

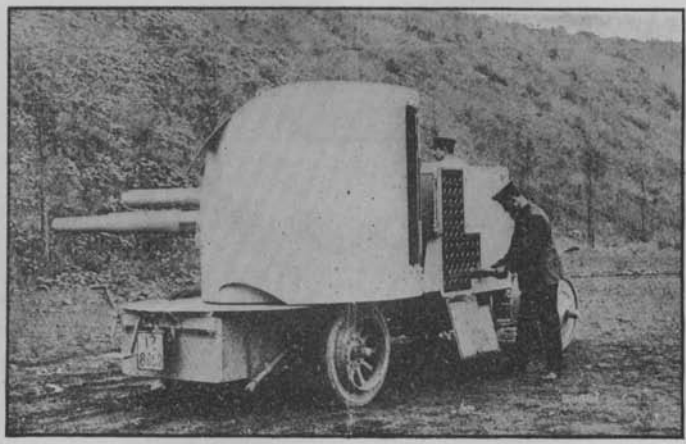
developing 160 horsepower. The driver is the only man on board. The officer in charge, the chief gunner, and four men follow in an armored car capable of 70 kilometers (43 miles) an hour and carrying munitions, as well as an armament of two machine guns. It is believed that this gun is frequently used on a fixed mount also.

A report submitted late in 1916 states that in order to prevent hostile aviators from flying low enough to do effective

work with their machine guns, as well as to provide for the close local defense of balloons, aviation parks, etc., the Germans have been installing machine cannon of 37 millimeters (1½-inch) caliber. They fire a solid shot with a smoke-tracing compound in the base. The feeding is by strips, 24 cartridges to a strip.

Another late report mentions a visit to two German anti-aircraft batteries for the protection of Ostende and Zerbruegge, respectively. Each battery consisted of four 4-inch 50-caliber guns mounted in a square about 100 meters on the side.

One late report also gives a few data concerning a 120-millimeter (4.72-inch) Krupp anti-aircraft coast gun, namely, that

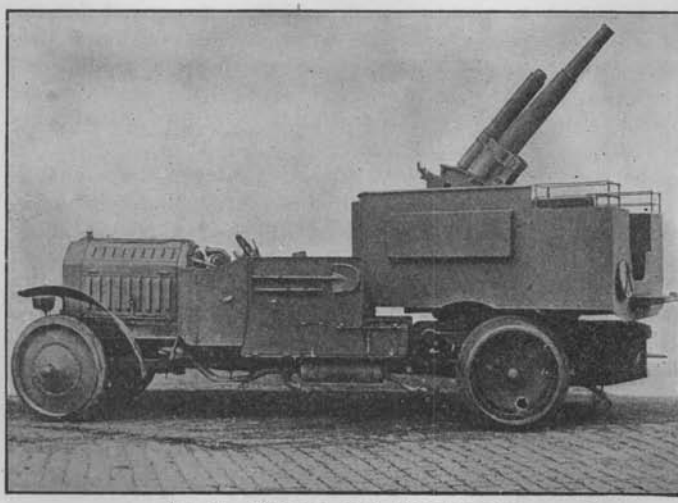


NO. 13.—KRUPP 105 MM. ON MERCEDES TRUCK.

it is 45 calibers in length and fires a 24-kilogram (53-pound) projectile with an initial velocity of 800 meters per second (2,625 feet per second) at a maximum elevation of 60°.

Illustration 14 shows an unidentified German anti-aircraft gun.

Captured 75-millimeter French field guns in improvised batteries are also often used for anti-aircraft work. To secure the high elevation necessary either the wheels are set on a raised center pintle with a circular track or, the wheels remaining on the level surface of the ground, a circular trench is excavated for the trail of the gun to move in.



NO. 14.—GERMAN ANTI-AIRCRAFT GUN.

The following table, though its data can not in general be brought into relation with those compiled above, is added because very recently received:

Type and caliber.	Initial velocity.	Projectile, weight.	Maximum elevation.	Range.	Weight of gun and carriage.	Weight of gun, carriage, and limber.	Muzzle energy.
KRUPP.							
	Meters.	*Kilograms.*	°	*Meters.*	*Kilograms.*	*Kilograms.*	*Meter-tons.*
75 mm. 30 cal. field carriage	510	6.5	65	.....	1,030	.....	.....
71 mm. 20 cal. on automobile	650	5	75	6,500	1,230	[1] 5,850 [2] 7,100	....
104 mm. 45 cal. coast gun.	800	15.5	60	.....	.....	.....	.....
120 mm. 45 cal. coast gun.	800	24	60	.....	.....	.....	.....
EHRHARDT.							
50 mm. 30 cal. on automobile	570	1.25	70	3,720	.....	[3] 3,100 [4] 2,800	....
65 mm. 35 cal. on automobile	670	4.1	75	7,900	.....	6,000	93.73
75 mm. 30 cal. on automobile	500	6.5	70	5,860	.....	6,300	82.76
105 mm. 32 cal.	605	17	70	8,300	.....	[5] 6,650 [6] 5,900	....
75 mm. 32 cal. field carriage	550	6.5	70	6,800	.....	1,800	100.10

[1] Without men and ammunition.
[2] With men and ammunition.
[3] With shields.
[4] Without shields.
[5] With trailer.
[6] Without trailer.

ENGLAND.

Aerial defense in the English Army consists of: (1) Fixed anti-aircraft artillery; (2) mobile anti-aircraft artillery; and (3) aeronautical units (not here under consideration).

Various types of anti-aircraft guns are in use. Among them are some 4.7-inch naval guns, some 75 mm. French guns, and some 5-inch breech-loading rifles. The later types in more common use are the 3-inch 13-pounder, the 3.3-inch 18-pounder, and finally the 3-inch 15-pounder, which ultimately is to replace them all.

The converted 3-inch 13-pounder is the former horse artillery gun, with breech bored to take a longer cartridge (with an 18-pounder charge) giving an increased muzzle velocity of about 2,000 foot-seconds. These guns are equipped with the ordinary field artillery hand-operated breech mechanism and are mounted for mobile work on pedestals built up on automobiles and revolving through 360°. There is one gun to each motor truck. These motors are of 45 horsepower. Their sides are dropped and their wheels blocked when in use. The maximum range is from 6,700 to 7,000 yards, and the highest elevation is 75°. Six batteries of these guns of six guns each are used in the London area.

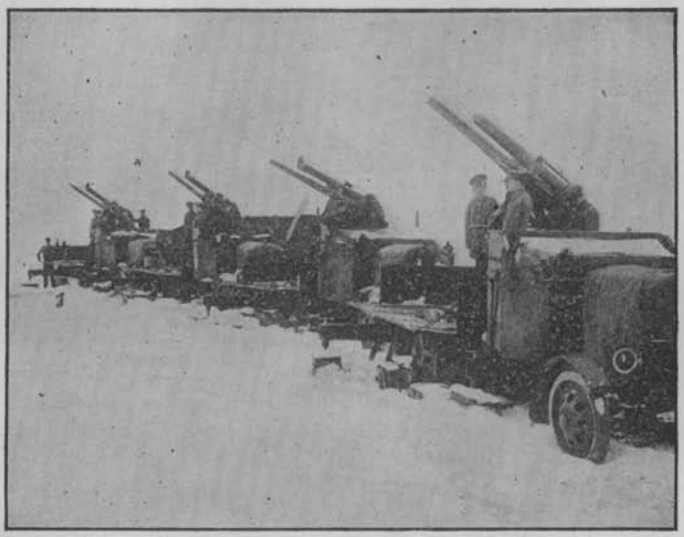
The 18-pounder is the service 18-pounder field gun mounted for anti-aircraft service. These guns also have the hand-operated breech mechanism. They give an initial velocity of about 1,750 foot-seconds. They are mounted on transportable platforms (see below). Some of these guns have been relined and the bore decreased to 3 inches. These relined 18-pounders fire a 13-pound projectile with an increased velocity of approximately 2,000 foot-seconds. Some of these relined 18-pounders are mounted on automobiles. The anti-aircraft guns which are on automobiles are mounted directly over the rear axle of standard 3-ton motor trucks provided with two outriggers, so as to permit of firing across the truck. The rear outrigger consists of a telescoping beam capable of being drawn out about 4 feet beyond the sides of the truck. At its outer ends are two jackscrews which distribute the load over about 3 square feet of ground by bearing upon blocks which are carried on the truck. The front outrigger just behind the driver's seat extends out only sufficiently to permit of the use of the jackscrews. The body of the truck is provided with sideboards

which, when dropped down, extend the platform about 20 inches on each side. The trucks have single tires in front and double tires in rear and are equipped with governors limiting the speed to approximately 18 miles an hour. They carry a small amount of ammunition, while additional ammunition is carried on other motor trucks.

The latest gun, one which has been especially developed during the war for anti-aircraft work, is the 3-inch 15-pounder 20 hundredweight gun on a pedestal mount. This is the one gun which has been adopted as standard for the service and is to replace all others. It is considered the best gun for the purpose and it is reported that both French and Italian officers admit its superiority to any yet developed. It is being supplied to all anti-aircraft stations as rapidly as possible. It was built to have an initial velocity of about 2,750 foot-seconds, now reduced, however, to 2,550 foot-seconds, because with a higher velocity the gun wears out too rapidly. The gun is 45 calibers long and has a height range of 25,000 feet. The gun had originally semi-automatic action including (1) on recoil, unlocking and opening of breechblock and ejection of shell case; (2) on loading, closing and locking of breechblock, thereby giving a rate of fire of 22 rounds per minute. Owing to difficulties experienced at the higher elevations in the operation of the semi-automatic mechanism, the standard Vickers type, straight-pull breech mechanism (rate of fire 20 rounds per minute) has been used instead. The gun has two recoil cylinders with springs and piston. The recoil is only 11 inches. The traversing and elevating mechanism are each of the rack and pinion type, the latter with worm gear to prevent running down. Two telescopic sights are used, one on the right for deflection and one on the left for elevation, so mounted and controlled that all corrections made are applied to both telescopes. Each telescope has interior illumination for night work by means of an electric-light bulb. It can be fired at an elevation of full 90°. The ammunition is fixed, and after the present supply of shrapnel has been exhausted, high-explosive shells are to be used exclusively. It is the intention eventually to supply guns with 60 per cent time H. E. and 40 per cent percussion H. E. fuses.

The 15-pounder 20-hundredweight guns and carriages (also some 18-pounders) are mounted on a transportable platform or autotrailers of structural steel 5 feet square and 18 inches deep. Four arms about 4 feet in length are hinged at the corners so

that they can be swung to the firing position on the diagonals of the platform and locked by pins through the platform, which is thus extended sufficiently to give the gun stability. On the bottom of the platform and on each of these arms are angles approximately 3 by 3 inches, which by engaging the surface of the ground prevent lateral movement. At the end of each arm is a jackscrew. To go into action the trailer is detached from the motor car, the arms swung out and locked, and the jackscrews run down until the weight is taken off the two wheels of

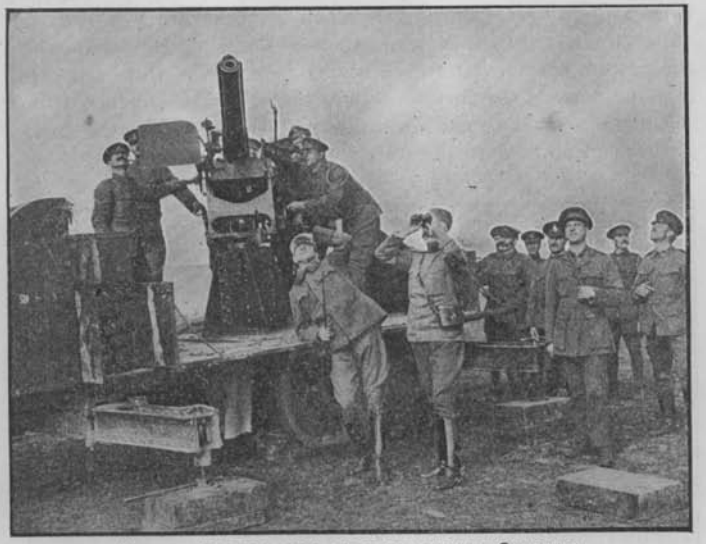


NO. 15.—BRITISH ANTI-AIRCRAFT GUNS ON THE WESTERN FRONT.

the trailer. As the wheel axle is jointed in the middle and held together by a latch, this latch is now released and the two wheels being then withdrawn, the jackscrews are run out until the platform rests on the ground ready for firing. It takes a trained crew only about one minute to place the gun in action. The gun crew consists of 11 men.

The 15-pounder guns, with some 18-pounders, mounted on trailers are used in anti-aircraft defenses in England (84 of the former are eventually to be provided for the aerial defense of London) for the protection of ammunition stores, bases, etc., and behind the firing line in France. The guns mounted on motor trucks (13-pounders and some 18-pounders) are used im-

mediately behind the front line trenches and also for reinforcing the anti-aircraft fire wherever necessary.



NO. 16.—BRITISH ANTI-AIRCRAFT GUN AT SALONIKI.

Illustration 15 shows a British anti-aircraft gun on the western front, and illustration No. 16 one at Salonica.

UNITED STATES.

The only weapon designed for use by our Army specifically against aircraft is a 3-inch 15-pounder, having the same construction and ballistics as the 3-inch 15-pounder model of 1903. This piece will be equipped, however, with a semiautomatic breech mechanism and a drop block. The carriage provides for firing the gun at elevations between 0° and 80°. It is anticipated that a maximum altitude of about 30,000 feet can be obtained with this gun when using a projectile with a 7-caliber ogive and a muzzle velocity of 2,600 feet per second.

The Ordnance Department is designing or building three different types of mounts for anti-aircraft artillery. The first is a fixed pedestal mount for the 3-inch 15-pounder gun; the other

two mounts are for a 3-inch field gun, model of 1902, one to be emplaced on an automobile truck, the other on a semiportable platform. All mounts will permit a maximum elevation of 85°. The minimum elevation of the automobile mount will be 35°, while that for the semifixed and 3-inch 15-pounder mounts will be 12° and 0°, respectively.

It is understood that the Engineer Department has plans for mounting the standard 3-inch antiaircraft gun and carriage as follows:

(*a*) On a standard railway flat car of 80,000 pounds capacity, equipped with outriggers which will enable the gun to be fired from the car at any point by blocking up under the ends of the outriggers.

(*b*) On a light flat car running on light standard gauge, which can be pushed, if necessary, from point to point and which can be quickly anchored to a concrete platform to be constructed in advance and laid flush with the ground under the track at points where it is desired to bring the gun into action, the gun to be fired from the car after it is anchored to the platform.

(*c*) On a truck from which the gun can be fired in the same manner as explained under (*b*), but which can be hauled over ordinary roads by teams or automobile tractors.

The methods outlined above are considered by the Engineer Department to be the cheapest and most practicable for the mobile use of the standard 3-inch anti-aircraft gun and carriage. By making use of concrete platforms for anchorages which are laid flush with the ground, a practically level base for the gun when fixed is secured and the platform can be concealed by an earth covering when not in use. It is also practicable to make provisions for bolting the gun pedestals directly to the concrete platforms if desired.

The new Navy anti-aircraft gun, developed after three years of experiment, is a machine rifle about 50 calibers long and capable of hurling a 3-inch shell 27,000 feet into the air at an angle of 90°, and can deliver its charge at rapid-fire rate.

CONCLUSIONS.

The aeroplane has been steadily forced to higher altitudes, and to counteract this the anti-aircraft gun has shown a corresponding tendency to increase in size, power, and range. The

size of aerial defense guns used in the present war has ranged from machine guns to those of 4, 5, and 6 inches in caliber.

Aircraft are comparatively safe from machine-gun fire at altitudes greater than 3,500 feet. For anti-aircraft work the machine guns, like the rifles, lack range and also effectiveness and facilities for observation, while field guns do not possess sufficient elevation to allow of their being trained on aircraft, nor, were they once trained on a so-rapidly moving target, would they be able to follow it.

The larger the caliber the better (always provided the requisite rapidity of fire can be secured) in order to compel the enemy to fly too high for good observation. Anti-aircraft guns on mobile mounts should have a caliber of not less than 3-inch, while for the really adequate defense of any important position some 4-inch guns should be included. If the guns are to be in fixed emplacements, their caliber should be 6-inch.

The anti-aircraft gun must have a high muzzle velocity, so as to obtain a flat trajectory. To secure the great rapidity of fire necessary it should have a small recoil and semiautomatic loading. The mounting should be such as to permit the greatest possible elevation (at least 70°) and quick traversing over the widest possible arc of fire, preferably 360°. It should be easy to sight and fire rapidly at high elevations. If suitable in other respects an ordinary fieldpiece can be used against aircraft on almost any kind of improvised mounting, which permits great elevations and all-around fire. Such mounts are makeshifts at best, however, as the gunnery will necessarily be unsatisfactory.

Until recently shrapnel was used almost exclusively against aircraft, but as experience during the war has shown shrapnel is almost useless against aeroplanes. High explosive shells are much more effective. A Farman biplane with its engine worn out from use, but otherwise practically undamaged, though with over 400 shrapnel and bullet holes, has been exhibited in Paris.

Mountings for anti-aircraft guns are either: (1) Fixed (in permanent emplacements); (2) transportable (either on railway cars with outriggers, on flat cars, or on auto trailers—the car or trailer is then either blocked up or anchored to a platform previously prepared); (3) mobile (on motor trucks, armored or unarmored).

Fixed mountings for anti-aircraft guns, however efficient, have the great disadvantage that their location soon becomes known to the enemy. Mobile mountings, on the other hand,

greatly enhance the value of anti-aircraft guns. They permit a more effective tactical use of the guns by introducing into air defense the very important element of surprise, as any different number of positions for temporary occupancy may be selected without previous knowledge of the enemy. Also, the guns can be better concealed. The principal disadvantage of mobile mounts is in the instability of the gun platform and the difficulty of keeping it always perfectly level. As, however, anti-aircraft guns on mobile mounts are in successful use by both sides abroad it is evident that this disadvantage has been overcome.

As the enemy aeroplane gets beyond range very quickly, there is no time for elaborate computations, and the use of tables should also be rendered unnecessary. The gun must go into action at once and maintain an extremely rapid fire involving continual changing of data between shots. It has been found best to fire very rapidly with as many guns as possible and try to get the range from the explosion of the shell. Anti-aircraft gunnery is thus extremely difficult, and gun pointers require careful instruction and long and continuous practice to attain any degree of proficiency and avoid waste of ammunition, the expenditure of which in war time is excessive. At best anti-aircraft firing is very inaccurate and volume of fire must be used to compensate for this lack of accuracy. The tendency is toward simplification in all sighting apparatus and relying largely on correcting fire by observation.

Anti-aircraft guns should accordingly not be fired singly. They have frequently been used abroad in pairs and in groups of three and four. The tendency, however, is toward still larger groups, and it is now a common opinion among officers that each anti-aircraft station should have a battery of not less than six guns in order to secure the maximum rapidity of fire, while at the same time avoiding some of the errors in spotting by establishing a zone of fire around the hostile aircraft. As nearly as practicable these groups of guns should be brought into action at least 1,800 yards apart. All gun stations should be occupied without intermission both night and day, and it is necessary to screen the guns from overhead observation.

Whereas at the beginning of the war aeroplanes flew at altitudes of 4,000 to 5,000 feet, and then at 6,560 feet (2,000 meters), with comparative safety, the so-called safe altitude has been gradually increased, first to 10,000 feet and finally to

12,000 feet and over on a clear day. It is not thought probable that artillery attacks against aircraft can be made effective for altitudes of 15,000 feet or over, though an occasional hit at such an altitude even may occur. Thus in October, 1916, an airman was badly wounded by a high-explosive shell from a German gun (presumably the 105 mm. gun) while flying at the great height of 5,200 meters (15,850 feet).

Several flyers are reported to have been brought down from a height of 4,000 meters (13,120 feet). Such hits are very rare, however. The speed and maneuvering power of aeroplanes make them extremely difficult targets to hit. The steadily increasing altitudes at which they have been forced to fly adds further to their security, but, on the other hand, greatly diminishes the effectiveness of their observations. Thus while pursuit aeroplanes now fly for safety at about 18,000 feet, the fighters and camera machines operate between 10,000 and 12,000 feet. Now, while air disturbances due to the bursting of a high-explosive shell within 100 feet of an aeroplane might cause the aeroplane to dive or even capsize, it would not necessarily wreck the machine; therefore a direct hit on some vital part of the aeroplane is necessary to bring it down. As above stated, such hits are rare, but the anti-aircraft gun need not hit the aeroplane to fulfill its function; if it can force the aeroplane to fly too high for good observation it is still worth more than it costs. After all, however, the only really effective defense against hostile aircraft lies in an aerial service of our own more efficient than that of the enemy. For this purpose powerful aeroplanes equipped with machine guns or light cannon should be used.

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NOTES ON ANTI-AIRCRAFT GUNS

Compiled at the Army War College
From the Latest Available Information

APRIL, 1917

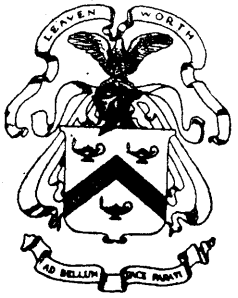
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WAR DEPARTMENT,
WASHINGTON, *April 28, 1917.*

The following Notes on Anti-Aircraft Guns are published for the information of all concerned.

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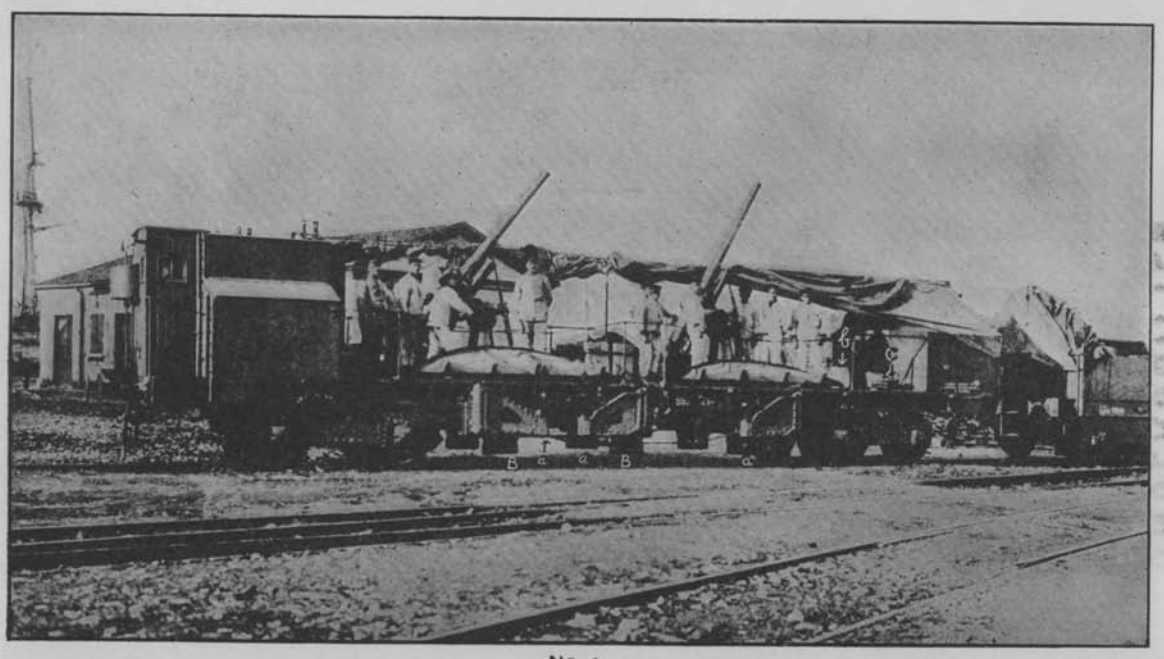
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No. 1.

ITALY.

The Italians use the 75 mm. (3-inch) Deport gun for anti-aircraft service. It has a maximum elevation of 85°, and fires 21 shots a minute. Shrapnel is considered inefficient; the high explosive shells, which are much preferred, carry either a time or a detonating fuse. The incendiary shell, used with a time fuse, throws out, upon exploding, a number of small balls containing a very efficient burning liquid. Six-gun batteries have been substituted for the formerly adopted two-gun battery.

The Italian Army in September, 1916, had 16 batteries (4 guns to a battery) of anti-aircraft guns mounted on automobiles. The gun, made by Ansaldo & Co., is of 102 mm. caliber. It is reported that the number of these guns has since been increased.

Illustration No. 1 shows an Italian flat car armed with two anti-aircraft guns. The three heavy brackets (B) are used to brace the car against recoil when the guns are fired. Before firing they are swung out at right angles to the car on the side away from the gun direction and a heavy, threaded, steel rod is screwed down through the band (a) until its lower end presses firmly against a truncated pyramidal block (b), which is placed on the ground to receive it. To facilitate rapid adjustment a detachable wheel (c) is attached to the top of the screw rod. It is believed that these braces are used only in the case of firing the heavier (6-inch) guns.

FRANCE.

The main reliance of the French for defense against aircraft is their 75 mm. gun, model of 1897, which fires 25 shots a minute and has a recoil mechanism so perfect that it can be fired continuously without relaying. This gun is shown in illustrations 2, 3, 4, and 5, but the reports show that the mountings have been modified. For anti-aircraft work this gun has been mounted in three different ways, as follows:

1. On an improvised fixed mount for the ordinary field carriage. The wheels of the carriage rest on a circular platform with a strong vertical pivot in the center. To obtain the high elevation necessary, the trail is sunk in a circular pit 32 inches below the level of the wheels. In order that the trail may not be driven into the ground, there is attached to it a chock, fitted with a traversing roller resting in the pit on a wooden traversing circle. To the pivot supporting the carriage is fixed a pivot collar which turns freely and carries four arms. To each of the two longitudinal arms is attached a tie-rod bolted at the other



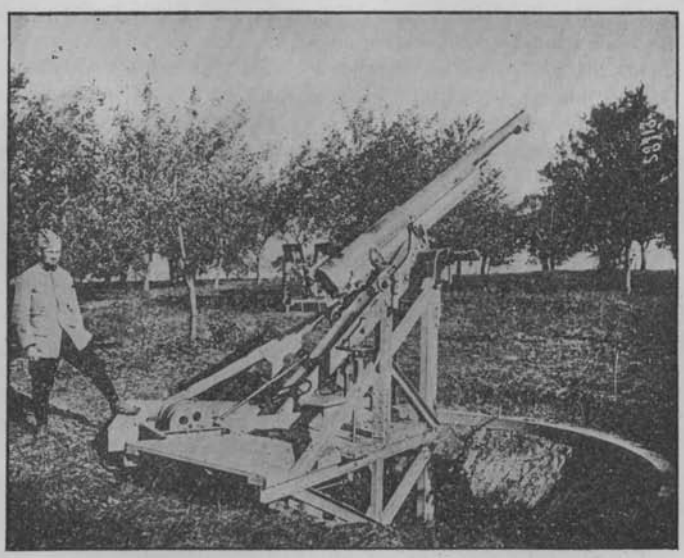
NO. 2.—FRENCH 75 MM. FIELD GUN ON FIXED MOUNTING FOR AERIAL DEFENSE OF PARIS.

end to the trail chock. These tie-rods resist the recoil of the carriage. To each of the two lateral arms is attached an elastic tie-rod fitted at the upper end with a bronze strap holding the axle of the carriage. The elastic tie-rods are equipped with spiral springs which steady the carriage. A pointing mechanism attached to the left-hand side of the trail includes a traversing wheel which actuates, by means of transmitting gears, the traversing chock roller.

The field of fire is 360°.

2. On a metallic demountable platform for the fixed defense of towns or with a modified substructure for use in the field. In the first case a concrete pit is prepared 4 meters in diameter and 1 meter deep. At the center of the pit is bolted a base plate with a socket in which turns the vertical pivot supporting the mounting.

The framework of this mounting is composed of two triangular trusses of riveted U beams in vertical planes, making an angle with each other of 30° and of two central brackets. To support the personnel, there rests on the trusses and the central brackets a flooring which is open between the brackets to provide space for the trail of the piece and for the winch used for pointing in elevation. The uprights of the two trusses are suitably cross braced, the lower brace being fixed to the pivot



NO. 3.—IMPROVISED ANTI-AIRCRAFT MOUNT FOR FRENCH 75 MM. FIELD GUN.

support. At the top these uprights are fitted with trunnion beds designed to receive the axle of the gun carriage from which the wheels, wheel brakes, and shields have been removed. The trail of the carriage is supported by a steel cable wound on the winch, which is operated by means of an elevating mechanism on the left-hand platform.

To facilitate the elevation and depression of the gun the carriage has a counterweight consisting of a cast-iron ball placed under the gun and supported from the axle of the carriage by a steel wire cable passing through a hole in the ball and held out

by means of a wooden outrigger, one end of which is placed in a recess of the counterweight while the other end is secured to the trail.

Each truss is fitted at the rear and under the flooring with a large cast-iron traversing roller, which travels on an iron traversing circle set in the exterior coping of the pit. By turning a handwheel connected to the right-hand roller, the entire framework can be made to rotate around the pivot.

Pointing in direction and pointing in elevation are distinct operations, done by separate men. For large movements in direction the mounting is pushed around by hand. The smaller movements are given by the before-mentioned traversing handwheel. The cannoneer pointing for direction is on a seat attached to the right-hand truss. In front of him, near the traversing handwheel on a sight bracket placed at the top of a column fastened to the truss, is the sight for direction, consisting of an ordinary telescopic sight provided with a deflection scale. The section commander computes the deflection from the travel of the target during the time of flight, drift, and wind. The cannoneer operating the sight is given the deflection, sets it off, traverses the carriage until the vertical cross hair is on the target, and then keeps the sight on the target.

Pointing in elevation is effected either by means of the handwheel operating the winch which revolves the entire carriage around its axle or by means of the elevating handwheel of the carriage which turns the gun on its cradle. Both handwheels are within reach of the cannoneer pointing for elevation, who stands on the left-hand platform. Elevations from 12° to 85° can be obtained.

The sight for elevation is an ordinary telescopic sight, the mounting of which is in gear with the range dial. The cannoneer at this sight keeps the horizontal wire of his sight on the target at all times by elevating or depressing the gun by means of the elevating handwheels. The range dial, about a foot to the left, is operated by another cannoneer. It consists of a small brass disk on which are curves corresponding to the different ranges. By moving the pointer along these curves to the range given, the necessary elevation is transmitted to the telescopic sight for elevation. Thus, when a change of range is announced, the gunner being already on the target, the cannoneer moves the pointer to the new range; this throws the gunner off the target, and he at once relays the piece.

The detachment consists of a chief of section and eight cannoneers viz, a pointer in elevation, a pointer in direction, a firer, a loader, a fuse setter, and three ammunition carriers.

For use in the field the substructure of this platform mount is simplified. The shape of the pit is that of a truncated cone; it is dug 1 meter deep, 1.8 meters in diameter at the bottom, and 4 meters in diameter at the top. A small parapet about 2 meters thick around the rim is formed of the excavated earth. The pivot socket is bolted to a bolster consisting of two layers



NO. 4.—ANTI-AIRCRAFT GUN ON AUTOMOBILE.

of wooden joists bolted together, and is centered in the traverse circle by 8 iron tie rods. The iron traverse circle is bolted to 12 blocks of wood.

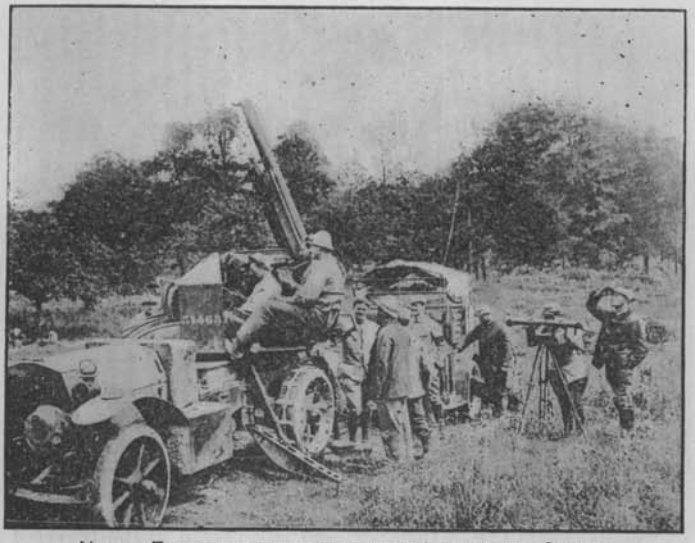
For transportation it is taken down in four parts, which can be carried in two wagons.

In mounting and dismounting the gun and carriage an assembling shears is used. The time taken is as follows: To dig ditch, 1½ hours; to mount platform, ½ hour; to mount gun, 5 minutes; to dismount the whole, 35 minutes.

3. On an automobile. To prepare for action the chassis is supported by four jack screws. In addition two side supports are lowered to the ground, to prevent overturning. The carriage permits angles of elevation from 0° to 70°. The hori-

zontal field of fire is limited to 240°, as the breach can not pass certain positions.

Until recently time shrapnel was used almost exclusively, but now the French are using high-explosive shells with time fuses. When shrapnel is used the entire percussion element is removed, for the protection of friendly troops, in case the time element of the fuse does not function. There is also a smoke-producing shell, filled with fuse composition, and the ogive is pierced with holes. It is primed with a time fuse, which communicates



NO. 5.—FRENCH OFFICIAL PHOTOGRAPH FROM THE SOMME.

flames to the interior charge, which escapes through the holes in the ogive. Thus it is possible to follow the projectile through its trajectory, which is of great assistance in anti-aircraft gunnery.

In addition to the 75 mm. gun, it is known that the French are using for aerial defense the 105 mm. gun, also the 37 mm. rapid-fire naval gun. In Paris some 37 mm. guns are on tripods, while one is in a cupola. No further information is on hand.

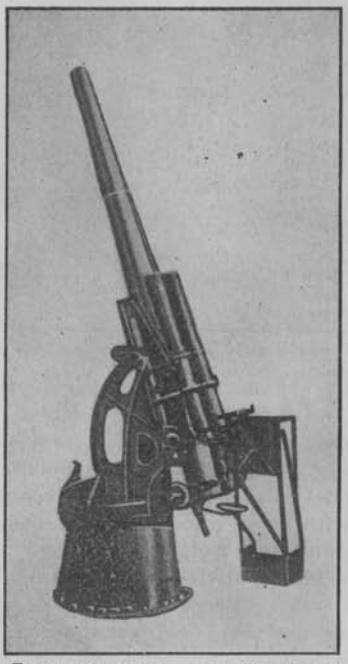
According to the latest information received on anti-aircraft guns on automobile mounts, the 75 mm. gun is used for firing a shrapnel weighing 7.4 kilograms (16¼ pounds) with a muzzle velocity of 525 meters per second (1,722 feet per second) and

a high-explosive shell weighing 5.315 kilograms (11⅞ pounds) with a muzzle velocity of 584 meters per second (1,815 feet per second). This fire appearing insufficient against aeroplanes flying at great altitudes there is now under consideration a 90 mm. anti-aircraft gun, with a muzzle velocity of approximately 750 meters per second (2,460 feet per second) for a shrapnel weighing 11 kilograms (24 pounds).

The use of the 75 mm. gun with a high muzzle velocity appears to be preferable to that of the 105 mm. with a reduced muzzle velocity.

GERMANY.

The German have used for anti-aircraft work numerous different types of guns, generally ranging in caliber from 50 mm.

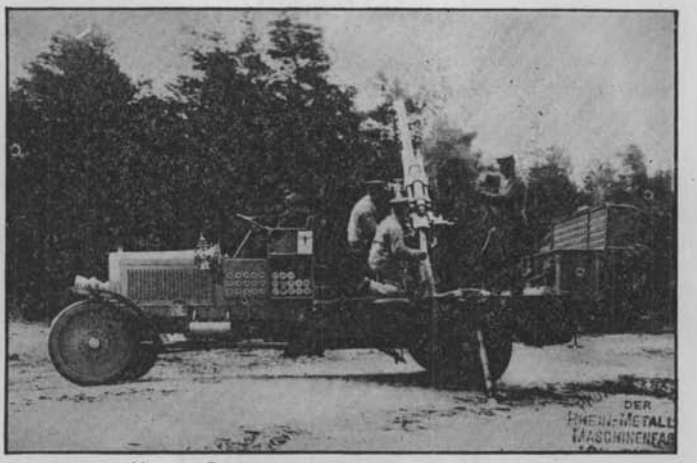


NO. 6.—EHRHARDT 65 MM. ANTI-BALLOON GUN L-35.

to 105 mm., though calibers as low as 37 mm. and as high as 120 mm. have been reported. Some of these guns had already

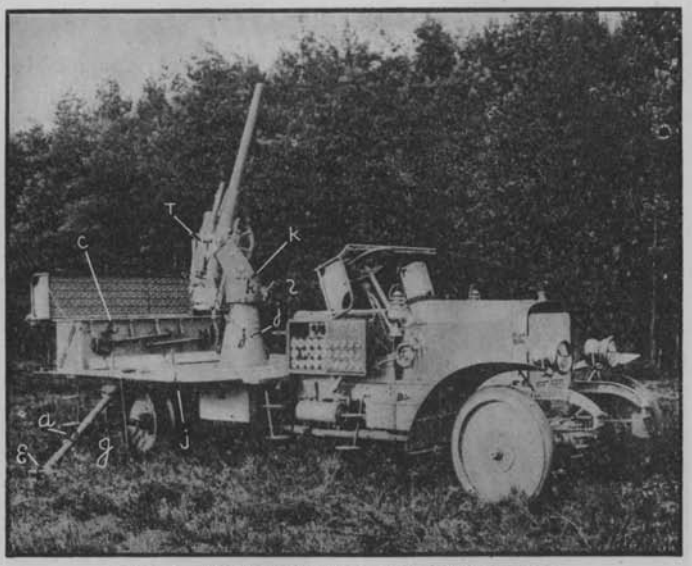
been developed before the war began, while others have since been brought out, the tendency being toward a constant increase in caliber, range, and muzzle velocity. The incomplete and sometimes more or less conflicting reports concerning some of these guns make it difficult to coordinate the data on hand, which for some guns are very meager.

The earliest German antiaircraft gun of which we have any information is the 65 mm. (2.56-inch) Ehrhardt anti-balloon gun developed several years before the war. This gun is 35 calibers long, fires with a muzzle velocity of 2,000 feet per sec-

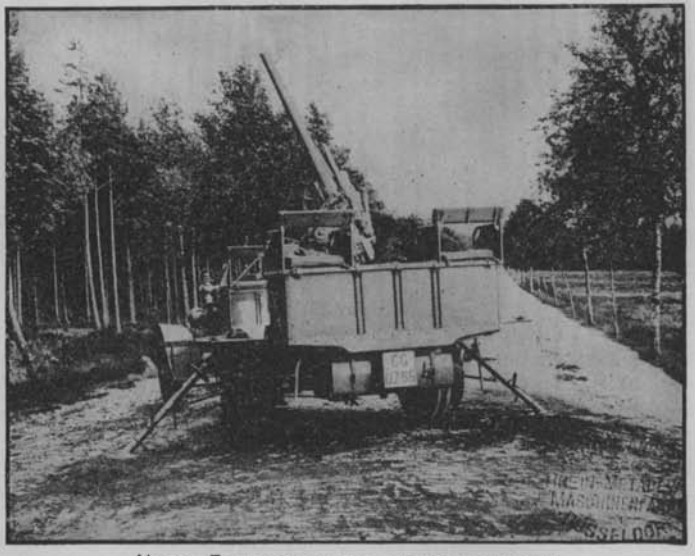


NO. 7.—EHRHARDT 65 MM. ANTI-BALLOON GUN.

ond, a 9.4-pound projectile, at a maximum elevation of 75° to a maximum height of 26,000 feet. The maximum range for time fuse is 5,960 yards, and for percussion fuse 7,760 yards. The gun has quick and slow movement in azimuth and all-around fire. It is mounted on a center-pivot cradle carriage on an automobile truck with broad wheels weighing about 7 tons (illustrations 6, 7, 8, and 9). Weight of gun and carriage is 1,900 pounds. With a level and two handwheels the upper carriage can be quickly leveled. The automobile has a wide gun platform with seats for the crew, ammunition chests for 130 rounds, and fuel tanks holding sufficient for 18 hours. In the firing position this platform is widened by dropping back its sides and is supported off the wheels by iron props resting on a broad metal base. The average speed is 50 kilometers (31



No. 8.—Ehrhardt 65 mm. anti-balloon gun.



No. 9.—Ehrhardt 65 mm. anti-balloon gun.

miles) an hour. In order to secure the necessary rapidity of fire, the breech mechanism has been provided with an apparatus for automatically opening and closing the wedge-shaped breechblock. A noteworthy feature of the gun is the automatic sight, which is so constructed that it is only necessary to set off the actual range in a straight line to the target whatever its altitude, found by means of a telemeter, and to bring the target on the cross hairs. The line of sight is capable of two movements, one which sets off the necessary angle between the

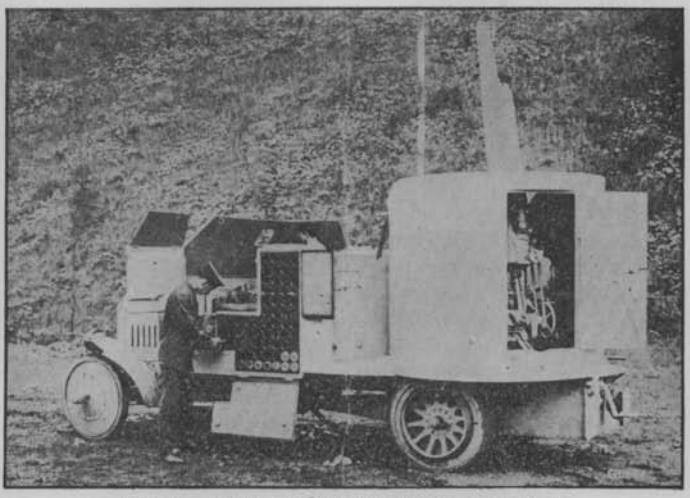


NO. 10.—KRUPP 71 MM. L-30 ANTI-BALLOON GUN.

axis of the bore and the line of sight when the target is in the horizontal and the other which corrects for the altitude of the target by automatically decreasing this angle to a theoretical zero at the zenith. There is also an automatic fuse time indicator. This is a brass plate with curves and a movable arm fixed in the trunnion opposite the sight. It is only necessary to set off the given range and lay the piece on the target, then the proper time can be read.

Another anti-aircraft gun developed by the Germans some years before the war is the 71 mm. (2.8-inch) Krupp anti-balloon gun (illustrations 10 and 11), firing 20 to 25 shots per minute.

This gun is 30 calibers long, fires with a muzzle velocity of 2,130 feet per second an 11-pound shell at a maximum elevation of 75° at a maximum height of 21,300 feet. Traverse, 360°. This gun is a barrel-recoil gun on a center-pivot carriage, mounted on an automobile which can also be armored. Weight of automobile without gun, 7,180 pounds; with gun, about 9,900 pounds; with armor and ammunition chest (carrying 122 rounds), about 15,400 pounds. Mean speed, 28 miles an hour. The gun has an automatic horizontal crank closure, rear trunnions and



NO. 11.—KRUPP 71 MM. L-30 ANTI-BALLOON GUN.

spring compensator, liquid brake, toothed-arc laying apparatus, and traversing apparatus which can be thrown out of gear for rapid movement.

It is also known that the Germans had before the war developed a 105 mm. (4.1-inch) anti-aircraft gun on center-pintle mount for fixed emplacements, with full automatic breech mechanism. Further details, however, are lacking.

A small-caliber anti-aircraft gun of high initial velocity was, according to one report, brought out by Krupp during the summer of 1915. This gun has a caliber of 53 mm. (2.09 inches) and a range of between 4,000 and 5,000 meters (13,120 feet and 16,400 feet). The initial range for firing being given the gun sights increase in range automatically 50 meters (164 feet), so

that the shells explode in series 50 meters apart. Three guns are usually placed in position together, and a zone of fire is thus established and maintained around the hostile aircraft. Several aeroplanes were brought down during that summer by this gun. No further data are available.

One report made during the summer of 1915 gives some information about the firing of a 77 mm. (3.03-inch) Krupp semiautomatic gun of about 35 calibers, mounted on a pedestal base upon a motor truck. The range finder, which was mounted on a tripod on the ground near the truck, was between 1½ and 2 meters long, and was of coincidence type, with internal and external readings. On the pedestal mount was a level, so that the mount could be leveled before firing. The sight consisted of a telescope with two eyepieces, one of low and one of high power, so close together that the eye could change readily from one to the other. In each eyepiece appeared a triangle, point up. The gun pointer brought the aeroplane within the triangle of the lower-power eyepiece, which was used as a finder, and then, shifting his eye to the high-power lens, he brought the aeroplane on the point of the triangle. The gun crew consisted of three men, one man to aim, one to load, and a third to bring the ammunition from the rack and adjust the fuses. Two officers were also present, one of whom managed the range finder, while the other gave the firing directions. Eighty-one shots at a French aeroplane at ranges increasing from 3,600 to 7,100 meters were witnessed. All shots were fired in groups, first of three and then of six shots. The mounts were clamped during the firing of each group. The interval between shots was 2½ seconds; the interval between groups varied, as each group was allowed to burst before the order to fire the next group was given. The shells burst with a thick white smoke. The powder used in the gun was absolutely smokeless, thus giving no clue to the location of the gun. The aeroplane was not hit.

A year later, namely, during the summer of 1916, a few data were received concerning an anti-aircraft coast battery of four 88-millimeter (3.46-inch) guns with semiautomatic breech mechanism on shielded pedestal mounts admitting of a maximum elevation of 75°. The guns were located at the corners of a square having a diagonal of about 100 meters. At the center of this square was the battery commander's station with self-contained horizontal base range-finding instrument, telephone connection with central to receive early notice of approaching

hostile aircraft, and megaphone for giving verbal orders to the gun crews.

According to a report submitted late in 1916, the Germans were then using four guns for anti-aircraft work, which, in the chronological order of their adoption by the Germany Army, were stated to be:

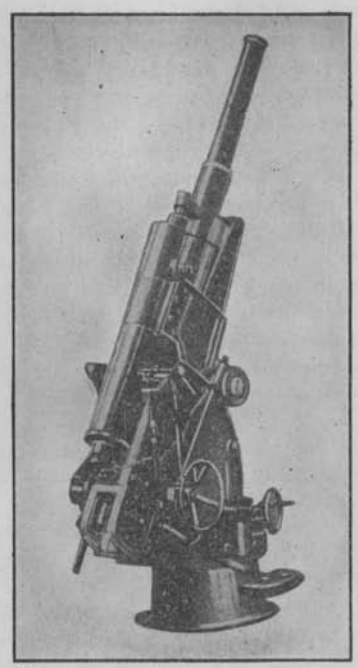
1. A 50-millimeter (1.96-inch) Ehrhardt gun 30 calibers long, firing a 1.25 kilogram (2.75 pounds) high-explosive shell with a muzzle velocity of 572 meters per second (1,877 feet per second). Sometimes a 2.4-kilogram (3.08 pounds) shrapnel shell is used. The maximum elevation is 70°. This gun, on a central pivot gun carriage with cradle, is mounted over the center of gravity of an armored car. The cradle contains a hydraulic brake and a spring recuperator. The sighting apparatus includes a muzzle sight and a mobile breech sight. The gun is pointed by means of a butt against the shoulder of the gunner. For this gun there are two models of motor car, differing only in their armor plating. The heavy model (plate of 7-millimeter nickel steel) can do 48 kilometers (30 miles) an hour on level ground and can climb gradients of 22°. The light model (4-millimeter nickel steel plate) can exceed 60 kilometers (37 miles) an hour. The latter car has a total weight of 3,200 kilograms (7,057 pounds) when carrying five men and material for 100 shots in the munition case at the back which also serves as a seat.

2. A 65-millimeter (2.56-inch) Krupp gun 35 calibers long, temporarily mounted on a 4-ton motor truck. No further details given.

3. A 75-millimeter (2.95-inch) Krupp gun, 35 calibers long (illustration 12). This gun has a muzzle energy of 110 meter tons, corresponding to a 5.5-kilogram projectile, and an initial velocity of 625 meters. With an elevation of 75° it can attain a maximum height of 6,300 meters (20,670 feet). Since January, 1915, it is mounted on a specially constructed motor truck with solid tires front and rear and weighing 3,920 kilograms (8,640 pounds). The motor develops about 75 horsepower and on a good track has developed a speed of 58 kilometers (36 miles) an hour.

4. A 105-millimeter Krupp gun, 35 calibers in length (illustration 13). This is the last gun developed. This special 105-millimeter gun fires an 18-kilogram shell with a muzzle velocity of 700 meters per second (2,300 feet per second) and at the maximum elevation of 75° reaches a height of 11,400 meters

(37,400 feet). The total weight of the gun is 3 tons (1,400 kilograms for the tube, 1,600 for the gun carriage). The gun was originally constructed for use on a field-gun carriage, but at the request of the German general staff the Mercedes workshop succeeded in constructing a motor truck for it which can easily make 40 kilometers (25 miles) an hour on good roads. The tires, solid front and rear, with a diameter of 1 meter, are of cast steel. The car is equipped with a 6-cylinder motor



NO. 12.—KRUPP 75 MM. L-35 FOR AUTOMOBILE MOUNT.

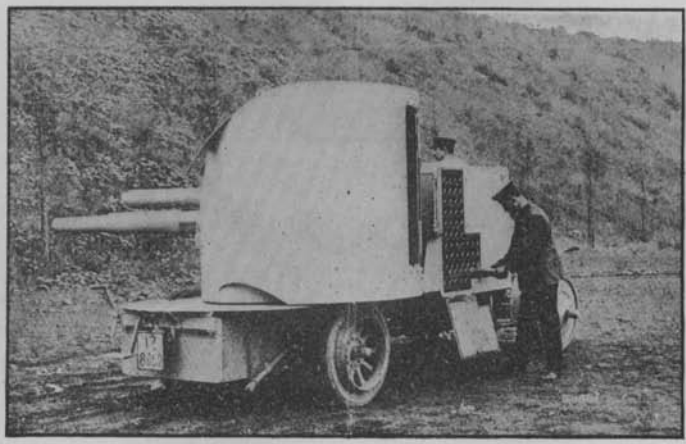
developing 160 horsepower. The driver is the only man on board. The officer in charge, the chief gunner, and four men follow in an armored car capable of 70 kilometers (43 miles) an hour and carrying munitions, as well as an armament of two machine guns. It is believed that this gun is frequently used on a fixed mount also.

A report submitted late in 1916 states that in order to prevent hostile aviators from flying low enough to do effective

work with their machine guns, as well as to provide for the close local defense of balloons, aviation parks, etc., the Germans have been installing machine cannon of 37 millimeters (1½-inch) caliber. They fire a solid shot with a smoke-tracing compound in the base. The feeding is by strips, 24 cartridges to a strip.

Another late report mentions a visit to two German anti-aircraft batteries for the protection of Ostende and Zerbruegge, respectively. Each battery consisted of four 4-inch 50-caliber guns mounted in a square about 100 meters on the side.

One late report also gives a few data concerning a 120-millimeter (4.72-inch) Krupp anti-aircraft coast gun, namely, that

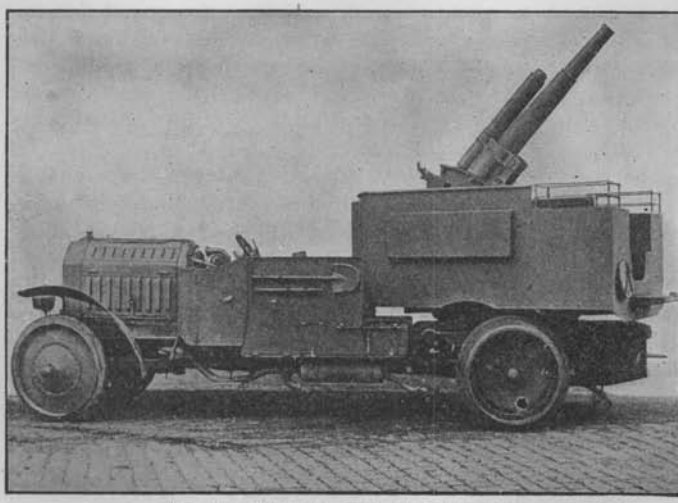


NO. 13.—KRUPP 105 MM. ON MERCEDES TRUCK.

it is 45 calibers in length and fires a 24-kilogram (53-pound) projectile with an initial velocity of 800 meters per second (2,625 feet per second) at a maximum elevation of 60°.

Illustration 14 shows an unidentified German anti-aircraft gun.

Captured 75-millimeter French field guns in improvised batteries are also often used for anti-aircraft work. To secure the high elevation necessary either the wheels are set on a raised center pintle with a circular track or, the wheels remaining on the level surface of the ground, a circular trench is excavated for the trail of the gun to move in.



NO. 14.—GERMAN ANTI-AIRCRAFT GUN.

The following table, though its data can not in general be brought into relation with those compiled above, is added because very recently received:

Type and caliber.	Initial velocity.	Projectile, weight.	Maximum elevation.	Range.	Weight of gun and carriage.	Weight of gun, carriage, and limber.	Muzzle energy.
KRUPP.							
	Meters.	*Kilograms.*	°	*Meters.*	*Kilograms.*	*Kilograms.*	*Meter-tons.*
75 mm. 30 cal. field carriage	510	6.5	65	.....	1,030	.....	.....
71 mm. 20 cal. on automobile	650	5	75	6,500	1,230	[1] 5,850 [2] 7,100	....
104 mm. 45 cal. coast gun.	800	15.5	60	.....	.....	.....	.....
120 mm. 45 cal. coast gun.	800	24	60	.....	.....	.....	.....
EHRHARDT.							
50 mm. 30 cal. on automobile	570	1.25	70	3,720	.....	[3] 3,100 [4] 2,800	....
65 mm. 35 cal. on automobile	670	4.1	75	7,900	.....	6,000	93.73
75 mm. 30 cal. on automobile	500	6.5	70	5,860	.....	6,300	82.76
105 mm. 32 cal.	605	17	70	8,300	.....	[5] 6,650 [6] 5,900	....
75 mm. 32 cal. field carriage	550	6.5	70	6,800	.....	1,800	100.10

[1] Without men and ammunition.
[2] With men and ammunition.
[3] With shields.
[4] Without shields.
[5] With trailer.
[6] Without trailer.

ENGLAND.

Aerial defense in the English Army consists of: (1) Fixed anti-aircraft artillery; (2) mobile anti-aircraft artillery; and (3) aeronautical units (not here under consideration).

Various types of anti-aircraft guns are in use. Among them are some 4.7-inch naval guns, some 75 mm. French guns, and some 5-inch breech-loading rifles. The later types in more common use are the 3-inch 13-pounder, the 3.3-inch 18-pounder, and finally the 3-inch 15-pounder, which ultimately is to replace them all.

The converted 3-inch 13-pounder is the former horse artillery gun, with breech bored to take a longer cartridge (with an 18-pounder charge) giving an increased muzzle velocity of about 2,000 foot-seconds. These guns are equipped with the ordinary field artillery hand-operated breech mechanism and are mounted for mobile work on pedestals built up on automobiles and revolving through 360°. There is one gun to each motor truck. These motors are of 45 horsepower. Their sides are dropped and their wheels blocked when in use. The maximum range is from 6,700 to 7,000 yards, and the highest elevation is 75°. Six batteries of these guns of six guns each are used in the London area.

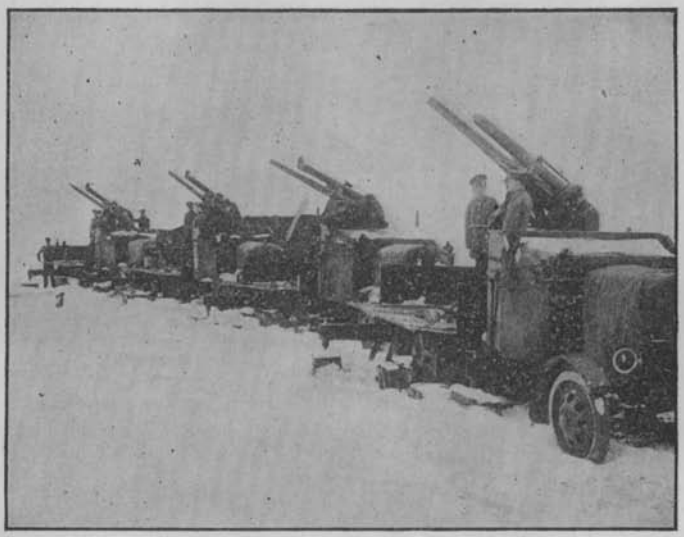
The 18-pounder is the service 18-pounder field gun mounted for anti-aircraft service. These guns also have the hand-operated breech mechanism. They give an initial velocity of about 1,750 foot-seconds. They are mounted on transportable platforms (see below). Some of these guns have been relined and the bore decreased to 3 inches. These relined 18-pounders fire a 13-pound projectile with an increased velocity of approximately 2,000 foot-seconds. Some of these relined 18-pounders are mounted on automobiles. The anti-aircraft guns which are on automobiles are mounted directly over the rear axle of standard 3-ton motor trucks provided with two outriggers, so as to permit of firing across the truck. The rear outrigger consists of a telescoping beam capable of being drawn out about 4 feet beyond the sides of the truck. At its outer ends are two jackscrews which distribute the load over about 3 square feet of ground by bearing upon blocks which are carried on the truck. The front outrigger just behind the driver's seat extends out only sufficiently to permit of the use of the jackscrews. The body of the truck is provided with sideboards

which, when dropped down, extend the platform about 20 inches on each side. The trucks have single tires in front and double tires in rear and are equipped with governors limiting the speed to approximately 18 miles an hour. They carry a small amount of ammunition, while additional ammunition is carried on other motor trucks.

The latest gun, one which has been especially developed during the war for anti-aircraft work, is the 3-inch 15-pounder 20 hundredweight gun on a pedestal mount. This is the one gun which has been adopted as standard for the service and is to replace all others. It is considered the best gun for the purpose and it is reported that both French and Italian officers admit its superiority to any yet developed. It is being supplied to all anti-aircraft stations as rapidly as possible. It was built to have an initial velocity of about 2,750 foot-seconds, now reduced, however, to 2,550 foot-seconds, because with a higher velocity the gun wears out too rapidly. The gun is 45 calibers long and has a height range of 25,000 feet. The gun had originally semi-automatic action including (1) on recoil, unlocking and opening of breechblock and ejection of shell case; (2) on loading, closing and locking of breechblock, thereby giving a rate of fire of 22 rounds per minute. Owing to difficulties experienced at the higher elevations in the operation of the semi-automatic mechanism, the standard Vickers type, straight-pull breech mechanism (rate of fire 20 rounds per minute) has been used instead. The gun has two recoil cylinders with springs and piston. The recoil is only 11 inches. The traversing and elevating mechanism are each of the rack and pinion type, the latter with worm gear to prevent running down. Two telescopic sights are used, one on the right for deflection and one on the left for elevation, so mounted and controlled that all corrections made are applied to both telescopes. Each telescope has interior illumination for night work by means of an electric-light bulb. It can be fired at an elevation of full 90°. The ammunition is fixed, and after the present supply of shrapnel has been exhausted, high-explosive shells are to be used exclusively. It is the intention eventually to supply guns with 60 per cent time H. E. and 40 per cent percussion H. E. fuses.

The 15-pounder 20-hundredweight guns and carriages (also some 18-pounders) are mounted on a transportable platform or autotrailers of structural steel 5 feet square and 18 inches deep. Four arms about 4 feet in length are hinged at the corners so

that they can be swung to the firing position on the diagonals of the platform and locked by pins through the platform, which is thus extended sufficiently to give the gun stability. On the bottom of the platform and on each of these arms are angles approximately 3 by 3 inches, which by engaging the surface of the ground prevent lateral movement. At the end of each arm is a jackscrew. To go into action the trailer is detached from the motor car, the arms swung out and locked, and the jackscrews run down until the weight is taken off the two wheels of

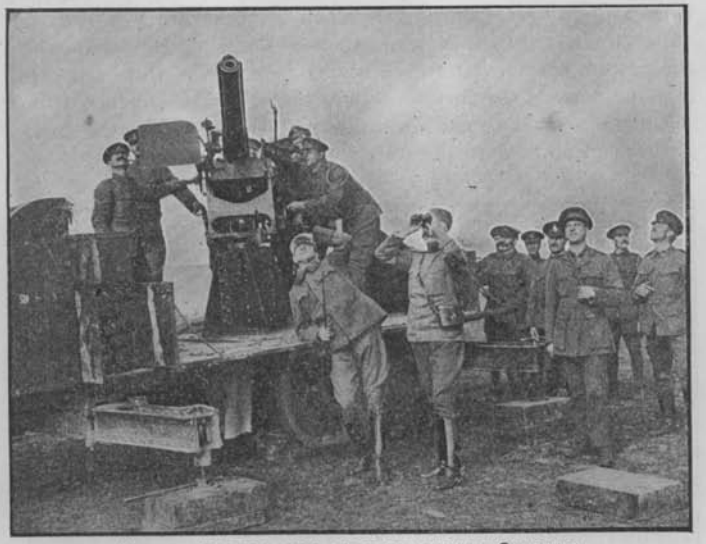


NO. 15.—BRITISH ANTI-AIRCRAFT GUNS ON THE WESTERN FRONT.

the trailer. As the wheel axle is jointed in the middle and held together by a latch, this latch is now released and the two wheels being then withdrawn, the jackscrews are run out until the platform rests on the ground ready for firing. It takes a trained crew only about one minute to place the gun in action. The gun crew consists of 11 men.

The 15-pounder guns, with some 18-pounders, mounted on trailers are used in anti-aircraft defenses in England (84 of the former are eventually to be provided for the aerial defense of London) for the protection of ammunition stores, bases, etc., and behind the firing line in France. The guns mounted on motor trucks (13-pounders and some 18-pounders) are used im-

mediately behind the front line trenches and also for reinforcing the anti-aircraft fire wherever necessary.



NO. 16.—BRITISH ANTI-AIRCRAFT GUN AT SALONIKI.

Illustration 15 shows a British anti-aircraft gun on the western front, and illustration No. 16 one at Salonica.

UNITED STATES.

The only weapon designed for use by our Army specifically against aircraft is a 3-inch 15-pounder, having the same construction and ballistics as the 3-inch 15-pounder model of 1903. This piece will be equipped, however, with a semiautomatic breech mechanism and a drop block. The carriage provides for firing the gun at elevations between 0° and 80°. It is anticipated that a maximum altitude of about 30,000 feet can be obtained with this gun when using a projectile with a 7-caliber ogive and a muzzle velocity of 2,600 feet per second.

The Ordnance Department is designing or building three different types of mounts for anti-aircraft artillery. The first is a fixed pedestal mount for the 3-inch 15-pounder gun; the other

two mounts are for a 3-inch field gun, model of 1902, one to be emplaced on an automobile truck, the other on a semiportable platform. All mounts will permit a maximum elevation of 85°. The minimum elevation of the automobile mount will be 35°, while that for the semifixed and 3-inch 15-pounder mounts will be 12° and 0°, respectively.

It is understood that the Engineer Department has plans for mounting the standard 3-inch antiaircraft gun and carriage as follows:

(*a*) On a standard railway flat car of 80,000 pounds capacity, equipped with outriggers which will enable the gun to be fired from the car at any point by blocking up under the ends of the outriggers.

(*b*) On a light flat car running on light standard gauge, which can be pushed, if necessary, from point to point and which can be quickly anchored to a concrete platform to be constructed in advance and laid flush with the ground under the track at points where it is desired to bring the gun into action, the gun to be fired from the car after it is anchored to the platform.

(*c*) On a truck from which the gun can be fired in the same manner as explained under (*b*), but which can be hauled over ordinary roads by teams or automobile tractors.

The methods outlined above are considered by the Engineer Department to be the cheapest and most practicable for the mobile use of the standard 3-inch anti-aircraft gun and carriage. By making use of concrete platforms for anchorages which are laid flush with the ground, a practically level base for the gun when fixed is secured and the platform can be concealed by an earth covering when not in use. It is also practicable to make provisions for bolting the gun pedestals directly to the concrete platforms if desired.

The new Navy anti-aircraft gun, developed after three years of experiment, is a machine rifle about 50 calibers long and capable of hurling a 3-inch shell 27,000 feet into the air at an angle of 90°, and can deliver its charge at rapid-fire rate.

CONCLUSIONS.

The aeroplane has been steadily forced to higher altitudes, and to counteract this the anti-aircraft gun has shown a corresponding tendency to increase in size, power, and range. The

size of aerial defense guns used in the present war has ranged from machine guns to those of 4, 5, and 6 inches in caliber.

Aircraft are comparatively safe from machine-gun fire at altitudes greater than 3,500 feet. For anti-aircraft work the machine guns, like the rifles, lack range and also effectiveness and facilities for observation, while field guns do not possess sufficient elevation to allow of their being trained on aircraft, nor, were they once trained on a so-rapidly moving target, would they be able to follow it.

The larger the caliber the better (always provided the requisite rapidity of fire can be secured) in order to compel the enemy to fly too high for good observation. Anti-aircraft guns on mobile mounts should have a caliber of not less than 3-inch, while for the really adequate defense of any important position some 4-inch guns should be included. If the guns are to be in fixed emplacements, their caliber should be 6-inch.

The anti-aircraft gun must have a high muzzle velocity, so as to obtain a flat trajectory. To secure the great rapidity of fire necessary it should have a small recoil and semiautomatic loading. The mounting should be such as to permit the greatest possible elevation (at least 70°) and quick traversing over the widest possible arc of fire, preferably 360°. It should be easy to sight and fire rapidly at high elevations. If suitable in other respects an ordinary fieldpiece can be used against aircraft on almost any kind of improvised mounting, which permits great elevations and all-around fire. Such mounts are makeshifts at best, however, as the gunnery will necessarily be unsatisfactory.

Until recently shrapnel was used almost exclusively against aircraft, but as experience during the war has shown shrapnel is almost useless against aeroplanes. High explosive shells are much more effective. A Farman biplane with its engine worn out from use, but otherwise practically undamaged, though with over 400 shrapnel and bullet holes, has been exhibited in Paris.

Mountings for anti-aircraft guns are either: (1) Fixed (in permanent emplacements); (2) transportable (either on railway cars with outriggers, on flat cars, or on auto trailers—the car or trailer is then either blocked up or anchored to a platform previously prepared); (3) mobile (on motor trucks, armored or unarmored).

Fixed mountings for anti-aircraft guns, however efficient, have the great disadvantage that their location soon becomes known to the enemy. Mobile mountings, on the other hand,

greatly enhance the value of anti-aircraft guns. They permit a more effective tactical use of the guns by introducing into air defense the very important element of surprise, as any different number of positions for temporary occupancy may be selected without previous knowledge of the enemy. Also, the guns can be better concealed. The principal disadvantage of mobile mounts is in the instability of the gun platform and the difficulty of keeping it always perfectly level. As, however, anti-aircraft guns on mobile mounts are in successful use by both sides abroad it is evident that this disadvantage has been overcome.

As the enemy aeroplane gets beyond range very quickly, there is no time for elaborate computations, and the use of tables should also be rendered unnecessary. The gun must go into action at once and maintain an extremely rapid fire involving continual changing of data between shots. It has been found best to fire very rapidly with as many guns as possible and try to get the range from the explosion of the shell. Anti-aircraft gunnery is thus extremely difficult, and gun pointers require careful instruction and long and continuous practice to attain any degree of proficiency and avoid waste of ammunition, the expenditure of which in war time is excessive. At best anti-aircraft firing is very inaccurate and volume of fire must be used to compensate for this lack of accuracy. The tendency is toward simplification in all sighting apparatus and relying largely on correcting fire by observation.

Anti-aircraft guns should accordingly not be fired singly. They have frequently been used abroad in pairs and in groups of three and four. The tendency, however, is toward still larger groups, and it is now a common opinion among officers that each anti-aircraft station should have a battery of not less than six guns in order to secure the maximum rapidity of fire, while at the same time avoiding some of the errors in spotting by establishing a zone of fire around the hostile aircraft. As nearly as practicable these groups of guns should be brought into action at least 1,800 yards apart. All gun stations should be occupied without intermission both night and day, and it is necessary to screen the guns from overhead observation.

Whereas at the beginning of the war aeroplanes flew at altitudes of 4,000 to 5,000 feet, and then at 6,560 feet (2,000 meters), with comparative safety, the so-called safe altitude has been gradually increased, first to 10,000 feet and finally to

12,000 feet and over on a clear day. It is not thought probable that artillery attacks against aircraft can be made effective for altitudes of 15,000 feet or over, though an occasional hit at such an altitude even may occur. Thus in October, 1916, an airman was badly wounded by a high-explosive shell from a German gun (presumably the 105 mm. gun) while flying at the great height of 5,200 meters (15,850 feet).

Several flyers are reported to have been brought down from a height of 4,000 meters (13,120 feet). Such hits are very rare, however. The speed and maneuvering power of aeroplanes make them extremely difficult targets to hit. The steadily increasing altitudes at which they have been forced to fly adds further to their security, but, on the other hand, greatly diminishes the effectiveness of their observations. Thus while pursuit aeroplanes now fly for safety at about 18,000 feet, the fighters and camera machines operate between 10,000 and 12,000 feet. Now, while air disturbances due to the bursting of a high-explosive shell within 100 feet of an aeroplane might cause the aeroplane to dive or even capsize, it would not necessarily wreck the machine; therefore a direct hit on some vital part of the aeroplane is necessary to bring it down. As above stated, such hits are rare, but the anti-aircraft gun need not hit the aeroplane to fulfill its function; if it can force the aeroplane to fly too high for good observation it is still worth more than it costs. After all, however, the only really effective defense against hostile aircraft lies in an aerial service of our own more efficient than that of the enemy. For this purpose powerful aeroplanes equipped with machine guns or light cannon should be used.

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