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No. 1320
G-5.

Not to be taken into front line trenches.

SUPPLEMENT TO

MACHINE GUN DRILL REGULATIONS

(PROVISIONAL) 1917

AND

PROVISIONAL MACHINE GUN FIRING MANUAL

1917

GENERAL HEADQUARTERS
AMERICAN EXPEDITIONARY FORCES

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SUPPLEMENT TO

MACHINE GUN DRILL REGULATIONS

(PROVISIONAL) 1917

PART I.

FOR ORGANIZATIONS EQUIPPED WITH HOTCHKISS MACHINE GUN.

(MODEL 1914.)

139-A. The gun squad consists of 1 corporal and 8 privates, and is the basic unit of the machine gun company. The squad is organized and equipped as follows:

1. When issued the Hotchkiss machine gun and the omnibus tripod, model 1915.

Corporal. — *Gun Commander.* Gun level and 1 box ammunition.
No. 1. — *Gunner.* Gun, traversing and elevating clamps.
No. 2. — *Assistant Loader.* Tripod and 4 sand bags.
No. 3. — *Loader.* Traversing head and 1 box ammunition.
No. 4. — *Ammunition Carrier.* Spare parts case, gunner's bag, and 1 box ammunition.
No. 5. — *Ammunition Carrier.* 2 boxes ammunition.
No. 6. — *Ammunition Carrier.* 2 boxes ammunition.
No. 7. — *Driver.* Mule and gun cart.
No. 8. — *Driver.* Mule and ammunition cart.

2. When issued the Hotchkiss machine gun and the Hotchkiss tripod, model 1916.

Corporal. — *Gun Commander.* Gun level and 1 box ammunition.
No. 1. — *Gunner.* Gun, traversing and elevating clamps.
No. 2. — *Assistant Loader.* Tripod and 4 sand bags.
No. 3. — *Loader.* 2 boxes ammunition.
No. 4. — *Ammunition Carrier.* Spare parts case, gunner's bag, and 1 box ammunition.
No. 5. — *Ammunition Carrier.* — 2 boxes ammunition.
No. 6. — *Ammunition Carrier.* 2 boxes ammunition.
No. 7. — *Driver.* Mule and gun cart.
No. 8. — *Driver.* Mule and ammunition cart.

Each member of the gun squad, in addition to knowing all his own duties, must be drilled in the position of every other member and must be thoroughly familiar with the duties of all members of the gun squad. The drivers are habitually with their carts, and do not form in ranks at drill with the gun squad. When a casualty occurs in action the next higher number moves up and replaces him.

Teaching Elementary Drill.

143-A. 1. Equipment required for each gun team : gun, tripod, traversing head, gun level, traversing and elevating clamp, 8 ammunition boxes, 4 sand bags, spare parts case, landscape targets.

2. The gun, tripod and traversing head will be placed in line on the ground about three paces apart and about 30 meters from the landscape target.

3. Tripod in the center, tripod legs folded and closed, legs and trail to the rear, pivot upward to the front, tripod pouch securely fastened to trail and closed.

4. Gun on the right, muzzle pointed to the front, handle block pin secure, rear sight leaf lowered with slide set at 250, firing mechanism down and trigger pulled, feed box locking pin securely fastened.

5. Traversing head on the left. This applies only when the omnibus tripod is being used. One box of ammunition is laid alongside the traversing head.

6. Spare parts case and ammunition boxes in place about three paces in rear of the gun, tripod and traversing head.

To Post the Gun Squad.

145-A. At the command *Posts,* No. 1 will repeat the order and all men move at double time to positions as follows : No. 1 will double time to his position and fall in on the right side of the gun; No 2 will fall in on the left of the tripod; No. 3 will fall in on the left of the traversing head; Nos. 4, 5 and 6 will fall in in rear of the ammunition boxes. As soon as No. 1 gets to his position, he will examine the gun and see that all parts are secure and in working order. No. 2 will examine tripod and tripod pouch, see that all parts are in working order and that the contents of the tripod pouch are complete. No. 3 will examine the traversing head. He will then report "Correct" to No. 2, who will report "Tripod and traversing head correct" to No. 1, who will in turn report "All correct" (or otherwise) to the instructor.

To Examine the Gun.

146-A. Before commencing drill, the instructor commands *Examine the gun.* Each number then examines the gun and equipment as follows :

No. 1 examines the gun and sees that :

1. The barrel is securely locked to the receiver and the barrel lock is in a forward position.
2. The gas regulator is set at 3.
3. The gas cylinder stop marks are opposite each other.
4. The gas cylinder locking screw is fully fastened down.
5. The feed box is seated in the receiver and the feed box locking pin fully home.
6. The sight is in working order.
7. The firing mechanism is in proper working order.
8. The handle block is securely fastened to the receiver.

9. The connecting link is fastened to the gun.
10. The trigger and sear work freely and the sear spring is properly seated in its bed.

No. 2 examines the tripod and sees that :
1. The legs are correctly folded.
2. The knee-joint locks and the trail arm lock are securely fastened.

No. 3 examines the traversing head and sees that :
1. The traversing clamp and elevating wheel are in working order.
2. The strips in his box of ammunition are not bent or broken.
3. The cartridges are correctly placed and aligned.
4. The strips are correctly packed in the box and the lid fastened.

No. 4 examines the spare parts case and sees that :
1. The contents of the spare parts case are complete and in working order.
2. The strips in his box of ammunition are not bent or broken.
3. The cartridges are correctly placed and aligned.
4. The strips are correctly packed in the box and lid fastened.

Nos. 5 and 6 examine their ammunition boxes and see that :
1. The strips in their boxes of ammunition are not bent or broken.
2. The cartridges are correctly placed and aligned.
3. The strips are correctly packed in the box and lid fastened.

To Mount the Gun.

147-A. 1. When equipped with the Hotchkiss machine gun and the omnibus tripod, model 1915.

At the command *Mount Gun,* the gun commander designates the position where the gun is to be mounted on the tripod. This should be about 6 paces in rear of the actual firing position. He then places his box of ammunition 2 paces to the left of the firing position on the ground and indicates the direction of firing.

When the gun is mounted and in position, the gun commander takes his post 2 paces in rear of the gun.

No. 2 double times to the left of the gun commander, halts in front of him about 6 paces in rear of the firing position, faces away from the direction of firing, lowers the tripod from his shoulder until the trail touches the ground, draws the legs of the tripod forward folded, spreads them and lowers the legs to the ground. He then takes his post facing the front 2 paces to the left of the firing position, opens the ammunition boxes and places them in a position handy for loading.

No. 3 follows No. 2 to the left of the tripod. He throws his box of ammunition up to No. 2 and, after fixing the traversing head upon the pivot of the tripod, clamps it. He promptly takes his position to the left of the gun,

No. 1 double times to the right of the tripod and places the gun in the trunnion beds of the traversing head. Assisted by No. 3 he fastens the gun to the tripod and No. 1 remains on the right side of the gun.

No. 4 places the spare parts case two paces to the right of the firing position, opens the case, and takes out the bore cleaning rod. The chain mittens and the shoulder pad are placed near the gunner. No. 4 then takes his post 15 paces in rear of the gun.

No. 5 double times forward and places his ammunition and sand bags on the ground 2 paces to the left of the firing position. He then assists No. 6 in leveling off the firing position.

No. 6 moves forward at a double time with a pick and a shovel. With the assistance of No. 5, he levels off the firing position and fills the sand bags.

As soon as the firing position is leveled, No. 1 and No. 3 carry the gun forward to its position and take their posts.

No. 1 seats himself on the trail and levels the gun.

No. 1's position at the gun is as follows : Body inclined slightly backwards, weight resting evenly on the trail seat, knees straight, feet apart and resting on the separators of the tripod, right hand grasping the pistol grip and holding downward, left hand grasping the hand wheel, thumb and first two fingers grasping the wheel

and the elevating wheel index, eyes to the front glancing along the sights.

No. 3 kneels, or sits down, facing to the rear on the left side of the gun.

No. 2 kneels down facing the rear on the right side of the gun and removes the hand extractor from the tripod pouch.

Nos. 4, 5 and 6 place the sand bags about the legs and trail and over the separators of the gun. When this is completed, they double time to their posts 15 paces to the rear of the gun.

The extra numbers, detailed as ammunition carriers, place their ammunition on the ground 15 paces in the rear of the gun, or at some spot chosen by the corporal. Not more than 4 boxes of ammunition are kept near the gun at any one time.

Nos. 4, 5 and 6 and any extra numbers lying down in their positions in order from right to left with an interval of 3 paces.

It is assumed in the above that the tripod is in its highest position. At other elevations, Nos. 3 and 1 take the most suitable positions for loading and firing. When the "T" base is used it is carried and placed in position by No. 5.

2. When equipped with the Hotchkiss machine gun and the Hotchkiss tripod, model 1916.

At the command *Mount Gun,* the gun commander designates the position where the gun is to be mounted on the tripod. This would be about 6 paces in rear of the actual firing position. He then indicates the direction of firing. When the gun is mounted and in position the gun commander takes his post 2 paces in rear of the gun.

No. 2 double times to the left of the gun commander, faces away from the direction of firing and lowers the tripod from his shoulder until the trail touches the ground. With his right hand he pushes the cam lever upward. No. 3 who has thrown his two boxes of ammunition to the firing position, takes a kneeling position at the right of the tripod, facing it. He grasps the trail with the right hand and the yoke of the traversing head with his left hand. Inclining the tripod

to the rear, he pushes the traversing head forward and upward, pivoting it on the trail joint. No. 2, holding a front leg in each hand, raises them until the front leg heads are exactly opposite the front leg head upper sockets. He separates the legs and inserts the front leg heads into the front leg head upper sockets. No. 3 then pulls the traversing head to the rear and down. No. 2 pulls the cam lever down and lowers the legs of the tripod to the ground. After No. 2 has set up the tripod he takes his post facing the rear 1 pace to the right of the firing position.

No. 1 double times to the left of the tripod and places the gun in the trunnion beds of the traversing head. After fastening the gun to the tripod he grasps the trail with his right hand and the left front leg with his left hand. Assisted by No. 3 he carries the gun to the firing position.

No. 4 places the spare parts case on the ground two paces to the right of the firing position, opens the case and takes out the bore cleaning rod. The chain mittens and the shoulder pad are placed near the gunner. No. 4 then takes his post 15 paces in rear of the gun.

No. 5 double times forward and places his ammunition and sand bags on the ground 2 paces to the left of the firing position. He then assists No. 6 in leveling off the firing position.

No. 6 moves forward at a double time with a pick and shovel. With the assistance of No. 5 he levels off the firing position and fills the sand bags.

As soon as the firing position is level, No. 1 and No. 3 carry the gun forward to its position and take their posts.

No. 1 seats himself on the trail and eliminates cant in the gun.

No. 1's position at the gun is as follows: Body inclined slightly backward, weight resting evenly on the trail seat, knees straight and feet placed just inside the front legs, right hand grasping the pistol grip and holding downward, left hand placed on top of the handle block, eyes to the front glancing along the sights.

No. 3 kneels, or sits down, facing to the rear on the left side of the gun.

No. 2 kneels down facing to the rear on the right side of the gun, and removes the hand extractor from the tripod pouch.

Nos. 5 and 6 place the sand bags about the legs and trail of the tripod. When this is completed they double time to their posts 15 paces to the rear of the gun.

The extra numbers, detailed as ammunition carriers, place their ammunition on the ground 15 paces to the rear of the gun or at some spot chosen by the corporal. Not more than four boxes of ammunition are kept near the gun at any one time.

Nos. 5 and 6 and any extra numbers lie down in their positions in order from right to left with an interval of 3 paces.

It is assumed in the above that the tripod is in its highest position. At other elevations Nos. 3 and 1 take the most suitable positions for loading and firing.

To Change the Height of the Tripod.

147 1/2. (A) *Omnibus tripod, model 1915.*

1. To drop the gun to the lowest position. (*a*) To bring the gun to the kneeling position upon the tripod : 1. *Drop Gun,* 2. DOWN. At the preliminary command, No. 3 unlocks the left knee joint lock and the trail arm lock.

No. 2 unlocks the right knee joint lock. No. 1, standing on either side of the trail, bends over and grasps it with both hands. As soon as the locks have been unfastened, he lifts the trail from the ground. At the command DOWN, numbers 1, 2 and 3 then shove forward on the upper part of the tripod and bring the tripod to its lowest position on the ground. No. 3 then locks the trail arm lock to hold the gun upright. The gun squad lie prone at their posts upon the ground, No. 1 with his feet to the front to the left of and along side the barrel.

(B) Upon Piquet support, or sled mount : At the command, *Drop Gun,* No. 3 fixes the Piquet support, or sled mount, in the ground. At DOWN, No. 1 and No. 3 mount the gun, all lie down, the gunner behind the piece

feet to the rear, No. 3 to the left of the piece on his left side, feet to the rear.

2. To raise the gun to its highest position :

When the gun is mounted on the tripod kneeling : 1. *Raise gun,* 2. UP. At the command *Raise gun* No. 2 unlocks the trail arm lock; at UP, Nos. 2 and 3 stand on the shoes of the lower legs of the tripod, seize the yoke on the traversing head and push upward and to the rear. No. 1, who has picked up the trail pulls to the rear. When the tripod has been raised to its highest position, Nos. 2 and 3 lock the knee joint locks and trail arm lock. No. 1 drops the trail to the ground. All resume their posts.

(B) *Hotchkiss tripod, model 1916.*

1. To drop the gun to the middle position.

1. *Drop gun to second position,* 2. DOWN.

At the preliminary command, No. 1 stands and No. 2 kneels at the right of the gun and facing it. No. 2 promptly pulls the cam lever up. At the command of execution, No. 2 grasps the trail of the tripod with his left hand and the right front leg with his right hand. No. 1 grasps the handle block with his right hand and lifts the rear end of the gun up. This causes the front legs to pivot at their axle. Assisted by No. 2, the gunner then allows the gun to settle to the second position and No. 2 pushes down the cam lever. The cams should enter the middle cam grooves. This is the most difficult position to assume and considerable practice is necessary to avoid going to the third or lowest position.

2. To drop the gun to the lowest position.

1. *Drop gun to lowest position,* 2. DOWN.

At the preliminary command, No. 1 springs from his seat and No. 2 pulls the cam lever up. At the command of execution, No. 1 grasps the handle block with his right hand and raises the rear end of the gun up until the front legs have pivoted. He then lets the gun down to the lowest position. No. 2 pushes the cam lever down. The cams should enter the highest cam grooves.

3. To raise the gun.

1. *Raise gun to highest (middle) position,* 2. UP.

At the preliminary command, No. 2 pulls the cam lever up. He then grasps the right front leg with his right hand and the trail with his left hand. The gunner stands up and grasps the barrel with his left hand and the handle block with his right hand. The gunner then lifts the gun up and No. 2 works the trail and the legs in such a manner that they will be in the desired position. No. 2 then pushes the cam lever down.

148-A. The points for criticism when the gun is mounted should follow a definite sequence.

(a) *Tripod.*

1. Tripod solidly mounted on "T" base and sand bags in proper positions.
2. Position of legs with reference to the ground.
3. Clamps of legs tight.
4. Trail on prolongation of line of aim to target.
5. Traversing head clamped.
6. Trunnion beds level.
7. Elevating mechanism fastened to gun.

(b) *Gun.*

1. Muzzle toward target or zero line.
2. Gun without cant.
3. All members of the squad in their proper positions.
4. The four ammunition boxes properly laid out.
5. Spare parts case open and properly placed.

To Dismount the Gun.

149-A. At the command *Dismount Gun,* No. 1, assisted by Nos. 2 and 3, unfastens the connecting link pin and the trunnion cap pins. He then removes the gun from the tripod and carries it back to its original position.

No. 2 removes the traversing head from the tripod, picks up one box of ammunition and replaces them in their original position.

No. 3 steps in front of the tripod, picks up the front legs, folds the tripod legs and swings the tripod over his shoulder. He then carries the tripod back to its original position.

Each of the other numbers double time forward to secure their loads and return with them to their original positions.

To Load the Gun for Automatic Fire.

152-A. The gun being unloaded, but mounted, the command is : 1. *Automatic Fire,* 2. LOAD.

No. 3 kneels opposite the feed box, faced to the rear, and grasps the far side of the yoke of the traversing head with his left hand to steady the gun while loading. He takes the strip with his right hand, clasping it about six inches from the rear end, cartridge bases against his palm, thumb under the strip, fingers resting on top, maintaining a firm grip on the strip. He then places the front end of the strip on the floor of the feed box, and carefully inserts the edges of the strip under the front and rear strip guides. With the right end of the strip raised at an angle of about 15 degrees, the strip is pushed forward until the first cartridge is directly in front of the chamber.

If the gun is in the lowest position, No. 3 lies on his back, feet to the rear, supporting his back with an ammunition box, or some similar article. No. 3 loads the gun as described above. In spite of any cramped position that he may have to assume he must load the gun carefully.

After the first command for loading, No. 3, unless otherwise directed, will keep the piece loaded.

PRECAUTIONS IN LOADING.

The following precautions are necessary in order to avoid damaging the stripping finger :

1. Loaders should learn by experiment the position they must assume to load the gun carefully.
2. If the front edges of the strips have become bent out of shape, they should be turned down again with a pair of pliers, in order to insure a proper entrance of the strip into the strip guides of the feed box.
3. The strip must be inserted so that the first cartridge is directly in front of the chamber. If the strip

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is inserted either too far or not far enough, a stoppage will result.

4. Instructors and gun commanders must exercise constant vigilance to prevent loaders jabbing the strip into the feed box, as this practice will result in damaged stripping fingers. Pieces loaded in accordance with foregoing instructions may be loaded and fired to the limit of their rate of fire without the point of the stripping finger touching anything except the lower surface of the cartridge.

To Lay the Gun.

154-A. (1) In case the target can be seen from the gun : At the command *Range*, No. 2 sets the rear sight at the range announced and repeats the sight setting. At the command *At (such an object)*, No. 1 repeats the command, traverses and elevates the gun until the sights are laid upon the target designated. No. 1 then signals "Ready" and assumes the correct firing position at the gun. The corporal checks the laying of the piece.

(2) In case the firing is to be indirect : At the command *Reference object*, No. 1 repeats the command and lays the gun on the reference object ordered. At the command (so many) *Mils right (left)*. the gunner repeats the command and traverses through the arc ordered and clamps the gun. No. 1 then signals "Ready" and assumes the correct firing position at the gun. The corporal checks the laying of the piece in direction.

At the command *Range...*, *Bubble...*, No. 1 repeats the command and No. 2 sets the given range by putting the forward edge of the slide on the mark indicating the range. The gun commander places the gun level on the sight and turns the elevating wheel until the center of the bubble reaches the announced bubble reading. The center of the bubble should be exactly under the numerals on the level to set it at a whole number of bubbles (e. g. 2, 5, etc.); for half a bubble the center should be at the straight line between the numerals; for smaller fractions the proper position of the bubble can be estimated.

In case a clinometer is used to lay the gun in elevation, at the command *Up* (*down*) so many *Mils*, the corporal sets the clinometer at the proper reading and places it on the barrel of the gun immediately in front of the radiators. He then turns the hand wheel until the bubble is central.

NOTE. — The same commands may be executed, without using the clinometer, by first leveling the gun and then turning off the desired angle up or down by means of the hand wheel.

To Fire the Gun.

155-A. The gun being mounted and loaded, or assumed to be loaded : 1. *Range* (800); 2. *At* (*such an object*); 3. *Fixed* (*distributed, searching, ranging*) *fire;* 4. (*so many*) *Rounds* (*as 2 strips,* etc.); 5. COMMENCE FIRING.

The details and methods to be used in teaching the different kinds of fire are given in the Machine Gun Firing Manual. For definitions of the different kinds of fire, see "Definitions".

At the first and second commands the operations prescribed in paragraph 154-A are performed. The third and fourth commands are preparatory and indicate the class of fire and the number of rounds to be fired. These commands are given when necessary.

At the command COMMENCE FIRING, No. 1 instantly pulls the trigger without deranging his aim and at the same time holds down and maintains a steady grasp on the pistol grip.

To Cease Firing.

157-A. At the command or signal *Cease Firing,* No. 2 places his hand across the gun at the rear sight. The gunner immediately ceases firing. The gun is unloaded, cleared, and oiled. No. 2 runs the cleaning rod through the barrel and cools it, if necessary. The gunner relays his gun in direction and elevation and after checking same the gun commander signals to the

rear "Ready". At any preparatory command for movements *Cease firing* is executed. The gun is dismounted from the tripod and all loads are prepared for carrying.

To Unload.

158-A. The gun being loaded : At the command *Unload*, No. 1 releases the feed ratchet pawl by drawing the cocking piece handle completely to the rear. No. 3 grasps the strip with his right hand and removes it from the feed box. The gunner then pushes the cocking piece handle forward and lets the mechanism down hard by pulling the trigger.

To prepare for Action.

170-A. The command is : *Action.* At this command the carts, if moving, halt. Squad leader marks the place at which the gun is to be set up. No. 1 secures the gun, No. 2 the tripod, No. 3 the traversing head and a box of ammunition, No. 4 the spare parts case and a box of ammunition, Nos. 5 and 6 each secure two boxes of ammunition. The squad then moves forward under the direction of the corporal and mounts the gun. The senior driver takes command of the carts, moves them on the run to the flank, or to the rear, to a position under cover. Nos. 5 and 6 establish an ammunition station as directed by the corporal.

No. 1.

355-A. 1. Carries the gun.

2. Personally cleans and looks after the gun and insures that the mechanism is working smoothly.

3. Observes his own fire when possible.

4. Is responsible for the operation of the gun and takes such steps as are necessary to insure proper functioning of the mechanism at all times.

5. Sets sight as directed by the corporal.

6. Directs kind of fire ordered.

7. Corrects stoppages.
8. Sees that the tripod pouch and spare parts case are open and conveniently within his reach.

No. 2.

356-A. 1. Carries tripod and sand bags.
2. Assists No. 1 in correcting stoppages.
3. Assists No. 3 in loading the gun.
4. Watches for signals.
5. Transmits signals to No. 1.
6. Runs the cleaning rod through the bore when directed by No. 1.

No. 3.

357-A. 1. Carries traversing head and one box of ammunition.
2. Loads the gun.
3. Assists No. 1 in correcting stoppages.
4. Adjusts the gas regulator when necessary.
5. Sees that ammunition is supplied in the necessary quantities by Nos. 4, 5 and 6.

No. 4.

358-A. 1. Carries spare parts case and one box of ammunition.
2. Returns with empty boxes to ammunition station.
3. Assists Nos. 5 and 6 in supplying No. 3 with ammunition.

Nos. 5 AND 6.

359-A. 1. Establish ammunition station.
2. Supply ammunition to No. 3.

No. 8.

361-A. 1. Is responsible for the care of the ammunition mule, cart, and ammunition.
2. Supplies ammunition to the ammunition station.
3. Refills his cart from the combat train.

Company Inspection.

602-A. The company being in line or in close line, the captain commands : 1. *In front of the carts,* 2. FALL IN. The gun squads "fall in" in front of the carts, as described in paragraph 162. The captain then causes the company to open ranks; as described in paragraph 128, and aligns the company on the right squad.

The captain dismounts and turns his horse over to one of the buglers. All mounted men dismount and stand to horse.

The captain then takes post 5 paces to the front of the right of the company. If the inspection is to be conducted by him, he faces to the left and commands : *Prepare for inspection.* He then passes down in front of the platoon leaders, inspecting them, and returns to the right of the company in front of the section leaders, inspecting them.

The inspection of the dismounted men is carried on by the company commander, assisted by the platoon leaders, if he so desires, as in the company dismounted.

Upon completion of the inspection of the gun squads the captain makes such inspection as he deems necessary of the drivers, carts, and equipment. If he desires to inspect all the guns and equipment, he gives the command : *Inspection equipment.*

At this command the gun squads secure the guns, tripods, etc., and mount them, as described in paragraph 147, 10 paces in front of their respective positions. The ammunition boxes, tool boxes, water boxes, etc., are placed in line, as described in paragraph 147. The men take position, as described in paragraph 147, and remain at attention during the inspection. The carts, signalmen, and agents do not move.

For this inspection the captain may direct each platoon leader to inspect the equipment of his platoon. This inspection of equipment should cover the following points :

Gun :

(a) *Front sight.*

1. Straight and without lost motion.

(b) *Gas regulator.*

1. Gas cylinder stop marks opposite each other.
2. Gas regulator set at 3.
3. Gas cylinder locking key tight.
4. Gas cylinder clean and free from carbon.

(c) *Barrel.*

1. Barrel stop marks opposite each other.
2. Barrel fully seated in receiver and barrel locking key in a forward position.
3. Barrel free from obstruction and clean.
4. No rust in the bore.

(d) *Receiver.*

1. Receiver free from obstruction and clean.
2. Stripping finger not worn.

(e) *Rear sight.*

1. Rear sight slide should work freely.
2. Rear sight base spring not broken.

(f) *Feed box.*

1. Feed wheel should work freely when locking piece handle is pulled fully to rear.
2. Safety sear spring should be tested by releasing the trigger and sear.
3. Feed ratchet pin spring should be tested to see if it will hold feed ratchet wheel from turning backward.
4. There should be no dirt nor friction in the feed box.

(g) *Piston.*

1. The piston should be clean and free from carbon or hardened grease.
2. Sight along piston to see if it is straight.

(h) *Breech block.*

1. The breech block and locking dog should be clean and free from hardened grease.
2. Test breech block and extractor with loaded cartridge to see if extractor or face of breech block are worn.
3. Examine locking dog to see that it is not cracked.

(i) *Return spring.*

1. Should be examined to see that it is not broken or worn.

(j) *Handle block.*

1. Should be securely fastened to receiver.

(k) *Trigger and sear.*

1. Test sear and sear spring by releasing safety sear.

2. Sear spring should be securely seated in its bed in pistol grip.

(l) *Tripod and traversing head.*

1. Inspect connecting link pin and trunnion caps to see that they fit securely.

2. Connecting link should have no lost motion.

3. Test traversing and elevating mechanism to see that there is no lost motion.

(m) *Tripod pouch.*

1. Contents should be checked to see that none are lost, worn or broken.

(n) *Spare parts case.*

1. Contents should be checked to see that none are lost, worn or broken.

(o) *Ammunition boxes and ammunition.*

1. Examine ammunition boxes to see that lids fasten securely and remain down.

2. See that handles for carrying are not broken.

3. Look for discolorations or verdigris on cartridge cases.

4. See that all cartridges are evenly aligned in strips.

PART II.

FOR ORGANIZATIONS EQUIPPED WITH BROWNING MACHINE GUN.

(MODEL 1917.)

139-B. The gun squad consists of 1 corporal and 8 privates, and is the basic unit of the machine gun company.

The squad is equipped with two carts, one carrying the gun and one the ammunition. The duties of the members of the gun squad are as follows :

The corporal commands the squad, No. 1 is the gunner, No. 2 is the loader, Nos. 3 and 4 are ammunition men, Nos. 5 and 6 are spare men and are in charge of the belt-filling station, Nos. 7 and 8 are drivers.

Each member of the gun squad, in addition to knowing all his own duties, must be drilled in the position of every other member and must be thoroughly familiar with the duties of all members of the gun squad. The drivers are habitually with their carts, and do not form in ranks at drill with the gun squad. When a casualty occurs in action the next higher number moves up and replaces him.

142-B. The preliminary drill consists of :

1. Forming the gun squad.
2. Examining the gun.
3. Mounting the gun.
4. Dismounting the gun.
5. Loading for automatic fire.
6. Laying the gun.
7. Suspending fire.
8. Ceasing fire.
9. Unloading.

Teaching Elementary Drill.

143-B. 1. Equipment required for each gun team : Gun, tripod, 2 belts and dummies, 3 ammunition boxes, water box, landscape targets.

2. The gun and tripod will be placed in line on the ground about 3 paces apart and about 30 meters from the landscape target.

3. Tripod on the right, clamps tight, strap around trail and buckled, traversing clamp sufficiently tight to prevent the pintle from coming out of the socket and to prevent the cradle from swinging around when the tripod is being carried, legs to the rear, cradle over trail.

4. Gun on the left, muzzle pointing to the front, muzzle gland tight, cork stem in, cover closed, bolt handle forward, trigger lock to the right, rear sight leaf lowered with slide set at 600, water jacket filled (see note below).

5. Gunner's pouch strapped to trail of tripod.

6. Ammunition boxes about 3 paces in rear of the interval between gun and tripod.

NOTE. — In elementary drill, water will not be placed in the water jacket until the stage of combined drill has been reached.

To Post the Gun Squad.

145-B. *Posts.* At the command *Posts,* No. 1 will repeat the order; and all men move at double time to positions as follows : No. 1 will fall in on the left of the tripod; No. 2 will fall in on the left of the gun; No. 3 will fall in on the left of the ammunition box; Nos. 4, 5, and 6 will fall in about 5 paces in rear of No. 3, No. 4 being on the right.

As soon as No. 1 gets to his position, he will attend to the point mentioned in paragraph 143, section 3, and, in addition, will see that the elevating and trunnion pins are properly in position.

No. 2 will attend to the points mentioned in para-

graph 143, section 4, and will inspect the gunneris pouch, making certain that the contents are complete. (The inspection of the gunner's pouch is done twice only during the drill; once by the first No. 2 and once by the last No. 2.)

No. 3 will examine the belt and see that the dummies are correctly placed in the box, and will then lock the box. The catch on the ammunition box will be toward the front. He will then report "Correct" to No. 2, who will report "Gun and ammunition correct" to No, 1, who in turn will report "All correct" (or otherwise) to the instructor.

To Examine the Gun.

146-B. Before commencing the drill the instructor commands : *Examine the gun.* Each member then examines the gun and equipment as follows :

No. 2 examines the gun and sees that :

1. The muzzle gland is screwed up tight.
2. The cork stem and water plugs are in.
3. The cover is down.
4. The sight is in working order.
5. The bolt is forward.
6. The trigger lock is moved to the right.

No. 1 examines the tripod and sees that :

1. The legs are closely folded, strap around trail.
2. The jamming pivot screw and clamping handle are tight with cradle over trail.
3. The pins are in and turned down.

No. 3 examines the belt and sees that :

1. The cartridges are correctly placed and aligned.
2. The belt is packed correctly in the box and the lid fastened.

As each man finishes his examination he reports to the corporal.

To Mount the Gun.

147-B. NOTE. — The instructor will now bring the team to the right of the spot where the gun is to be

mounted, so that they may see all movements clearly and listen to explanations. He will then act as No. 1, himself, giving and repeating the order *Mount Gun,* and will point out a spot which will be about 30 meters from the target where the gun is to be mounted.

On the command *Mount Gun,* No. 1 picks up the tripod with his right hand at the balance, steadies it with the left hand, and moves forward at a run to the designated position. He then places the tripod on the ground, unclamps the legs, swings legs to the front and clamps them in such position that the socket will be upright and at a convenient elevation. He then sits down behind the tripod and withdraws elevating pin with the left hand and the trunnion pin with the right hand. While adjusting the tripod, the following points must be attended to : The left forearm must be supported by the left thigh and the clamping handles should, if possible, both be manipulated with the right hand.

As soon as the tripod is nearly in position, No. 2 grasps the grip with the right hand, passes the left arm under the water jacket and lifts the gun so that the barrel will be pointing to his left over his left arm, moves forward at a run, and takes position at the left of the tripod and facing it.

He must reach the position at the moment No. 1 is removing the elevating and trunnion pins. He places his left foot between the front legs of the tripod, kneels on the right knee, supporting the weight of the gun on the left knee. With the assistance of No. 1 he puts the gun in position, inserts the elevating and trunnion pins and turns them down. He then removes the cork stem and lies down opposite the cradle of the tripod, placing the ammunition box on the ammunition box support.

After putting in the elevating pin, No. 1 will at once level the gun, adjust the jamming pivot screw to see that it is moderately tight and take the correct hold, eyes must be directed toward the target.

No. 3 takes two ammunition boxes and places them in reach of No. 2, then returns to his original position. The catches should be to the front and the boxes must not be placed in such a position that No. 2 is likely to knock them over as he lies down. The ammunition must be at hand by the time No. 2 is ready for it.

When the men have made sufficient progress in the foregoing lessons, they will be exercised in combining them and coming into action. Three aiming marks will be pointed out on the landscape target by the instructor; one of these marks should be in the foreground, one in the middle distance, and one in the background.

The instructor will name the range and target and at the command or signal *Action* the gun will be mounted, loaded, and laid. As soon as No. 2 puts up his hand, the aim and sight setting will be checked, and then the various points taught in the earlier lessons will be criticized. No. 2 must not be allowed to adjust the sights. Each number must perform the duties laid down for him in the earlier lessons and the aiming marks given by the instructor must be service targets and not haystacks, windmills, or steeples.

148-B. When the gun is mounted and Nos. 1, 2 and 3 are in position, the following points should be criticized by the instructor :

1. Actions of Nos. 1, 2, and 3 until the gun is mounted.
2. Trail away from the target.
3. Feet and legs on ground (necessary for rough ground drill).
4. Clamps of legs tight.
5. Socket upright.
6. Jamming pivot screw tight (this must be tested by the instructor in the same way that the No. 1 tests it).
7. Pins in properly and turned down.
8. Tripod a suitable height for the firer.
9. Gun level.
10. Cork stem out.
11. Cover locked.
12. Rear sight leaf down, slide at 600 meters.
13. No. 1 sitting and holding the gun correctly.
14. No. 2 lying down with head below the level of the gun.
15. Ammunition box in correct position.
16. No. 3 lying down in rear and to a flank.

NOTE. — When the instructor criticizes, faults should be pointed out in such a manner that all the team benefit from the criticism.

To Dismount the Gun.

149-B. At the command *Dismount Gun,* No. 1 removes both pins and clamps the legs, carries the tripod back to its original position and lays it on the ground on the right of the gun. In folding the legs he first loosens the clamps, allowing the tripod to collapse, next he seizes the cradle with both hands, and with a sharp upward, forward, and downward movement folds up the legs. He then tightens the clamps, and, if necessary, aligns the cradle over the trail and lies down on the left of the tripod.

No. 2 passes the ammunition box to No. 3, lifts the gun from the tripod, replaces the cork stem before leaving the gun position, and then double times back to the original position. Before placing the gun on the ground he will reset the sight at 600 meters.

No. 3 goes forward at double time to the gun position and brings back both ammunition boxes to the original position.

NOTE. — At the beginning of this exercise it is well to divide the action of dismounting the gun into two parts, the dismounting of the tripod being mastered first by all members of the team, after the instructor has shown how the tripod is dismounted. When all of the numbers have made reasonable progress with the tripod, the instructor will then continue the instruction in mounting the gun and dismounting the gun.

To Load the Gun for Automatic Fire.

152-B. 1. *Automatic fire,* 2. LOAD.

NOTE. — The instructor first demonstrates the duties of No. 1 and No. 2.

At the command *Load,* No. 2 opens the ammunition box and inserts the brass tip on the end of the loaded belt through the feed way from left to right. No. 1

pulls the brass tip to the right with his right hand, then releases the brass tip and pulls the bolt handle twice to the rear. The gun is now loaded for automatic fire and No. 1 resumes his hold on the gun, gripping the pistol grip lightly with the right hand.

153-B. The Browning machine gun can not be loaded for single shots.

To Lay the Gun.

154-B. NOTE. — It is an advantage to combine the adjustment of sights with laying the gun; therefore, instruction in aiming should be given prior to instruction in laying the gun.

The target being indicated by the instructor, the command is given : 1. *Range* (800 meters) *right* (*left*) (this being the deflection in mils to the right (left), 2. AT (SUCH AN OBJECT). At the first command, No. 1 raises the rear sight leaf (unless battle sight is announced) and moves the slide until the line of sight coincides with the line on the leaf corresponding to the range ordinate. He then traverses the gun over until the direction is obtained and elevates or depresses until the aim is correct. Should a fairly large change in direction be necessary No. 1 will order No. 2 to loosen the clamp, swing roughly on the target, order No. 2 to tighten, and then lay accurately by traversing. It is most important that while traversing or manipulating the elevating wheel, the correct hold should be maintained with the other hand. As soon as the aim is correct, he then grasps the grip, places the finger on the trigger, releases the trigger lock and by calling *Ready,* orders No. 2 to put up his hand. Care must be exercised when checking the aim, to prevent the gun being moved as No. 1 moves his head to one side to allow the aim to be viewed by the instructor.

To Fire the Gun.

155-B. The gun being mounted and loaded, or assumed to be loaded : 1. *Range* (800) *right* (*left*) (this being the deflection in mils to the right or left), 2. *At* (*such an object*), 3. *Fixed* (*distributed, searching, ranging*) *fire*, 4. (*So many*) *Rounds* (as 1 belt, etc.), 5. COMMENCE FIRING.

The details and methods to be used in teaching the different kinds of fire are given in the Machine Gun Firing Manual. For definitions of the different kinds of fire see "Definitions".

At the first and second commands the operations prescribed in the previous paragraphs are performed. The third and fourth commands are preparatory and indicate the class of fire and the number of rounds to be fired. These commands are given when necessary.

At the command COMMENCE FIRING, No. 1 instantly pulls the trigger without deranging his aim and at the same time maintains a steady hold on the grip.

To Cease Firing.

157-B. At the command *Cease firing*, No. 1 releases the trigger, lowers the rear sight and unloads the gun as prescribed in paragraph 158.

To Unload.

158-B. At the command *Unload*, No. 1 will lower the sight leaf, if it be raised, with the left hand. He will then pull the latch back, raise the cover, lift the loaded belt from the feed way and pull the bolt handle back once by hand to empty the chamber. The trigger is then pulled to ensure that the gun is clear.

To prepare for Action.

170-B. The command is: *Action.* At this command,

the carts, if moving, halt. The squad leader marks the place at which the gun is to be set up. No. 1 secures the tripod; No. 2, the gun; No. 3, the water box and one ammunition box; No. 4, the condensing device, and two ammunition boxes; Nos. 5 and 6 secure the belt-filling machine and loose ammunition.

Nos. 1, 2, 3 and 4, as soon as they have secured their equipment, move forward as described in paragraph 147, and, under the direction of the corporal, mount the gun.

The senior driver takes command of the carts, moves them on the run to the flank, or to the rear, to a position under cover.

Nos. 5 and 6 establish a belt-filling station as directed by the corporal.

No. 1.

355-B. 1. Carries the tripod.

2. Personnally cleans ant looks after the gun, insures that the mechanism is working smoothly and that water jacket is full.

3. Observes his own fire when possible.

4. Is responsible for the operation of the gun and takes such steps as are necessary to insure proper functioning of the mechanism at all times.

5. Sets sight as directed by the corporal.

6. Directs kind of fire ordered.

7. Corrects stoppages.

8. Sees that the gunner's pouch is conveniently within his reach.

9. Watches bolt handle in order to diagnose stoppages.

No. 2.

356-B. 1. Carries the gun.

2. Loads the gun.

3. Sees that the belts being fed into the gun are clean and that the cartridges are properly loaded in belt.

4. In case of a stoppage, assists No. 1 in reducing it.

5. Sees that ammunition is supplied in the necessary quantities by Nos. 3 and 4.

No. 4.

358-B. 1. Carries condensing device and two ammunition boxes.

2. Returns emptied belts to belt-filling station.

3. Assists No. 3 in supplying No. 2 with ammunition.

Company Inspection.

602-B. The company being in line or in close line, the captain commands : 1. *In Front of the carts,* 2. FALL IN. The gun squads fall in in front of the carts, as described in paragraph 162. The captain then causes the company to open ranks, as described in paragraph 128, and aligns the company on the right squad.

The captain dismounts and turns his horse over to one of the buglers. All mounted men dismount and stand to horse.

The captain then takes post 5 paces to the front of the right of the company. If the inspection is to be conducted by him, he faces to the left and commands : *Prepare for Inspection.* He then passes down in front of the platoon leaders, inspecting them, and returns to the right of the company in front of the section leaders, inspecting them.

The inspection of the dismounted men is carried on by the company commander, assisted by the platoon leaders, if he so desires, as in the company dismounted.

Upon completion of the inspection of the gun squads the captain makes such inspection as he deems necessary of the drivers, carts, and equipment. If he desires to inspect all the guns and equipment, he gives the command : *Inspection Equipment.*

At this command, the gun squads secure the guns, tripods, etc., and mount them as described in paragraph 147, 10 paces in front of their respective positions. The ammunition boxes, tool boxes, water boxes, etc., are placed in line as described in paragraph 147. The men take position as described in paragraph 147 and remain at attention during the inspection. The carts, signalmen, and agents do not move.

For this inspection the captain may direct each platoon leader to inspect the equipment of his platoon. This inspection of equipment should cover the following points :

Gun :

(a) *Front sight.*

1. Straight and without lost motion.

(b) *Rear sight.*

1. Half nut should hold slide in any position.
2. Elevating screw should work freely.
3. Aperture disk should be straight.
4. Pivot spring should hold aperture disk in position.
5. Movable base without lost motion.

(c) *Water jacket.*

1. Inspect cork stem.
2. Inspect water plugs.

(d) *Feed mechanism.*

1. Open cover.
2. Belt feed lever and slide should work freely.
3. Test belt feed pawl and belt holding pawl springs for strength.
4. There should be no dirt or friction in the feed mechanism.

(e) *Bolt.*

1. Operate bolt to see that it works freely and without excessive friction.
2. Examine extractor, ejector, extractor cam plunger, and extractor cam plunger spring.
3. Test trigger lock.
4. Pull trigger to test firing mechanism.

(f) *Side Plates.*

1. The side plates should be straight and free from burrs.
2. The extractor cams should be smooth and free from burrs.

(g) *Barrel.*

1. The barrel should be free from obstruction and clean.
2. The bore should be inspected for corrosion.
3. The barrel extension should fit close up to the trunnion block when fully forward.

(h) *Latch.*

1. Close cover and see that latch holds cover down.

(i) *Tripod.*

1. Inspect trunnion and elevating pins to see that they fit without lost motion.

2. Inspect the elevating mechanism to see that there is no lost motion.

(j) *These tests should be applied :*

1. Tilt the gun forward to see that outer steam tube is working.

2. Inspect belts to see that the points of the cartridges are uniform.

PART III.

CHAPTER I.

ROUGH GROUND DRILL.

171 1/2. In all attacks in trench warfare, semi-open and open warfare, where machine guns must move forward, suitable formations must be adopted by all machine gun units to bring the guns forward ready for action in the least possible time and with the fewest losses. In these attacks units must move forward over ground torn by shells and criss-crossed by trenches in all stages of obliteration.

To accustom machine gun units to advances over rough ground with reduced numbers in action, drill on rough ground is given to all units of the command until the personnel of each is thoroughly familiar with his duties. The drill is carried on first by squads, later by sections and platoons. Various kinds of ground should be drilled on — steep slopes, shell-torn ground, wooded or marshy areas, etc. The following conditions among others should be assumed at different stages in the drill :

(*a*) That certain numbers in the gun squad have become casualties.

(*b*) The replacement of these casualties.

(*c*) The reassignment of loads. It should be borne in mind that it is of prime importance that the gun be gotten forward to its position with enough ammunition to keep it in action.

(*d*) That immediate action is necessary.

(*e*) That the squad has a few minutes that can be used in consolidating or strengthening the position taken up.

(*f*) That the squad has to creep forward over an area exposed to the enemy's observation in order to avoid detection.

(*g*) That the squad must dash forward from shell crater to shell crater across a heavily fire-swept zone to avoid losses.

Practice in rough ground drill will be had (1) with the tripod, and (2) with auxiliary mounts. The commands in rough ground drill are the same as in the elementary squad drill.

1. With the tripod :

The gun will be mounted in the highest and lowest positions on a steep slope for firing in each of the following directions in turn :

(*a*) Up hill.

(*b*) Down hill.

(*c*) Horizontally to the right.

(*d*) Horizontally to the left.

If time is allowed, the gun will be dropped to its lowest position and the trunnions leveled by digging away a place for the front leg on the high side of the hill. If immediate action is necessary and the tripod in its highest position, the trail should be on the down hill side to shoot up hill, horizontally to the right or horizontally to the left. The gunner will not be mounted on the seat to fire horizontally to the right or to the left. In firing down hill, the trail should be broken.

At the command *Prepare for action*, the corporal, No. 1, No. 2 and No. 3, with the gun, tripod and ammunition boxes, and No. 4 with the spare parts case and gunner's bag, will jump into a position of readiness under cover not more than fifteen paces from the selected position. The other numbers will be conveniently placed in shell holes, trenches or other cover in the vicinity. It will be their duty to bring up ammunition and replace casualties in action. At the command 1. *Action*, the corporal sends out scouts in the desired direction to reconnoiter and see that the ground is clear. At the signal from the scouts the squad moves forward to the selected position and goes into action under the direction of the corporal. Care should be exercised that the men do not crowd together and that all the numbers do not move forward at one time. The gun and tripod

should be made as inconspicuous as possible so as to avoid detection by the enemy. The gun will be loaded and laid on the target at the range indicated. Upon going into action the following points should be observed :

(*a*) Correct setting up of the tripod and gun.

(*b*) The positions adopted by the gun numbers as regards fire effect, exposure and comfort.

(*c*) The position of the ammunition boxes to ensure continuous feed.

(*d*) The ability of No. 2 to watch for signals.

(*e*) The gun must be properly in action, and all details of elementary training must be observed.

2. With auxiliary mounts :

Auxiliary mounts may be of various kinds. Of these the sled mount and the Piquet mount are the most common. The auxiliary mount is not intended to replace the tripod. It is intended for use in :

(*a*) Rapid advances.

(*b*) Trench to trench rushes.

(*c*) Fighting in captured trenches when hurried changes of position are essential.

(*d*) Trench fighting, when the gun has to be fired hurriedly from a position other than the battle emplacement, or when the tripod has been destroyed.

The gun can be carried by either one or two men, as desired. A carrying handle placed on the barrel near the front sight and the handle block enables No. 1 and No. 3 to carry the gun between them. They should move in single file, thus concealing the gun from the front. In this way, the fact that a machine gun is being brought up will be more easily concealed from the enemy.

When it is desired to have the gun carried by one man, No. 3 and No. 1 should move extended to two or three paces, but conforming as far as possible to neighboring infantry extensions, No. 1 carrying the gun and No. 3, two or more boxes of ammunition.

The following method will be taught in addition to other methods which may be suitable on special occasions. The gun will be carried vertically on the right hand side, muzzle upwards, the right hand grasping the handle block and taking all the weight, the left

hand steadying the muzzle end. The method of carrying the gun on the shoulder leads to exposure and is unsuitable in trenches or when in close contact with the enemy.

Drill with "Double Load". — The gun, with auxiliary mount will be placed on the ground 20 meters in the rear of the selected position upon which the gun is to be brought into action. The muzzle of the gun will be placed to the front. No. 1 and No. 3 each with an ammunition box containing a few dummy cartridges, will assume the prone position, the gunner behind the gun, No. 3 on the left of the gun.

On the caution *Prepare to advance,* No. 1 will :

(*a*) Pull the cocking piece handle to the rear.

(*b*) Turn the gun on its right side.

No. 3 will :

(*a*) Load the gun.

(*b*) See that the carrying handle or strap is fastened to the barrel.

(*c*) Have the auxiliary mount handy for setting up.

On the command 1. *Action,* the numbers spring to their feet, seizing the appropriate handles and each, carrying an ammunition box in the disengaged hand, will move rapidly to the position selected. No. 1 has the handle block in his left hand, No. 3, the barrel or barrel-carrying handle, in his right hand.

On arrival at the position, No. 1 will call out *Action,* and :

(*a*) Fasten the gun to the mount and lie down, placing the ammunition box in a convenient place for No. 3.

(*b*) Adjust the rear sight if necessary.

(*c*) Open fire.

No. 3 will :

(*a*) Put the auxiliary mount in the ground.

(*b*) Turn down the carrying handle.

(*c*) Lie down along side the gun.

(*d*) Open the ammunition box and hold a strip ready.

On the caution *Prepare to advance,* preceded by the command *Cease firing,* No. 1 ceases firing. No. 3 will reload if the gun is empty.

On the command *Assemble,* the gun will be unloaded. No. 3 will then :

(*a*) Pack away the ammunition.

(*b*) Adjust the barrel-carrying handle.

Both will then jump up and retire, carrying the boxes and gun.

Drill with "Single Load". — As for drill with the two men load, except that No. 3 will carry both ammunition boxes, and No. 1, the gun.

On the caution *Prepare to advance,* the same procedure will be followed as for the double load, except that No. 3 should see that the carrying handle is under the gun barrel.

On the command *Action,* the same procedure will be followed as for the double load, except that No. 1 carries the gun alone, No. 3, the ammunition boxes. In moving forward, No. 3 should extend to the left and close in again on No. 1 on nearing the position.

The remainder of the drill follows the same lines as for the double load.

CHAPTER II.

TRENCH DRILL.

171 3/4. The object of trench drill is to practice :
(*a*) Posting and relieving sentries and gunners.
(*b*) Relieving detachments.
(*c*) Action in trenches.
(*d*) Preparing to advance and coming into action.
(*e*) Quick change to an alternative position.
All the above should be practiced on level ground before drill takes place in the trenches.

POSTING AND RELIEF OF SENTRIES AND GUNNERS.

The principles involved are identical with those of posting and relief of an infantry sentry on guard or outpost duty.

At a gun position in the trenches :

(*a*) By day only one number need be on duty at the gun position, and he will be the sentry.

(*b*) By night two men will always be on duty, one being the sentry, who is keeping a lookout, and the second being the gunner for the term of duty. The latter is actually at the gun, and may sit down, but must be awake.

A gun number (if by night, usually the last number on gun duty) will be posted as a sentry — by day with a periscope, or at a loop hole if no periscope is available; by night, looking over the parapet. He will be acquainted with the position of all emplacements allotted to his gun, and will have a thorough knowledge of the following :

(*a*) The sector of ground covered by the gun which it is his duty to watch.

(*b*) Points shown on the range cards.

(*c*) Special orders for his gun position during his relief. These may include action as regards patrols, wiring parties, etc.

(*d*) Standing orders for the sentry on machine gun emplacements.

He will be informed of any unusual circumstances noticed by his predecessor.

The relieving gunner will inspect the gun and ensure that the gun is in firing order, also that all the necessary equipment is in place. He will be informed of any special fire orders which may have been issued for that gun.

All the foregoing is applicable to internal relief within a gun detachment. For relief of sentries when sections or companies are concerned, the following paragraphs govern.

RELIEF OF DETACHMENT.

The guide with the relieving detachment will lead them to the dugout of the detachment to be relieved, and report to the gun commander of that detachment that the relieving detachment has arrived.

The relieving non-commissioned officer or private in charge will:

(*a*) Ascertain the position of the gun, the sentry, alternative emplacements, his officer's headquarters, the nearest telephone, and the latrine.

(*b*) Take over and give a receipt for trench stores.

(*c*) Receive a report from his gunner when his gun and gun equipment are present and correct.

(*d*) Ensure that his gunner understands his orders, range card, etc., for his gun and show him the alternative emplacements.

(*e*) Order his gunner to mount his tripod (and gun if relief is by night), and see that this is done correctly.

(*f*) Detail his first sentry, and instruct him to take over.

(*g*) Report to his officer, "Relief Complete".

(*h*) Draw up a duty roster.

The relieving sentry will ascertain the orders from the sentry as detailed in (*d*) above, and in addition will find out :

(*a*) Whether the gun has been fired during the previous relief.

(*b*) If so, at what target, and from what emplacement.

The officer in charge of the relieving detachment will :

(*a*) On arrival in the trench sector to be defended by his guns report to the officer of the guns to be relieved.

(*b*) Remain with him and receive reports from his gun commanders.

(*c*) Receive any information or instructions with regard to the situation, other than those he has learned during his previous reconnaissance.

(*d*) As soon as the relieved detachment has moved off, he will go around to all his guns and make sure that his gun commanders have carried out their work correctly. At the same time he will see that any special orders that may have been issued with regard to work to be done, standing fire orders, etc., are being complied with.

(*e*) Report "Relief Complete" to his machine gun company commander and to the company commander of the trench sector in wich he finds himself.

(*f*) See that his arrangements for communication are satisfactory.

Officers in charge of the detachments relieved will not move off until their detachments are reported closed up and complete.

ACTION IN TRENCHES.

(*a*) By day — on the command *Action*, the sentry runs to the dugout, wakes the other members, takes the gun to the emplacement, mounts, loads, and lays. No. 1 takes his position as gunner, No. 3 follows immediately with the ammunition boxes, and the remaining numbers stand by in the dugout. When the occupants of the trench are ordered to *Posts* the above procedure is carried out by the machine gun detachments, except that the gun is not loaded.

The loophole (if blinded) will have to be cleared before fire is opened; the actual moment when this should be done depends on the nature of the situation.

(*b*) By night — on the command *Action*, the gunner will be ready to fire. The sentry will waken the men in the dugouts and return to his post.

(*c*) Practice should be given in mounting the gun on the Piquet mount in alternative positions during drill by day to represent the tripod having been destroyed. Practice will also be given with improved mounts.

TO PREPARE TO ADVANCE.

(*a*) By day — The sentry will run to the dugout and warn the other members. No. 1 and No. 3 will carry out their duties as laid down for the caution *Prepare to advance* in Rough Ground Drill. After this is completed they will carry the gun from the dugout to the correct place in the trench. No. 2 will come up and dismount the tripod.

(*b*) By night — No. 1 and No. 3 will be in their proper positions — spare numbers in the dugouts. On the command *Prepare to advance*, No. 1 will unload, withdraw the ammunition belt, if used, insert a strip, and perform the loading motions, while No. 3 warns the spare numbers in the dugout. The latter then returns to the gun, helps No. 1 to dismount the gun, gets the auxiliary mount, and both adjust the carrying handle. The gun is then brought to the easiest place from which to climb over the parapet, two ammunition boxes, spare parts, etc., being brought with it. No. 2 dismounts the tripod when the emplacement is clear, and awaits further orders.

(*c*) On the command 1. *Single load*, 2. ACTION, or 1. *Double load*, 2. ACTION, either by day or night; No. 1 and No. 3 will act as laid down in "Drill with single or double load". No. 2 will assist Nos. 1 and 3 with their equipment over the parapet.

(*d*) At the command *Out of action* the gun numbers will retire with the gun to their original position, or gun commander will order No. 2 to advance with tripod and mount it near No. 3, taking care that there is no crowding of men.

CHAPTER III.

BARRAGE DRILL.

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200 1/2. Successful and accurate barrage fire by machine guns depends on the simplicity of and the thoroughness in :

(*a*) Organization.
(*b*) Laying and fire control.
(*c*) Drill.

The methods adopted must be equally applicable to the set piece, where the time factor, as regards preparation is relatively unimportant, and to the latter stages of large scale operations involving the forward movement of machine guns to new positions from which to create a barrage, in which case the time factor becomes of paramount importance.

These methods must also apply to conditions of semi-open and open warfare in which barrage fire by machine guns will often be asked for, becoming relatively more important as the troops get out of range of the bulk of their own artillery.

Again, it must be possible to obtain flexibility; that is, it must be possible for the controlling officer to give a fire order creating a zone of intense machine gun fire on any line, or on any area, in short space of time.

Finally, it must be possible to teach the methods as a drill.

The simplicity is attained by the following considerations which must be regarded as general principles rather than fixed rules, owing to such tactical factors as ground features, reference objects, etc. Experience alone can guide the controlling officer in his selection of the best method to adopt under any one set of circumstances.

Barrage guns are organized into platoons and groups.

The platoons are lettered A, B, C, from right to left in each group. If the platoons move forward they become A2, B2, C2; if another move forward is made, they become A3, B3, C3.

When it can be avoided *no* barrage platoon should be closer than 60 meters to a communication trench or parallel. These are precautions to be taken to prevent destruction by hostile artillery fire. The interval between guns may reach 50 meters. Guns may at times have to be grouped in very small areas in order to facilitate control and avoid locations heavily shelled by the enemy. In a frontal barrage, one gun will never engage more than 40 meters of front.

The platoon commanders are connected either by telephone, signal men or runners with the group commander who is in turn similarly in communication with the Brigade Machine Gun Officer. All these forms of communication are necessary, as one may be put out of action by hostile artillery fire.

During battle, the post of the Division Machine Gun Officer is at Division Headquarters; the post of the Brigade Machine Gun Officer is at Brigade Headquarters. These commanders, however, go wherever they are needed.

DUTIES.

1. *Brigade Machine Gun Officer.* — He is responsible for :

(*a*) The carrying out of the orders issued by the Brigade Commander.

(*b*) The organization into groups of the guns allotted to barrage fire.

(*c*) The issuing of operation orders which will include the allotment of tasks to the various barrage groups.

(*d*) The attaching of an experienced machine gun officer to the headquarters of each attacking infantry battalion for duty as an observer of the machine gun firing.

2. *Group Commander.* — He is responsible for :

(*a*) The organization of his group into barrage platoons.

(*b*) All preliminary preparations, which includes estimates of small arms ammunition, oil, water, spare parts, and materials required for emplacements, the formation of dumps and communications.

(*c*) The issue of operation orders, which deal with the locations and tasks of each platoon. The task is in the form of a table showing the times, targets, rates of fire for each lift and any moves. These orders must be issued in ample time for the platoon commander to make his calculations and send these to the group commander to be checked.

(*d*) The construction of a *fighting map* showing the positions, tasks and zero lines of each platoon and the lifts.

(*e*) Finally, carrying out the orders of the Brigade Machine Gun Officer.

3. *Platoon Commander.* — He is responsible for :

(*a*) Laying out the zero lines of his platoon in the positions ordered by the Group Commander.

(*b*) Carrying out the orders of the Group Commander.

(*c*) The calculation of a barrage chart for his platoon. Issuing a gun chart to each gun commander.

(*d*) The construction of a fighting map for his platoon.

(*e*) Seeing that every "Commander" in his platoon, including himself, is provided with an understudy who understands completely what is going on.

(*f*) Finally, supervising personally in every way the fire of his platoon.

4. *Section Commander.* — He is responsible for :

(*a*) The proper rate of fire of his section.

(*b*) The proper expenditure of ammunition in his section.

5. *Gun Commander.* — He sees to it :

(*a*) That the fire of his gun is carried out as ordered on his gun chart.

(*b*) That the gun numbers carry out their duties as taught in "Barrage Drill".

(*c*) That the correct elevations are placed and maintained on his gun.

(*d*) That the gun is clamped after each change of elevation, or direction.

(*e*) That No. 2 watches for signals.

(*f*) That in case of a barrage not on the chart, being ordered, the correct fire order is passed down and his gun correctly laid before repeating *"No. ... Gun, Ready"*.

LAYING AND FIRE CONTROL.

All the guns of one platoon are laid on parallel lines initially. These lines are called *zero* lines of the platoon and from these all changes in direction of fire are taken.

The guns are numbered from right to left throughout the platoon.

The position of one gun is fixed accurately on the map. This gun is known as the *directing gun*. It is usually the left gun in the barrage position.

The choice of the *zero* line is arbitrary. In general, it is the line from the directing gun through the middle of the platoon sector. Once the line has been established it does not change. Parallel to this line is established the zero line for each gun in the platoon. Their positions are marked by zero stakes. From these lines each gun is laid in direction so as to fire on the new target.

Each gun usually traverses fifteen mils either side of its line of fire. This enables the guns to cover their fronts and prevent gaps if one gun goes out of action. It also causes the fire of each platoon to overlap into the line covered by the flanking platoons.

In order that the greatest possible results may be obtained from barrage fire, and to prevent errors, it is necessary to drill all ranks in their special duties before they take part in an actual barrage. If properly carried out, the drill will stimulate interest and make all ranks proficient in the particular tasks at hand. It will, in addition, give them speed in sight setting and laying, the use of the gun level, zero stakes and auxiliary aiming posts, the methods employed in lifting from one barrage to another and in switching from one target to another during a barrage. In battle, however, dependence cannot be placed in commands. Therefore, after the gun numbers have the drill well learned, exercises will

be given where battle conditions are assumed. In these exercices the use of time tables, signals, and the platoon and gun charts will be relied upon.

The drill is divided into two stages, elementary and advanced. In the elementary drill it is assumed that all the necessary calculations have already been made by the platoon commander, and the practices are confined to the duties of the gun commander and gun numbers. In the advanced stage the whole personnel of the platoon takes part and service conditions should be attained as nearly as possible.

ELEMENTARY BARRAGE DRILL.

(*a*) Practices conducted on the company drill ground without ball ammunition.

(*b*) Practices at 27 7/9 yards range with ball ammunition.

(*c*) Practice in the use of prepared charts with or without ball ammunition, assuming battle conditions to exist.

ADVANCED BARRAGE DRILL.

(*a*) Practice for the whole platoon with or without ball ammunition, camouflaged shell holes and other gun positions will be used; different methods of laying out parallel zero lines will be practiced; questions of supplies of small arms ammunition, communications and control will be dealt with; surprise targets will be engaged.

(*b*) Practice in barrage work at night will be given.

Elementary Barrage Drill.

The platoon is marched with its equipment to the drill grounds and formed in line. If accompanied by the carts, the lieutenant commands *Action*. The equipment is removed from the carts as prescribed for the platoon. The carts then go to the rear at a trot for a distance of twenty paces and halt under cover. The

platoon is then marched by the lieutenant to the barrage position.

(a) *Prepare for barrage.*

Each gun squad, organized and equipped as prescribed for the squad, moves forward to the position previously staked out for its gun, places the "T", fills the sand bags, and sets up the gun 6 paces in rear of the stakes as in "To Mount the Gun", in the School of the Gun Squad. The guns are not put over the position staked for each squad until so directed by the platoon commander. The lieutenant's equipment, which includes a signal shutter, a megaphone, a sketching board and tripod, and barrage charts, is placed ten paces in rear of the directing gun by his orderly. No. 5 remains 10 paces in rear of the line with the *zero* stakes and the aiming stakes.

(b) *Mount guns.*

All guns are mounted on the "T's" simultaneously and laid on the reference object designated by the lieutenant. Should it be desired to measure the parallax by means of the flank guns, the lieutenant may command *Flank guns on the line* before giving the command *Mount guns*, whereupon the two flank guns would be mounted on their "T's" and the parallax determined.

(c) *The guns being mounted, to lay on the reference object:*

All guns on reference object.

Each gunner repeats and *lays* on the reference object ordered.

(d) *All the guns being laid on the reference object, to announce the directing gun:*

No. 4 (or other number) *The directing gun.*

(e) *The directing gun being known, the guns laid on the reference object and the parallax determined to bring all guns parallel:*

Open 2 *degrees* (*mils*).

The gunner of No. 4 gun shouts, *Open* 2, but does not move his piece.

The gunner of No. 3 gun shouts, 2 *right*, *Open* 2, and swings his muzzle 2 degrees (mils) right. The corporal

checks up the laying and, when the gun is correctly laid the gunner clamps the traversing mechanism.

The gunner of No. 2 gun shouts, 4 *right, Open* 2, and swings his muzzle 4 degrees (mils) right. The corporal checks up the laying and when the gun is correctly laid the gunner clamps the traversing mechanism.

The gunner of No. 1 gun shouts, 6 *right,* and swings his muzzle 6 degrees (mils) right. The corporal checks the laying and when the gun is correctly laid the gunner clamps the traversing mechanism.

Each gunner has now set off the amount of adjustment for that gun to bring its line parallel to the line of aim of the directing gun. The amount of adjusment for each gun varies. The left gun, being the directing gun, does not move its direction. The next gun must make the necessary adjustment ordered — 2 divisions. The third gun from the left lays off *twice* the adjustment ordered; the fourth gun from the left *three times* the adjustment ordered.

(f) *The guns all being parallel. to switch them to their* zero *lines :*

All guns 30 degrees (*mils*) *right* (*left*).

The gunner of the directing gun repeats the command and sets off 30 degrees (mils) right. Each gunner in succession repeats the command and sets off the deflection ordered.

The guns are now all parallel and on their zero *lines.* Nos. 5 double time out in front of the guns and set the *zero* stakes where ordered by the gunners. The corporals check the laying, the sight setting and the placing of *zero* stakes. The gunners then clamp the traversing mechanism and the corporals call or signal "Ready'.

The *zero* stakes are not changed, but should remain the same for all firing at this barrage position.

(g) *The guns being laid on their* zero *lines, to lay the guns on their portion of the target in direction :*

Open (*close*) 3 *degrees* (*mils*).

The gunner of the directing gun repeats, *Open* (*close*) 3 *degrees* (*mils*) but does not swing his gun off his zero line. No. 5 places the aiming stake where directed by the gunner.

The gunner of No. 3 shouts, "3 *right* (*left*) — *Open*

(*close*) 3 ", and swings the muzzle of his gun 3 degrees (mils) right (left). The corporal checks the laying and clamps the gun. No. 5 places the aiming stake where directed by the gunner.

The gunner of No. 2 shouts, " 6 *right* (*left*) — *Open* (*close*) 3 ", and swings the muzzle of his gun 6 degrees (mils) right (left). The corporal checks the laying and clamps the gun. No. 5 places the aiming stake where directed by the gunner.

The gunner of No. 1 shouts, " 9 *right* (*left*) " and swings the muzzle of his gun 9 degrees (mils) right (left). The corporal checks the laying and clamps the gun. No. 5 places the aiming stake where directed by the gunner.

The guns are now laid on the target with proper *distribution or concentration.*

(h) *To swing all guns the same direction by the same amount.*

All guns (so many) *degrees* (*mils*) *right* (*left*).

The gunner of the directing gun shouts, *all guns* (so many) *degrees* (*mils*) *right,* and swings the muzzle of his gun towards the indicated direction by the designated number of degrees. The corporal checks the laying and the gunner clamps the gun.

Each gunner in succession from the directing gun shouts the same data and swings the muzzle of his gun the *same* amount in the indicated direction. The corporal checks the laying and the gunner clamps the gun.

Guns may be shifted in direction in this manner to correct for wind, to correct for an error in direction to the target, or to keep on slowly moving objects.

(i) *The guns being laid in direction, to lay in elevation : Range* 1750 *bubble* 5, *or elevation* 60 *mils* (*degrees*).

Each gunner in succession beginning with the gunner of the directing gun shouts, " 1750 *bubble* 5 ", and the gun is laid. No. 5 then adjusts the aiming stake under the direction of the gunner so as to place the aiming mark accurately in the line of aim and double times to his post. The corporal signals " ready ".

Combined sights should not be set off with the gun level, as changes in level readings are not uniform for different elevations.

(j) *To lay the guns in elevation by use of mils above or below the horizontal :*

All guns horizontal.

The gunners repeat the command loudly from left to right. All guns are brought to the horizontal by spirit level or by setting the sights at " 1600 " and by leveling the bubble at " 4 ". The corporal checks the laying of the guns and then signals " ready ".

1. *With a single sight setting for all guns :*

All guns up (*down*) (so many) *mils.*

The gunners from left to right repeat the command loudly. All guns are laid at the same elevation. The corporal checks the laying and signals " ready "

2. *By combined sights :*

Up 20, *add* 10; or *down* 10, *less* 4.

The gunner of No. 4 repeats the command loudly and increases his elevation 20 mils (or lowers 10 mils). The corporal of No. 4 gun checks the laying and signals " ready ".

The gunner of No. 3 shouts, *up* 30, *add* 10 (or *down* 14, *less* 4).

He then increases his elevation 30 mils (or lowers 14 mils). The corporal of No. 3 gun checks the laying and signals " ready ".

The gunner of No. 2 shouts *up* 40, *add* 10 (or *down* 18, *less* 4). He then increases his elevation 40 mils (or lowers 18 mils). The corporal of No. 2 gun checks the laying and signals " ready ".

The gunner of No. 1 gun shouts, *up* 50 (or *down* 22), and then increases (or lowers) his elevation and the amount announced. The corporal checks the laying and then signals " ready ".

(k) *To shift the fire from one target to another :*

All guns on zero.

Each gun is then shifted by its gunner to the zero line. Thereafter, data for firing upon the new target is announced by the lieutenant.

(l) *To open or close the sheaf upon any gun :*

No. 3 *Directing gun.* The gunner of No. 3 gun repeats loudly " *No.* 3 *Directing gun* ". The gunners to either side of the directing gun then repeat the command and it passes down the line to both flanks.

Close 2 *divisions* (*mils*). The gunner of No. 3 repeats the command "*close* 2". The gunner of No. 4 shouts, "2 *right, close* 2". The proper commands pass along to both flanks, the gunner of No. 1 shouting, "4 *left*".

The sheaf may be opened on any gun by the same means.

The changing of the directing gun should be done frequently at drill to keep the gunner's wits working, and to add zest to the exercises.

(m) *To traverse, or search, or both :*

Traverse 35 *mils; search* 4 *mils.*

The gunner of the flank gun on the side nearest the lieutenant repeats the order loudly and sets his traversing and elevating blocks accordingly. The blocks are set so as to permit the traverse of 35 mils and search of 4 mils. The corporal checks the blocking.

Each gunner thereafter repeats loudly the command and sets his traversing and elevating blocks.

(n) *To load the piece :*

Executed as prescribed for the gun squad in elementary drill.

(o) *To commence firing :*

Commence firing.

At the signal or word of command, Nos. 3 smartly slap the gunners once on the leg. The gunners start firing immediately in bursts of five or ten shots, relaying carefully between bursts.

(p) *To stop firing :*

Cease firing.

At the dropping of the shutter, the signal or the word of command, the gunners cease firing as prescribed for the squad in elementary drill.

(q) *To unload the piece :*

Unload.

Executed as prescribed for the squad in elementary drill.

(r) *To stand clear :*

Stand clear.

At the command *Stand clear* all numbers fall in at ease 6 paces in rear of their guns.

(s) *To fall out :*
Fall out.
Executed as prescribed in elementary drill.

(t) *To form the squad :*
Fall in.
Executed as prescribed in elementary drill.

(u) *To call off :*
Call off.
Executed as prescribed for the squad in elementary drill.

PART IV.

TACTICAL USE OF MACHINE GUNS.

CHAPTER I.

CHARACTERISTICS OF MACHINE GUNS.

1. A clear understanding of the characteristics of machine guns is absolutely necessary to their correct tactical use. A confusion of ideas as to their powers and limitations will lead to a failure to utilize them to the fullest extent, or to positive disaster by expecting from them functions which they are not capable of performing. The confusion of the words machine gun and automatic rifle has been responsible for a great amount of erroneous teaching.

An Automatic Rifle is a rifle which fires infantry ammunition on the automatic principle, but its recoil is supported by the body of the firer.

A Machine Gun is a gun that fires infantry ammunition on the automatic principle, but its recoil is supported by some sort of a fixed mount, and the direction of the fire is capable of being clamped.

Machine guns form an integral part of infantry and cavalry regiments, and a knowledge of their characteristics and uses is necessary to all officers, to enable them to realize :

1. The kinds of tasks to allot to them.
2. The kinds of assistance to expect from them.

2. By characteristics of any weapon, we mean its peculiarities, and a grasp of these is necessary to understand properly the tactical employment. The machine gun has many characteristics in common with the rifle, and some with the artillery piece. Like the rifle, same

ammunition, same range; like the artillery piece mounted on a fixed platform or rest, it is capable of delivering various classes of fire.

It has one characteristic, perhaps the most important, which is not possessed by any other weapon; — its fire may be thrown on a target as if by hose, without alteration of the sights.

Its fire is, therefore, peculiarly applicable against our most difficult target — the moving target.

3. *Types of Machine Guns.*

From the point of view of the method of operation, there are two general classes of machine guns :

(1) Those operated by the direct recoil, the Vickers and Browning are examples of this type.

(2) Those operated by a small portion of the gas passing through a port and acting on a piston or actuator.

The Hotchkiss is an example of this type.

Considered from the point of view of the method of cooling there are two classes :

(1) Air Cooled.

The Hotchkiss is an example of this type.

(2) Water Cooled.

The Maxim, Vickers and Browning are examples of this type.

4. *The Fixed Rest.*

Effect of personal factor in holding reduced. Concentration of fire by close grouping. This gives opportunity for accurate observation, and increases safety of overhead fire and the effect of surprise. Range same as rifle, but effect at long ranges greater though correct aim is essential. Useful for night firing, as gun can be laid by day and used at night for command of avenues of approach, sweeping parapets, catching reliefs or working parties repairing entanglements, etc., firing on dumps, rendezvous, etc.

Results from demonstrations in peace with machine guns can, to a great extent, be relied upon as a guide to results obtainable in war. This is not so with the rifle. Only one man is firing the machine gun, whereas

many men are necessary to fire the rifles, and all have nerves to be considered.

Control is simplified, and the close grouping and highly concentrated fire are particularly suitable for surprise effect, and in the crises of the fight. But, to be of use in the crisis, the machine gun must not waste its ammunition on targets that properly belong to other arms, and the guns must be ready to deliver a heavy fire when wanted.

The dispersion of the machine gun has a direct bearing on the accuracy with which the range should be estimated, and on the choice of targets.

Since the dispersion of the machine gun is less than that of an equal volume of rifle fire, it follows that the question of estimation of the range is of relatively greater importance.

If the machine gun is correctly laid at an incorrect range, it will probably make a complete miss. The disadvantage of close grouping is that widely extended targets are unsuitable for machine guns, — e. g. widely extended infantry. There will be occasions, however, when such targets will have to be engaged, and then the desired effect can be obtained by the employment of several guns. Suitable targets are those which are narrow and deep.

On the defensive, such targets can as a rule be obtained:

(1) By surprise, when the gunner catches the enemy in some close formation, not suspecting that he is within rifle range.

(2) By so placing the machine guns that they can bring oblique or enfilade fire to bear on the enemy. The guns should never fire directly to the front when it is possible to obtain oblique or enfilade fire. To use such fire requires an appreciation and a utilization of all the features of the terrain. It requires co-operation of different units, so that each will cover with fire that portion of the terrain that its position best enables it to cover. The nearer the fire approaches enfilade fire, the more efficacious it will be.

5. *Rapid Production and Application of a Large Volume of Accurate Fire.*

Guns can be laid ready for firing.

Maximum volume 400 rounds per minute (not 400 rounds in one minute), because after each burst or two, the aim must be checked, and the gun relaid. If firing about 300 rounds per minute, roughly speaking, one machine gun is equal to 25 men. At long ranges the fire of one machine gun equals from 30 to 50 marksmen. The School of Musketry places a higher value of fire power on machine guns, as expressed in the following table :

"Fire power of one machine gun when firing at the rate of 100 shots per minute, expressed in terms of riflemen."

Range.	Men.
200	15
400	18
600	22
800	29
1000	40

NOTE. — The fire power of the gun varies directly as the rate. For example, should the firing rate be 200 shots per minute, then the figures in the second column would be doubled.

For surprise effect upon group targets, the machine gun is greatly superior to rifle fire.

For fire on moving targets, no conclusive comparison is possible between rifle and machine gun fire.

One man receives and carries out the fire orders.

Fire can be suspended, re-directed, and redistributed instantly, and with sustained accuracy. Fire control being in the hands of one man, delay in indicating target, passing orders down a scattered line, setting 50 sights, etc., is avoided.

This rapidity of production and application of fire assists greatly in surprise effect, which is one of the most important factors in war.

6. *Narrow Front and Shallow Depth From Which a Large Volume of Fire can be Delivered.*

Six square feet required for gun and crew. Only two riflemen could use their rifles properly in the same space. Can be used where the number of riflemen re-

quired for equal volume of fire could not be placed — as in street fighting, a defile, a cramped locality, enfilading a trench or line. Almost every position affords several small protected places from each of which not more than two or three riflemen could fire. These are frequently good machine gun positions. A machine gun is difficult to range on and hit; can be brought into action unseen. Although firing discloses its presence, it does not necessarily disclose its location.

7. *The all-around traverse.*

This characteristic enables the gun to meet attack from any direction, with little or no movement or exposure. Compare this with changing direction of rifle fire. A sudden attack from a flank can be dealt with at once. This indicates the usefulness of machine guns on a flank, in a detached post, in a salient, or for engaging an enveloping attack without increasing its vulnerability to enfilade fire, as is the case with extended infantry in similar circumstances.

Consider this all-around traverse when taking up a position in attack or defense, and also when making cover or intrenchments. It may sometimes be necessary to sacrifice cover to field of fire.

8. *Invulnerability.*

A gun in action offers a small target, hence is difficult to locate, and still more difficult to hit. The difficulties of hostile artillery can be greatly increased by quickly changing position after a brief burst of fire. A gun occupies 1/25 of the front of 50 riflemen, and delivers same volume of fire. Full volume and accuracy of fire can be obtained even if 80 % of the gun crew are out of action, but mobility is reduced. Invulnerability depends largely upon invisibility. Guns should be posted with a view to concealment. In advancing, take same formations as troops. By this means, you may often get close in without being identified, and thus have full fire power available for a crisis of the fight.

Guns are entirely helpless when marching, but can be brought into action very quickly. The latter quality, coupled with the short road space occupied in proportion to great fire power available, makes the machine

gun a very important element in advance guards where strong resistance is anticipated.

9. *Mobility.*

Machine guns can go anywhere that a man on foot can go, and thus are able closely to support infantry in country of any nature. In close and hilly country, machine guns will often take the place of artillery, when the ranging power and ability of that arm can no longer be used for close support, as between ranges of 1500 and 1800 yards, where rifle fire is least effective. In other circumstances machine guns should never attempt to act as artillery. Machine guns with pack transportation can go wherever a mounted man can go. Machine guns are particularly valuable as a mobile reserve to strengthen threatened points, meet unexpected situations, etc...

10. *Liability to Accidental Cessation of Fire* (an adverse characteristic).

Machine guns, like all mechanical instruments, are liable to get out of order. Stoppages are classified :

1. Avoidable.
2. Unavoidable.
3. Temporary.
4. Prolonged.

1. The first is due to carelessness or ignorance.

2. The second to some minor breakage or fault of ammunition.

3. "Immediate action" will cure at once.

One gun may be put out of action, but the other gun of the section can continue to fire. This is one of the reasons for not separating the guns of a section as a rule. The use of single guns should be regarded as exceptional. (They may be far enough apart to escape destruction by one shell, and still be under one control.)

In our service, each platoon is equipped for action independent of the company.

This adverse characteristic requires a high state of training of the personnel. It must be borne in mind that the gun has but one power—fire—and if it is deprived of this by inability of the crew to maintain it in operation, it is worse than useless.

11. *Noise of Firing* (Sometimes an adverse characteristic).

It is an unmistakable sound, but, on the battlefield, there are many noises which tend to neutralize it. Wind, and the sound of bullets, will often cause the sound of firing to seem to come from a different direction from the true one. The sound is very disconcerting to troops being fired at, and is correspondingly stimulating to our own troops.

Machine guns have been found easier to locate by sound when they are in the infantry firing line, than when they are on its flank. In the line, they are likely to draw artillery fire to contiguous troops. Prolonged bursts of fire render it easier for the enemy to locate the guns.

At night, the flash may disclose the position of the gun. Alternative positions are necessary. Great skill is needed in reconnaissance and choice of fire positions.

By day, rapid traversing impedes discovery. Cross fire renders location of the guns almost impossible.

12. *Summary.*

Prolonged firing causes a heavy expenditure of ammunition, a tax on the mechanism, and overheating of the barrel, with consequent loss of accuracy.

Full use should be made of the ground suitable for machine guns. Their fire power is best used for surprise effects, and to develop heavy bursts of fire against important targets, and for decisive action.

It is valuable for use against moving targets, for night firing, for indirect firing, and as a mobile reserve. It is a weapon for which opportunities should be made.

Volume and concentration of fire necessitates large and vulnerable targets to avoid waste of ammunition. When in doubt as to the employment, think, "Shall I get full value for my fire?" and "Am I going against the characteristics of the gun?"

The action must not be guided by machine gun requirements, but the machine gun action by the requirements of the arm with which they are serving.

CHAPTER II.

GENERAL CONSIDERATIONS.

13. The Division Machine Gun Battalion—motorized (2 companies) should be assigned to the "Division Reserve" at the beginning of an engagement unless the machine gun requirements of the action can be most clearly foreseen or the nature of the ground is such as to preclude the profitable employment on the remainder of the division front. The battalion has been motorized in order that the division commander might have at his disposal a great fire power of extreme mobility. Prematurely to relinquish control of this fire power will often result in an inability to influence the action at its most critical stage. The battalion may be employed either under the direct control of the Division Commander or may be used to reinforce either one or both brigades.

The division machine gun officer is a member of the Division staff and is the advisor of the Commanding General on all matters pertaining to machine guns. He will, through his agents of communication, keep constantly in touch with the tactical situation and will apprise the Division Commander of any opportunity for the employment of his guns. He will exercise command over such part of the machine guns of the division as the plan of action requires.

14. The brigade machine gun battalion (4 companies) is a tactical command and must be treated as such. *A general assignment, for all tactical exercises,* of the companies of this battalion to the infantry battalions of the brigade is a distinct violation of the spirit

of G. O. 82, H. A. E. F., 1917. The battalion may be employed in any one of the following ways :

(*a*) As a unit.

(*b*) One or more companies may be assigned to infantry regiments and the remainder of the battalion act as a unit.

(*c*) All of the companies may be assigned to infantry regiments or battalions.

The second method will be the most usual case.

Whether or not the machine gun companies of the brigade machine gun battalion should be attached to the infantry battalion in any special case depends entirely upon the task to be assigned to them and must be determined for each tactical situation. As a general principle, the companies of the machine gun battalion should only be taken from the control of the Commander of the machine gun battalion when they can more efficiently serve the infantry by acting directly under the command of infantry battalion or regimental commanders.

When the terrain is such that the machine guns will evidently have a series of missions which cannot be clearly foreseen at the beginning of the action, the machine gun companies should be attached to infantry battalions or regiments.

Barrage fire calls for a concentration of guns and centralization of command. When the terrain permits and the tactical situation calls for an overhead barrage, either direct or indirect, it will usually be best to keep the companies, so employed, under the control of the machine gun battalion commander.

The brigade commander should relinquish command of the whole of the machine gun battalion at the beginning of the action only for a very special reason.

The commander of the machine gun battalion is the machine gun officer of the brigade staff and his duties as such are analogous to those of the machine gun officer of the division staff.

15. Regimental machine gun companies or machine gun companies attached to a regiment may be used in any of the following ways :

(*a*) The company may be retained under the direct control of the regimental commander.

(*b*) One or more platoons may be attached to battalions and the remainder retained under the direct control of the regimental commander.

(*c*) The whole company may be assigned to one battalion or the platoons assigned to different battalions, the regimental commander retaining control over no part of the company.

16. *Direct fire* is the primary consideration. Indirect fire is secondary. Therefore, all guns must be sited for an extensive field of fire. However, machine guns which are placed to cover ground by direct fire, must also be able to carry out their tasks by indirect fire at night, in case of smoke, fog, etc., and must be in a constant state of readiness to execute such fire. Indirect fire may always be employed to harass the enemy, providing the supply of extra barrels and ammunition is sufficient and the damage inflicted is commensurate with the cost. The indirect S. O. S. barrage is justifiable only when the hostile infantry attack is really imminent.

17. In the war of movement, seek constantly for opportunities *for direct overhead fire, overhead fire with auxiliary aiming target, or flanking fire.* Indirect fire is practicable only when time and detailed knowledge of our own and the enemy's troops are available. Maps of not less than 1/20000 scale or accurate range finding and angle measuring instruments are also essential.

CHAPTER III.

THE OFFENSIVE.

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18. The Machine Guns available for any operation are most effectively employed when they are organized as a whole in accordance with a general plan, and allotted to formations in accordance with the tactical requirements of the situation. Machine Gun resources must be kept flexible, the work of every gun considered and a definite role allotted to it.

There must be co-ordination of the Machine Gun work throughout the whole force taking part in any operation.

PLAN OF EMPLOYMENT.

19. In trench warfare, the plan of employment of the commander should include information as to the following :

(1) General mission of the division.
(2) Time schedule, if any, of the infantry advance.
(3) Artillery barrages.
(4) Companies to be attached to infantry battalions or regiments, battalions or companies to be used for barrage fire, battalions or companies to constitute the reserve.
(5) Positions of units.
(6) Distribution of command.
(7) Firing missions.
(8) Possible missions.
(9) Materiel to be provided.
(10) Command posts and liaison within the group.
(11) Liaison with infantry.
(12) Changes of position.
(13) Materiel and ammunition supply (where, when how), food, water supply, etc.
(14) First aid stations.

The plan should be accompanied by maps showing the duration and location of barrages, interdiction fire areas and protective barrage lines, and also the existing and probable positions and lines of advance of the accompanying guns. Coordinated effort can only be secured by the adoption of a complete plan emanating from Division Headquarters. The divisional plan may be based on a corps plan, but in any case it should include and show the coordination and co-operation arranged for with adjacent troops. In open warfare orders will usually take the place of plans of employment and machine gun organizations will receive orders at different stages of the attack assigning them different tasks. Whenever possible, however, each gun squad should understand thoroughly before the action commences just what is expected of it.

20. The machine guns in the attack are separated into three classes :

(1) Regimental machine gun companies and other companies attached to the attacking infantry regiments or battalions.

(2) Machine gun battalions or parts thereof for covering the infantry advance.

(3) Machine gun battalions or parts thereof held as a reserve.

Regimental Machine Gun Companies and other Companies attached to Battalions or Regiments of attacking Infantry.

BEFORE THE INFANTRY COMBAT.

21. In the approach in open warfare the machine guns should continue in pack as long as possible.

The process of advancing the combat equipment by hand is a most fatiguing one, and hence every effort should be made to discover covered routes by which the guns may be carried in pack at least to a point as far advanced as the first firing position. The principal endeavor of the machine guns, during the advance through the zone of artillery fire, is to gain a position within effective machine gun range. As there can be no reply to the enemy's fire until such a position is reached, there exists no necessity for the guns to advance by

the identical route followed by the infantry. Should the guns take a separate route, however, such route should avoid detours that would be so great as to preclude the probability of the guns arriving at their first firing position by the time they are needed, and also those that would leave the guns, if attacked, beyond the reach of supporting infantry. Should the distance to be gained to the front be so great that carriage by hand would delay unduly the arrival of the guns, and should there be no practical covered route for pack trains that can take the guns beyond the reach of supporting infantry, then the pieces may still be advanced in pack by sending a special infantry escort with the guns. An infantry escort must be provided for machine guns where surprise is at all probable. In the absence of cover, under artillery fire, the combat equipment must be taken forward by hand. The formation of the machine gun company should conform to that of the infantry and be such as to reduce vulnerability (see Instructions for the Offensive Combat of Small Units).

22. In trench warfare ammunition dumps are established well forward and parallels of departure provided for the guns which are to do no firing before the advance. The location of the guns at H hour will be chosen with regard to the line on which the hostile barrage will most probably first descend.

DURING THE COMBAT.

23. It is not sufficient to use machine guns to obtain isolated successes at decisive points in the infantry combat. They must be so used that they will exert a continuous influence during the whole of the fight. This can only be accomplished if all commanders understand the principles of machine gun employment and plan carefully, not only the initial use to be made of the guns, but their employment during the later stages of the fight. Whether employed by battalion, company or platoon, definite tasks must be assigned to the machine guns but the machine gun commander must not be too restricted in carrying out this task. The initiative of machine gun commanders must be developed.

The following are suitable tasks for machine guns :

In the offensive.

(*a*) To support the assaulting troops with a powerful fire, thus reducing the losses of the infantry.

(*b*) To protect the flanks of the attack.

(*c*) To occupy an interval.

(*d*) To occupy the conquered ground.

(*e*) To assist in resuming the attack in open ground.

24. The initial task of the machine guns in the attack is to cover the first objectives of the infantry with a belt of fire. The object of this is to immobilize the enemy and keep him down in the trenches.

Whether the machine gun fire is directed against the enemy's front line or against the ground in rear, depends upon the distance between the opposing lines and the terrain. As the infantry approaches the objective it will become necessary for the machine guns to fire upon reserves, the retreating enemy or other objectives further to the rear. If the duration of the fire is not regulated by a time table, arrangements must be made for machine gun agents to accompany the assaulting waves so as to signal when the fire is becoming dangerous.

25. Machine guns attached to the assaulting battalions will advance between the assaulting and supporting companies or in the rear of the supporting companies, from one position to another, keeping a sharp lookout over the danger zones. They must keep in close liaison with those units which they are to support. In trench warfare it is usually best to cross "No Man's Land" early, so as to avoid the enemy barrage, and to make the enemy front or support lines the first halt.

26. Distribution in depth must be maintained in the offensive as well as on the defensive. This will provide security against counter-attacks and protection for the flanks. Machine guns must be put in the infantry lines only when an immediate increase of fire power is demanded and the machine guns cannot intervene by flanking fire or from the rear by use of overhead fire or firing between units. Occupying an interval does

not usually mean placing the guns in the infantry line but filling the gap between the infantry units with fire.

27. If the engagement develops into a steady advance a very high degree of initiative is required of the machine gun commanders. Sections, platoons or companies are advanced alternately. At least one section must always be in action ready to open fire. During the advance the platoons must always be prepared to offer resistance to a hostile counter-attack and must be able to intervene rapidly to the flank. The advance of the machine gun company is made in accordance with the instructions of the commander of the infantry which it is supporting. Nevertheless the machine gun commander must never hesitate to take the necessary measures in case orders fail to reach him. The machine gun objectives are points from which they can obtain overhead or flanking fire on the enemy most dangerous to our infantry. Their principal task is to cover with a heavy fire the hostile infantry which is decisively engaging the infantry which the various machine gun units have been designated to support. The automatic rifles, trench mortars and 1 pounders can better engage the hostile machine guns.

THE CONSOLIDATION.

28. Machine guns assist powerfully in holding the conquered ground. Posted in the open, behind a mound or in a shell hole, echeloned in depth in checker-board formation, acting by surprise and, as a rule, by flanking the successive lines of resistance, they stand ready to break up hostile counter-attacks.

Every success, every step gained by assaulting troops is, as a rule, marked by a critical time, during which they are exposed to more or less violent hostile counter-attacks.

One of the essential duties of the machine guns accompanying the attack, is to protect the infantry during these stops, to assist them in resuming an orderly and guarded formation and to cover their flanks. Machine guns allotted to the consolidation will devote all

their energy to the organization of their defensive positions, and in principle will not engage unimportant scattered parties of the enemy. Only specially designated platoons will fire on hostile aircraft. Less than four guns will usually prove ineffective.

BATTALIONS, OR PARTS THEREOF, FOR COVERING INFANTRY ADVANCE.

29. The offensive power of the machine gun has been increased by the progress made in the tactical employemnt of large numbers of machine guns for indirect fire. The experience of recent fighting proves that in attacks on organized defences, machine guns have rendered most assistance to the infantry when they have been handled collectively and used in the main to give indirect fire, and that to resist counter-attacks the fullest value from machine guns is obtained by a combination of direct and indirect fire, part of the guns being retained in the rear to put down an overhead barrage on an S. O. S. line, and part being sent forward to support closely the attacking infantry.

30. Indirect fire may be used :

(1) During the preparation, for harassing fire.

(2) During and after the attack, for fixed barrages ahead of the infantry.

(3) Under any circumstances, for concentration or box barrages.

BEFORE THE ATTACK.

31. (a) *Harassing.* — Harassing is intended to wear out the morale of the enemy. Its chief effect lies perhaps less in inflicting heavy casualties on the enemy than in compelling him to maintain a continuous watch by delivering frequent bursts of fire and keeping him unaware of the opening, duration, and origin. Harassing fire can thus assume at some points the character of real prohibitive fire.

It should, in the majority of cases, be executed by night at the usual hours of hostile traffic.

The benefit of observation of fire by day should be utilized when exceptional opportunities are afforded from some point of the sector or from a neighboring sector.

It must be observed that harassing fire allows continued individual instruction of machine gunners and the training of machine companies for indirect fire.

(b) *Targets assigned to harassing fire.* — Selection of targets as well as the time schedule of fire, depends upon miscellaneous information collected concerning the enemy.

The principal targets are :

Communication and supply roads, trails, crossings, approaches to command posts, communicating trenches which it is possible to enfilade, narrow gauge tracks and depots, reverse slopes, such zones as have been wrecked by our artillery or swept with special shells, and lastly any points at which it is desired to obstruct work.

If the target be small, it should be included in a fairly large zone over which the fire of the guns will be distributed.

DURING AND AFTER THE ATTACK.

32. *Barrages.* — Barrages assist in covering the infantry in its lines of departure, at halts or when it has reached its objective. The machine gun plan of barrages should be drawn up by the division commander assisted by the divisional machine gun officer, in close coordination with the plan for artillery barrages.

(a) *Preparation and execution of barrages.* — Every machine gun battalion and company commander is given a fire organization order and every platoon commander and gun commander a fire chart. Battalion, company and platoon commanders prepare fighting maps indicating their different positions, targets and time schedule for each barrage. Barrages should be put down on hostile entrenchments (most especially on shell crater fields between trenches) or on zones favorable to hostile counter-attacks (reverse slopes, folds, natural passages). If a sufficient number of machine

guns are available, barrages will be put down along the whole front of attack. They should be maintained as long as the infantry is at a halt at an intermediate objective and after the last objective has been carried. Machine guns will then resume harassing fire. Machine gun companies however should always stand ready to meet the infantry's requests for barrage. There is, as a rule, but one barrage signal for both machine guns and artillery. A particular signal for machine guns may sometimes be used to advantage.

To keep the enemy in doubt as to the exact time of the attack it is well to put down the barrage at irregular intervals for a minute or two at a time for an hour or two previous to the assault.

(b) *Siting of guns.* — The four guns of a platoon will be placed close enough together to be controlled by the platoon commander.

Guns must be carefully sited in inconspicuous places. When the positions are in view of the enemy, the emplacements must be dug by night and kept camouflaged during the day. If the terrain is very exposed it may be inadvisable to dig any emplacements before D night, the ground being merely staked out in advance.

Care must be taken to avoid movement near the positions by day, and the making of beaten tracks leading up to them, tracks being very visible on aeroplane photographs.

Once the battle has begun, it is often no longer possible, except in very favorable conditions, to conceal the positions, and the success of the battle must be relied on to prevent the enemy being able to divert sufficient artillery from his original program to deal effectively with the guns.

Precautions should be taken against low flying aeroplanes. Machine gun detachments are responsible for their own protection.

(c) *Changes of position.* — In the case of an attack which is to penetrate to a considerable depth, changes of position should be provided for by certain machine gun companies. The locations of the new positions and the time of moves should be prescribed in the plan for changes of positions drawn up by the division commander. Should these new positions be situated in rear

of our line of departure, the arrangements for fire from the new positions should have been made as complete in every detail as from the original positions.

Previous reconnaissance of approaches and emplacements should be made by machine gun company commanders, who should be equipped with all necessary means such as maps and plans, aerial photographs, etc.

Changes of position are usually executed by successive echelons and preferably during a halt of the infantry, at an intermediate objective, at the normal objective, or at a possible objective which is contingent upon circumstances.

MISCELLANEOUS OPERATIONS.

33. (a) *Concentrations.* — Concentration fire is directed on smaller targets of special importance, such as combat groups, strong points, centers of resistance, village exits, gatherings of troops, defiladed zones from which counter-attacks might start, ravines or depressions in the ground suitable for machine gun or artillery battery emplacements.

Such firing should be executed either in accordance with the provisions of the plan of employment, or by order of the group commander in case of transient or unforeseen objectives.

In the latter case, should concentration fire be requested while harassing or barrage fire is being executed, the initial mission which is momentarily interrupted, should be resumed as soon as the concentration fire has been carried out.

(b) *Box barrage.* — The purpose of a box barrage is to isolate a zone with a view to occupation or organization or else to facilitate a reconnaissance. Such fire is provided for in the plan of employment.

In open warfare covering fire will be usually provided either by *direct overhead* barrage or by *flanking fire.* Direct fire must be looked upon as the primary consideration and the indirect barrage as the exception which will be applicable only under very favorable circumstances. Direct covering fire on a large scale calls for the same centralization of control as the indi-

rect barrage and in addition demands a high state of training in range finding, target designation, distribution of fire, fire direction, control and discipline.

34. Harassing fire will not be so extensively used as in trench warfare. During the attack the direct fire barrage will serve the same purposes as the indirect fire barrage in trench warfare. What has been said of the siting of machine guns and the changes of position in the attack on highly organized defences is equally applicable in the war of movement, but the preparations will necessarily be less elaborate.

MACHINE GUN BATTALIONS OR PARTS THEREOF HELD AS A RESERVE.

35. Owing to their characteristics, machine guns are valuable as a reserve of fire power, and when kept in reserve in the hands of the commander may prove of the utmost value at the critical moment. It must be remembered, however, that a great development of fire power is most useful in the opening stages of an attack, to cover the advance of the infantry, and it is a mistake to keep too many guns in reserve if they can be usefully employed in supporting the advance. The division battalion will usually be held as a reserve by the division commander. The brigade commander may or may not use a portion of the brigade battalion as a reserve. The regimental commander will seldom find it advantageous to keep guns in reserve unless additional machine gun companies have been assigned to his regiment. Machine guns held in reserve may be used for long range fire, but must be available to move forward at once when required.

36. Machine gun reserves must be employed unhesitatingly when needed, but must be withdrawn and reorganized as soon as the necessity for their employment has passed. Only by such methods can machine guns attain their maximum usefulness.

CHAPTER IV.

THE DEFENSIVE.

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37. However numerous the guns employed, the defence will never possess the maximum power of resistance unless a complete plan of co-operation between the machine guns employed in a defended area is arranged. The perfection of this co-operation will depend to a very great extent upon the length of time that the position has been occupied. In the hasty occupation of a defensive position the greatest degree of co-operation that can be expected is the distribution of all the guns of the division in accordance with a comprehensive plan. Later, under the direction of the division machine gun officer, the positions of all guns and the sectors of fire should be so coordinated as to procure the greatest amount of enfilade and oblique fire.

Co-operation with other Arms.

38. Divisional and brigade commanders must ensure that the plan of machine gun defence is in harmony with the distribution of troops whom it is designed to support, and company and battalion commanders must coordinate their automatic rifles with this scheme and prevent overlapping or waste of fire power. There are cases where a machine gun can do more reliably the work which belongs to an automatic rifle, but only at the expense of neglecting work which is essential to the general scheme of defence and which the machine gun alone can do. The aim is not to site machine guns so that every yard of ground is swept by machine gun fire, but so to combine the machine gun defence with that of the automatic rifles that machine guns will play

the part dictated by the characteristics of the weapon and will not be wasted in doing work which can be performed by automatic rifles, such as firing on small depressions or down trenches. Machine gun fire should be reserved for protection on a bigger scale, covering the more important features and denying to the enemy the most favorable routes of advance. Points of tactical importance must be strongly covered even though, owing to a shortage of guns, it is necessary to leave gaps on parts of the front where an enemy attack is improbable.

(All machine gun officers should be familiar with Part III, Manual of the Automatic Rifle.)

39. Co-operation with the artillery and trench mortars is required in order :

(*a*) To work out an S. O. S. line of combined artillery, trench mortar and machine gun fire in the proper proportions and of the desired depth.

(*b*) To co-operate in schemes of harassing fire at all times, and not merely on the eve of a big attack.

(*c*) To obtain information about the enemy, which the artillery with its more elaborate system of observation has at its disposal.

Missions.

40. The missions assigned to machine guns in defensive combat are the following :

(1) *Counter-preparation.* — When the enemy's activity indicates an impending attack, counter-preparation fire (artillery and infantry) is delivered. Such machine guns as can be used with advantage participate by enfilading trenches, approaches, trails, by sweeping obligatory passage ways, etc.

(2) *Barrages.* — Machine gun firing reaches its maximum intensity when the enemy is attempting to debouch; it then results in a barrage fire executed by every available machine gun, including those guns which, being posted too far in the rear, are not available for flanking action, but are nevertheless in a position

to combine their fire with that of the flanking machine guns.

(3) *To support counter-attacks.* — If the enemy gains a foothold in the position, machine guns will execute the inner barrages according to prearranged plans. As soon as counter-attacks are launched, they support them with fire (machine guns posted on the reverse-slopes along the flanks of counter-attack zones, machine guns posted in the rear at commanding points and delivering direct fire over the friendly troops).

The execution of the missions defined above should be regulated in the plan of defense.

(4) *Harassing fire.* — Harassing fire is usually carried out only by machine gun battalions, otherwise the missions of the machine guns attached to infantry battalions or regiments and those employed as parts of machine gun battalions do not differ materially but the methods used to accomplish these missions may be quite different. The guns attached to regiments, being further forward, will make greater use of direct fire than the guns functioning as a part of the machine gun battalions which will frequently be better able to carry out their mission in the early stages of the action by the use of indirect fire.

Indirect fire against limited and well defined targets (enfilading fire against communication trenches and parallels, prohibitive fire on a crossing, flanking the approaches to a neighboring position) may be assigned to machine guns attached to infantry battalions and regiments.

DISTRIBUTION OF MACHINE GUNS.

41. The distribution of machine guns should be based on the missions assigned and the following considerations :

In Trench Warfare.

Very few machine guns should be given positions flanking the front line trench; such emplacements will be advisable only when located on rising ground in the rear of the trench. Within the trench or close to it,

such an emplacement would usually entail the destruction of the guns by hostile artillery and trench mortars. The zone of the intense mortar barrage is at least 800 yards in depth and machine guns placed in it will usually be destroyed unless protected by concrete emplacements. The defense of this zone should to a very great extent be assigned to the infantry and trench mortars.

In Open Warfare.

A larger number of guns can be pushed well forward for three reasons :

(1) The enemy will have less artillery and trench mortars.

(2) Opportunity for accurate registration of artillery and trench mortars is lacking and their fire will be relatively less effective.

(3) Owing to the nature of the fighting the positions of the most advanced troops of neither side will be clearly defined, and the enemy's artillery being uncertain of the location of their own troops, the danger to machine guns well forward is less.

42. When conditions are such that guns can be pushed well forward, additional machine gun companies should be attached to infantry regiments. When the opposite is true it will usually be best to keep the larger part of the machine gun battalions under the control of the machine gun battalion commanders. Liaison being more difficult in open warfare is an additional reason for attaching machine gun companies to infantry regiments in such operations.

43. Machine guns should be echeloned so as to insure :

Interior barrages on zones suitably selected in which obstacles should be organized to permit maximum firing efficiency (wire entanglements marking out compulsory passages for the enemy's advance).

Support for counter-attacks.

These machine guns should contribute, if possible, to the barrage in advance of the front. In the latter case, they will be assigned :

A standing barrage mission in advance of the front.

An emergency combat mission within the position.

The machine gun barrages should sweep most effectively those zones where the lie of the ground does not permit of dense artillery barrages.

Conversely, the artillery barrage is to be intensified upon such zones as are swept poorly or not at all by machine gun fire.

All necessary suggestions or directions concerning these matters should be laid down in the plan of defence.

This plan should decide the emergency machine gun barrage missions to be fulfilled by each unit for the benefit of the adjacent ones.

The efficiency of machine gun fire is such that defenders should be able to stop short the enemy's advance if they have penetrated into the position and then to throw them back by a counter-attack, providing machine guns have been disposed in depth according to the above principles, have not suffered too much from hostile artillery fire, and have been given positions which make immediate emergency action possible.

44. The machine gun defence should extend to the position that defends the gun line of the artillery which covers the division front. This will usually be about 3000 yards from the front line. If the machine guns of a division are drawn out to too great a depth, sufficient fire power cannot be produced on any line. The problem is therefore how to balance the two essentials.

(1) Requisite depth to ensure against the hostile break-through.

(2) Sufficient fire power on any given line to hold up a hostile attack.

Reserve Guns.

45. *In Open Warfare* the Division Machine Gun Battalion should usually be held in reserve at the beginning of the action. The Brigade Commander should usually retain some portion of the Brigade Machine Gun Battalion as part of his reserve. Unless additional machine gun companies have been attached to the regiment, the regimental commander will usually find it unprofitable to hold any guns in reserve.

In Trench Warfare where the intentions of the enemy can be more clearly foreseen, a smaller number of guns should be placed in the reserve.

Siting of Guns.

46. Fire effect is the essential. Therefore an extensive field of fire is required for machine guns. Generally guns attached to regiments should be employed by section. In the machine gun battalions the two sections of a platoon should be close enough together to be controlled by the platoon commander. This facilitates the control of a considerable volume of fire.

47. Machine guns must be sited for all around defence. Any dead ground in the vicinity must be covered by auto-rifles, rifles or grenades.

48. In order to be secure from artillery fire, machine guns must be :

Removed from visible defences, liable to be destroyed by methodical demolition fire (communication trenches and especially parallels).

Concealed from view by skilfully utilizing natural covers (shell-holes, woods, ruins, emplacements in trees, etc.) and hiding the approaches (gallery approaches, Russian saps, etc.) from hostile observers.

Sheltered : bomb-proof shelter for machine gunners and machine guns at rest and, if possible, in their firing positions.

It frequently will be difficult or even impossible to establish a firing emplacement under bomb-proof shelter (i. e. proof against isolated shots of the 210 mm. mortar), owing to the elevation of the relief even if concrete has been used. Bomb-proof casemates, however, are advantageous and every opportunity should be taken to obtain them.

Rapid interference of machine guns in an emergency depends upon the possibility of securing good observation and of rapidly passing from rest to combat emplacements.

Bomb-proof casemates best fulfill the latter requisite.

Should an alarm be given, the machine gunners will take their posts at the firing emplacements and instantaneous opening of fire will be possible.

With an open firing emplacement and a deep rest shelter in a mine gallery, too much time is required to reach the combat emplacement. This disadvantage will be remedied by establishing in the vicinity of the firing emplacement a concrete shelter of dimensions strictly sufficient to receive both machine gun and gunners.

Mobility, alternative positions, and frequent changes of location are, along with camouflage, the best ways of ensuring concealment. Alternative emplacements should be allotted before the beginning of the action and all gun squads should be familiar with the routes to the emplacements to which they are assigned.

Withdrawal.

49. If withdrawal becomes necessary there must be close cooperation between the infantry and machine guns. In the withdrawal machine guns cover the infantry and, in turn, are covered by the automatic rifles of the infantry. As soon as the infantry has withdrawn and reorganized on its new position part of the machine guns should take up new positions in depth. An officer should be sent to the rear to make a reconnaissance of these positions before the arrival of the guns in order that there may be no delay in opening fire. These successive positions must be separated by a considerable distance to permit of an orderly withdrawal. Each gun squad should know the line of retirement, and the positions of the guns on its right and left. Range cards should be prepared for each gun position in advance if practicable.

Liaison.

50. It is essential that good liaison be established and maintained not only within machine gun organizations but between machine gun organizations and the infantry units they are supporting.

For barrage work the battalion commanders must be connected by telephone with division machine gun officer and with their company commanders. The latter should in turn be connected with their platoon commanders when equipment is available, otherwise by runners and visual signalling.

The division machine gun officer remains at the Headquarters of the division. The commander of the brigade machine gun battalion should be near the brigade commander.

Machine gun commanders will keep infantry commanders whose units they are supporting, informed of the condition of emplacements, obstacles, stores and ammunition.

In the war of movement the importance of liaison is greatly increased. On it depends the regulation of the alternate advances of infantry and machine gun units, the opportune application of machine gun fire to support the infantry, and in extreme cases, the reinforcement of the firing line by machine guns to obtain definite superiority of fire over the enemy.

In withdrawal close liaison between the infantry and machine guns is of the greatest importance.

It is the duty of infantry commanders to keep machine gun commanders informed of all changes and developments of the situation which may effect their action.

Machine Guns with Cavalry.

319 1/2. Machine guns enable the cavalry to retain the mobility and power of maneuver so necessary to security and success.

The predominating idea with cavalry must be to close with the enemy as soon as possible without ruinous losses. The fire power of the machine gun unit should be utilized to the utmost, remembering that machine guns have but one kind of action—fire.

"A large degree of independence of action must be granted the cavalry commander; the sudden changes of a cavalry action require quick decisions, therefore the chief of machine guns must act upon his own ini-

tiative, and be ready to seize all opportunities for effective action against the enemy, in accordance with general instructions of the cavalry commander. He remains with him until his command is assigned to a definite mission, and, later on, maintains communication. The cavalry commander, for his part, should keep him informed as to his plans and intentions."

The machine gun, by its power of following a moving target, by turn of wheel, without alteration of sights, is the ideal fire arm in a cavalry engagement.

In the mounted action of cavalry against cavalry, the machine guns are used to augment, or as a substitute for, dismounted fire action, thus permitting the use of a larger percentage of the cavalry for the mounted shock action. In the dismounted action of cavalry, the machine guns are handled as with infantry.

Their action, particularly with independent cavalry, is fire action, with the aim of increasing the offensive and defensive power of mounted troops, and facilitating the execution of their tactical mission.

The machine gun unit may be used in the attack as a *pivot of maneuver*, or disposed so as to cover possible rallying points with its fire. It should never be placed in such position that its fire will be masked by the advance of the attacking line.

When cavalry advances for the attack, the machine guns should be pushed well forward, so as to prepare the way. Should the attack fail, the machine guns must remain in action to cover the retirement. If the attack is successful, the machine guns must be pushed forward rapidly to assist in the pursuit.

When the machine guns can be concealed, the cavalry should endeavor to draw the hostile troops under their fire. This maneuver may be accomplished by placing the guns at the rear or unexposed flank element of the cavalry, which, acting as a screen, drops off the guns under cover as selected, while the cavalry maneuvers for position or action.

The flank attack is the favorite maneuver of the cavalry. The flanks of attacking cavalry are its weakest parts. Machine guns echeloned on the flanks, afford efficient protection.

During the cavalry battle, machine guns fire on that

portion of the hostile cavalry against which the decisive charge is to be delivered.

During the mounted attacks against the flanks of dismounted troops, or artillery, machine gun fire from the front may hold the enemy in place, and prevent his changing position to face the attacking cavalry.

Machine guns echeloned on the flanks of cavalry may fire to the front, or bring cross and enfilade fire to bear on the enemy's line, or quickly change direction so as to fire toward the flanks.

"When machine guns are employed to support a cavalry charge, the concealment of the guns in the fire position is of minor importance. The chief object is to keep them hidden until such moment as they can be brought into action suddenly, from a position whence the fire of every gun can be concentrated on the enemy just before the moment of shock."

To effect this, the machine gun commander must act with promptitude and decision, and must clearly understand his commander's plan of action.

When the fire becomes masked by the advance, the machine gun commander must be on the alert for opportunities to fire on the hostile supports and reserves, and to assist his own cavalry when it is re-forming after the melee.

PART V.

ORGANIZATION AND DIRECTION OF FIRE.

CHAPTER I.

MACHINE GUNNERS' MATHEMATICS.

A knowledge of the following simple mathematical facts is of great assistance in modern machine gunnery.

1. *Triangles.*

(*a*) The three angles of a triangle are together equal to two right angles. Thus, if any two angles are known, the remaining angle can be found.

ABC + BCA + CAB = 2 right angles = 180° = 3200 mils.

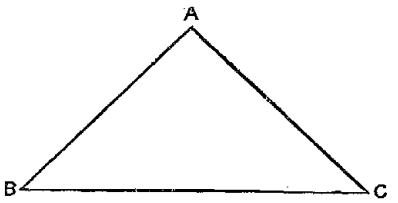


Fig. 1.

(*b*) The exterior angle of a triangle is equal to the two interior and opposite angles.

$$DBA = BAC + BCA$$

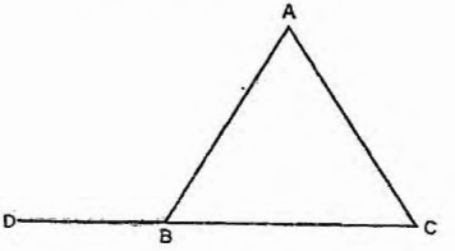


Fig. 2.

(*c*) If a line is drawn parallel to one side of a triangle it divides the other side into proportional parts.

DE is parallel to BC

$$\text{Then } \frac{AE}{AC} = \frac{AD}{AB} = \frac{DE}{BC}$$

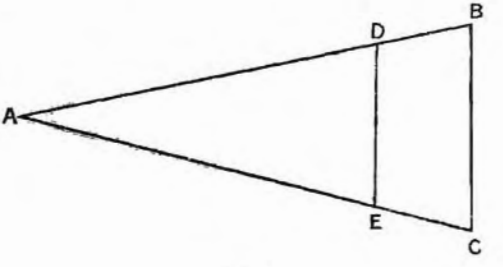


Fig. 3.

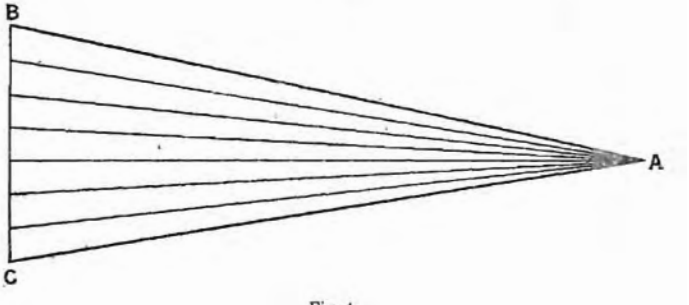


Fig. 4.

(*d*) When the apex angle of a triangle is small, the following is true for all practical purposes : "If the base of a triangle be divided into a number of equal divisions and these divisions be joined to the apex, then the apex angle will be divided into the same number of equal angles".

Example. — If BC be divided into seven equal divisions, the angle BAC is also divided into seven equal angles.

2. *Angles and parallel straight lines.*

(*a*) When two straight lines intersect, the vertically opposite angles are equal.

$$ABE = DBC$$
$$ABD = EBC$$

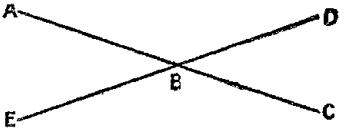


Fig. 5.

(*b*) When two parallel straight lines are cut by another straight line, the following are true :

$$AGF = GFD$$
$$BGF = GFC$$
$$HGB = GFD$$
$$AGH = CFG$$
$$BGF + GFD = 180^{o} = 3200 \text{ mils.}$$
$$AGF + GFC = 180^{o} = 3200 \text{ mils}$$

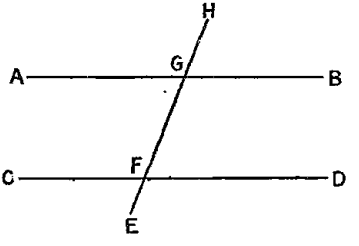


Fig. 6.

(*c*) If straight lines are parallel, they will still be parallel if all are switched through the same angle.

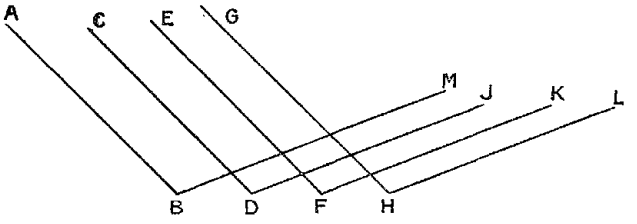


Fig. 7.

If the lines AB, CD, EF, GH are parallel, then if the angles B, D, F, H are equal, the lines BM, DJ, FK and HL will be parallel.

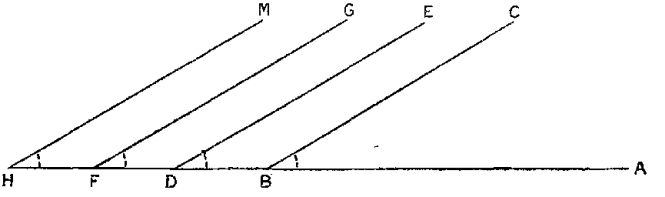


Fig. 8.

If the angles B, D, F, H are equal, then the lines BC, DE, FG, HM, are parallel.

3. *The Mil Scale Formulae.*

For computations required in the control of fire, the system of angular measurement in terms of degrees, minutes and seconds, is very cumbersome. A much more satisfactory angular unit is the *mil.* This is the angle whose natural tangent is 1/1000. An object one meter long at a distance of 1000 meters subtends an angle of one mil. The value of the mil is 3′ 26.2″.

The mil is used in target and sector designation, in estimating and measuring ranges, in computing and making all angular measurements used in fire control where the French equipment is used.

The mental calculations of problems involving these

elements is simple, provided the following equations are kept in mind :

$$(1)\ R = \frac{W}{M} \times 1000$$

$$(2)\ W = \frac{R \times M}{1000}$$

$$(3)\ M = \frac{W}{R} \times 1000$$

In which R is the range; W is the width or heigth in the same unit as R; M is the number of mils subtended by W.

1st example. — A target or the top of a crest is 20 meters above the gun and the range to the target or crest is 2000 meters. How many mils is the target or crest above the gun?

Formula (3) :

$$M = \frac{W}{R} \times 1000 = \frac{20}{2000} \times 1000 = 10 \text{ mils.}$$

2nd example. — A gun is required to switch from one object to another. The objects are 100 meters apart and the range to them is 2500 meters. Required the angle through which the gun must be switched.

Formula (3) :

$$M = \frac{W}{R} \times 1000 = \frac{100}{2500} \times 1000 = 40 \text{ mils.}$$

3rd example. — Two objects at a distance of 1200 meters subtend an angle of 20 mils. What is the distance between them in meters?

Formula (2) :

$$W = \frac{R \times M}{1000} = \frac{1200 \times 20}{1000} = 24 \text{ meters.}$$

4th example. — Two objects known to be 50 meters apart subtend an angle of 20 mils. What is the range to them?

Formula (1) :

$$R = \frac{W}{M} \times 1000 = \frac{50}{20} \times 1000 = 2500 \text{ meters.}$$

These formulae are true only under the condition that the line joining the two objects which fix the angle is at right angles to the line on which the range is measured. They are approximately true if the angle between these two lines is practically a right angle, i. e., not more than 270 mils off. When this angle does not lie within these limits, certain corrections must be made when using the formulae.

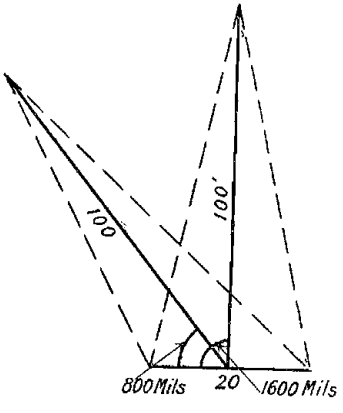


Fig. 9.

Set a stake 100 feet from the center of a twenty-foot scale at an angle of 1600 mils to the plane of the scale (Fig. 9). Make a mil measurement of the angle subtended by the scale from the stake; it will be found to be 200 mils. Formula (3) also gives 200 mils.

Next set a stake 100 feet from the center of the same twenty foot scale at an angle of 800 mils to the plane of the scale.

Make a mil measurement of the angle subtended by the twenty foot scale from this stake. The measurement will be found to be 141.4 mils instead of the 200 mils found from the 100 foot stake set at right angles to the twenty foot scale. If the observer neglects the fact

that the line of the twenty foot scale is not at anywhere near a right angle to the line of sight, he may be led into the following errors in the application of the formulae. Let him use M equal 141.4 mils and R equal 100 feet, then W would apparently be 141.4 feet; let him use M equal 141.4 mils and W equal 20 feet, then R would apparently be 141.4.

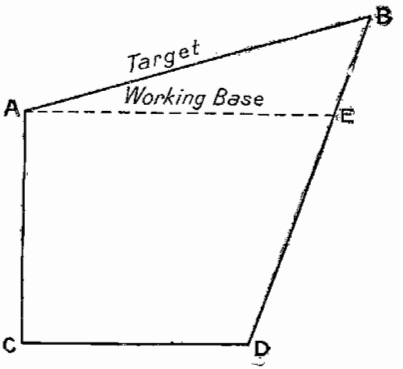


Fig. 9A. — Barrage position.

The necessary correction may be quickly made by the same method as calculating a "Working Base", see Appendix V, Graph. 3.

CHAPTER II.

MAPS.

MAP WORK.

4. — *True North, Magnetic North, and Grid North.*

On the older maps it was usual to divide the map by grid lines into squares, and to show in the margin the True North and the magnetic variation from True North. It was therefore necessary, in using the map and compass for field work, to allow for three things :

(*a*) *True North and Magnetic North are not the same.*

In Figure 10, T. N. represents the position of True North (at the North Pole), and M. N. represents the position of Magnetic North (a point at present in the northern extremity of North America).

If any point P is taken on the Globe, True North

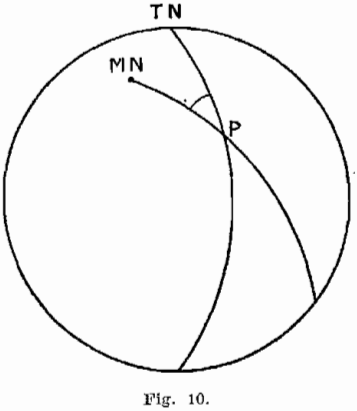


Fig. 10.

will be in the direction of T. N. and Magnetic North will be in the direction of M. N.

The angle TPM is the magnetic variation for the

point P, and not only does this angle vary for different points, but it also varies year by year for any particular point.

(*b*) Each country bases all its maps on one particular meridian, and all other North and South lines are drawn parallel to this meridian. All other maps, such as the Trench Maps in use, are enlargements of portions of an

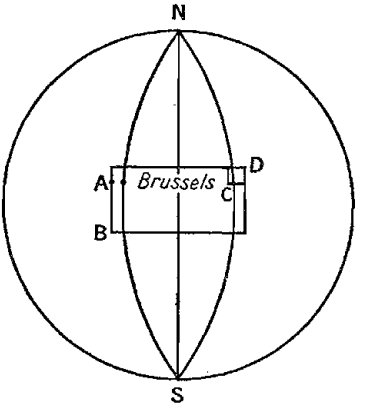


Fig. 11.

original map thus compiled, *e. g.*, France bases its maps on the True North and South Meridian through Brussels, and the grid line through Brussels is the True North and South.

But if any other point A is taken, the line AB, though parallel to NS, is not True North and South. The curved line SAN is True North and South.

When a small part of this map is enlarged (e. g. CD)

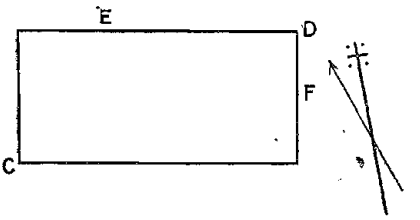


Fig. 12.

there is no grid line on the map which is True North and South. The deviation of the grid line from True North must therefore be allowed for, and it was usual to insert this on the maps at points E or F.

(*c*) The magnetic variation of a particular compass is rarely the same as the correct variation (as shown, e. g., on the map) for the locality in which it is being used. The compass has an error which must be deducted from or added to the correct magnetic variation.

So long as reference is made to a True North, the above three things complicate work with map and compass, e. g., suppose the machine gunner desired to lay out a line of fire by compass to a target shown on the map. In obtaining the bearing from the map he had to allow first for the fact that the grid lines were not True North and South (and this was often difficult because the difference was not clearly shown); and secondly for the error of his particular compass. Finally he had to remember whether the magnetic variation had to be added or subtracted. It is therefore better, as is now done on maps, to omit True North altogether, and work simply by Compass North and Grid North as follows :

(*a*) Find the magnetic variation of your compass from the grid lines on map.

(*b*) Measure all bearings with reference to the grid lines on the map.

(*c*) To convert a grid bearing into a compass bearing, add (in France) the magnetic variation of your compass; and conversely to convert a compass bearing into a grid bearing, subtract (in France) this variation.

To find the magnetic variation of a compass from the grid lines on the map.

Select two distant points A and B, which are mutually visible on the ground and which are accurately marked on the map.

With the compass, take three separate bearings from A to B.

Take the mean of these three bearings as being the

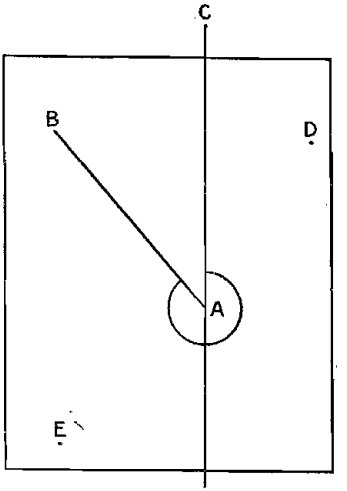


Fig. 13.

correct magnetic bearing of the compass from A to B (say 324° 40′).

On the map, measure the bearing of AB with reference to the Grid North and South line passing through A (i. e., AC). (Say 312° 20′).

Then the magnetic variation of that particular compass from this map is 324° 40′ — 312° 20′ = 12° 20′.

Repeat the above process on a second object D, and again on a third object E. Three values for the compass variation will thus be obtained, and the average value may be taken as correct.

NOTE. — It will generally be found that the variations of the compass obtained from different points do not differ by more than 30 min., and the average value may be taken; but where the variations differ by more than 1 deg., it will be necessary to note the variation in each direction. This difference is due to the compass cards being incorrectly centered. Where the error is considerable, it is best to procure a new compass.

The above results can be conveniently arranged as follows :

Map Location from which bearings are taken	Map Location on which bearings are taken	Magnetic bearing	Mean Magnetic bearing	Grid bearing	Variation	Average Compass Variation
3670 · 1935	3845 1860	(i) 143°10 (ii) 143°30 (iii) 143°20	143°20′	131°40	11°40′	
						say 12°5′

Fig. 14.

The compass variation must be found for every new map and in every fresh locality.

5. *Resection.*

The position on the ground being known, to find it on the map.

Accuracy is essential at every stage.

(*a*) Find out your exact compass variation.

(*b*) Take several accurate bearings and take the mean as correct.

(*c*) Avoid metal likely to affect the compass readings.

(*d*) Draw carefully with a hard sharp pencil.

(*e*) Whenever possible fix the position on the map by the detail close at hand rather than by resection.

Method A. Using compass.

The observer at D, wishing to fix the position of D on the map, selects two points A and B, visible on the ground and accurately marked on the map, and whenever possible a third point C, which checks the position of D, as fixed by AD and BD.

In order to obtain accurate results, the angles ADB,

ADC, should not be greater than 130° nor less than 50°, and the points A, B, C, must be as close to D as possible.

The observer at D takes three compass bearings on A and finds the average bearing. He repeats this on B

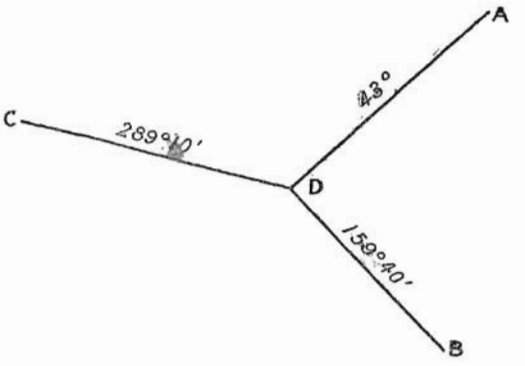


Fig. 15.

and then on C.

From these bearings he obtains the grid bearings to A, B and C, by subtracting his compass variations from each.

OBJECT taken	AVERAGE compass bearing	GRID bearing	
A	43°	30° 40'	When the grid variation of the compass is 12° 20'.
B	159° 40'	147° 20'	
C	289° 10'	276° 50'	

Fig. 16.

To plot these resections, plot the bearings taken from D at the points identified on the map, with the protractor turned to the right for bearings over 180° and turned to the left for bearings under 180°. This is quite simple with a protractor graduated in both directions.

To transpose the compass bearings from degrees or

fractions thereof into mils, multiply by 17 7/9 and the result will be in mils.

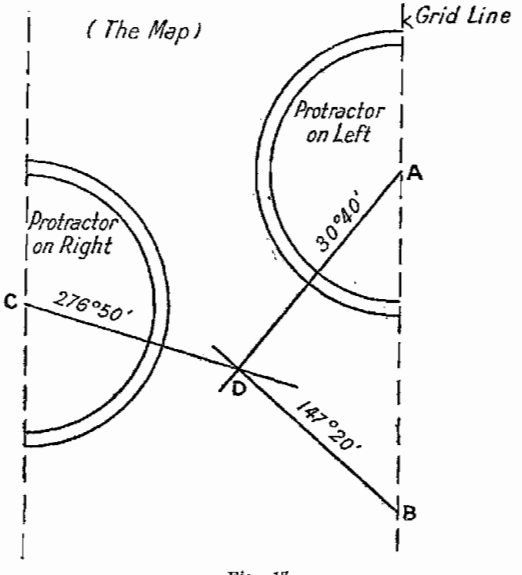


Fig. 17.

If the three straight lines drawn from A, B and C do not intersect at a point, it indicates (assuming the map to be correct) either that the grid variation of the compass has been inaccurately obtained, or that the drawing is inaccurate. If the triangle is large, the whole operation must be repeated; but if it is not much larger than a pencil point, the center of the triangle may be taken as the position of D on the map.

Method B. Using a range-finding instrument.

This method is very useful when it is impossible to use a compass. The instrument must be accurately adjusted.

From D, the point whose position on the map is desired, take the range to three points A, B and C. These should be as near as is consistent with the minimum reading of the instrument (450 meters on the Bausch and Lomb 80 cm. base range finder).

Then with a pair of compasses stretch the distance AD by the scale on the map, and with compass point at A, draw an arc. Repeat this for B and C, and the

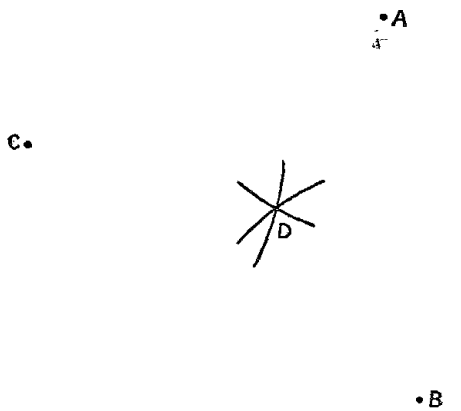


Fig. 18.

point of intersection of the three arcs will be the position of D.

In this case also, a triangle at D, and not a point, indicates inaccuracy, and the same rule applies as in Method A.

Method C. Method of super-position.

Using a machine gun with direction dial, or a goniometer.

From D find the angles ADB, BDC, and CDA by laying on A, B, C, in succession and reading off the angles on the direction dial.

Then on a piece of transparent paper draw a line AD, and from D draw a line DB so that the angle ADB = the angle ADB found above. Similarly draw DC, making the angle CDB = the angle CDB found above.

Place this transparent paper on the map, so that DA passes through A on the map, DB through B on the map, and DC through C on the map. With a pin, prick through the point D, and the point thus obtained will be the position of D on the map.

NOTE. — The best results will be obtained when the points A, B, C are near D.

The reglette may also be used as follows :

Mount the gun at D and lay it on A. Obtain the angle ADB by means of the reglette and plot this angle

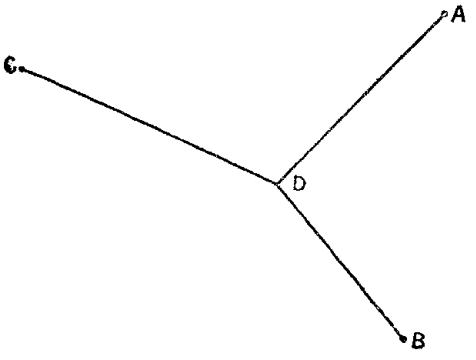


Fig. 19.

on transparent paper. With the gun still laid on A obtain the angle ADC by means of the reglette and plot it so that the side AD coincides with the side AD of the angle ADB already plotted, with the vertex D of each angle in coincidence. Superimpose the lines thus plotted on the map as described above and proceed as before described.

Instead of the Direction Dial the goniometer may be used. Take bearings on A, B and C. By subtracting the bearing of A from that of B obtain the angle ADB, and by subtracting the bearing of B from that of C obtain the angle BDC.

The position on the map being known, to find it on the ground.

Select two points A and B which are recognisable on the ground and are marked on the map.

On the map join A and B, to D.

Through D draw a line parallel to the grid lines of the map, and by laying the center of the protractor on D find the grid bearings from D to A, and B. Convert

these bearings to compass bearings, by adding the compass variation.

Then with a compass variation of 220 mils :

From D the compass bearing to A = 800 + 220 = 1200 mils.

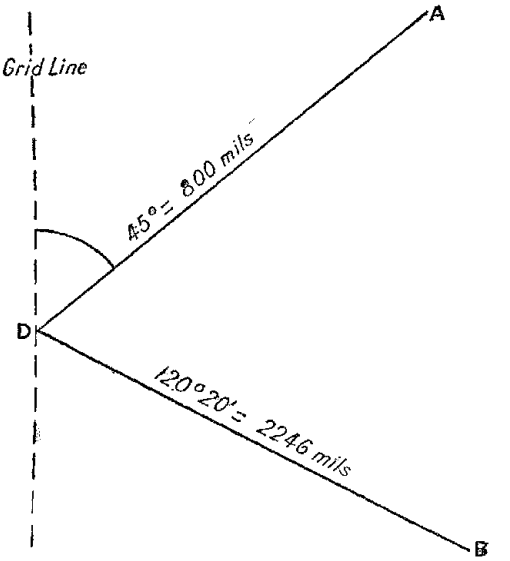


Fig. 20.

From D the compass bearing to B = 2246 + 220 = 2466 mils.

Proceed next on the ground to a point X, which you imagine is near the point D, and take a bearing on A. Then facing A, if the bearnig XA is less than 1020 mils, you must move to your left; if the bearing XA is greater than 1020 mils, you must move to your right. Suppose than, that the bearing XA is too small, you will move to the left until a point P is obtained such that the bearing PA is 1020 mils. Then the point D must be somewhere along the line PA. Place a stick at P, to fix the line PA. Take a bearing from P to B. If this is too great, then face B and move to the right along

the line AP until a point D is obtained such that the bearing DB is 2466 mils.

Then D is the point required, because the bearing DA is 1020 mils and the bearing DB is 2466 mils which was required.

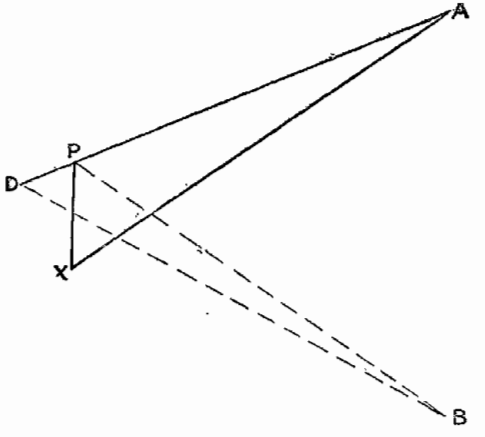


Fig. 21.

NOTE. — (*a*) As a final check, the bearing on a third point should be obtained.

(*b*) Whenever possible, fix the position D by detail close at hand.

The gun and reglette may also be used as follows : From the map obtain the angle ADB with the reglette. Proceed to a point X on the ground which you think is near D. Lay the gun on A. Sight along the arm of the reglette toward B. If this line of sight does not pass through B, move the gun until a gun position is found from which the line of sight with the gun passes through A and that of the reglette arm through B.

When the obliteration of all landmarks makes resection impossible, it is sometimes possible to get the position fixed by the help of the Field Artillery or an Engineer Company.

6. *Scales.*

The word scale is used to denote the proportion which

a distance between any two points on a map bears to the horizontal distance between the same two points on the ground. This same proportion can be expressed as a fraction which is called the Representative Fraction (R. F.).

Thus R. F. $= \frac{1}{20000}$ indicates that 1 unit on the map represents 20000 of the same unit on the ground. A sketch should always have a scale attached, which, for convenience of use, should be about 15 cm. in length.

To construct a scale of 1/5000 showing divisions of 100 meters and sub-divisions of 20 meters :

First, find how many meters are represented by 15 cm.

1 meter represents 5000 meters.

$\therefore$ 15 cm. represents $15/100 \times 5000 = 750$ meters.

Then, as the scale must be divided into hundreds of meters, make the scale to represent 800 meters.

Secondly, find what length of line will represent 800 meters.

5000 meters are represented by 1 meter.

$\therefore$ 1 meter is represented by 1/5000 meters.

$\therefore$ 800 meters are represented by $1/5000 \times \frac{800}{1}$ meters.

Then the scale must be $\frac{1 \times 800}{5000} = 16$ cm.

Thirdly, draw a line 16 cm. and divide it into 8 equal parts, each division representing 100 meters. Divide the left division into 5 equal parts, each representing 20 meters.

Method of dividing the scale into parts :

Draw AB = 16 cm.

Draw AC = 8 cm. (this length being easily divisible by 8), and divide AC into eight equal parts.

Draw BD = AC and parallel to AC and divide it also into eight equal parts.

Then by joining the corresponding divisions of AC and BD, the line AB will be divided proportionately as desired.

Similarly, by dividing the left divisions of AC and DB into 5 equal parts and joining up the corresponding sub-divisions, the left division of AB will be subdivided as desired.

To construct a scale of 10 cm. to the kilometer (i. e., 1/10000) to read 100 meters and subdivisions of 20 meters.

Draw a line 10 cm. in length. This represents 1 kilometer or 1000 meters. Since the scale is to be into

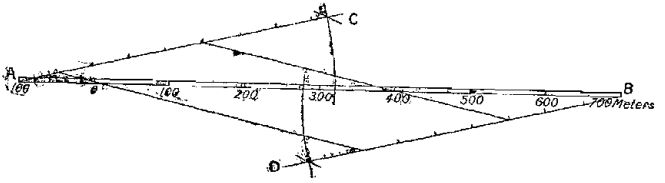


Fig. 22.

hundreds of meters, divide this line into 10 equal parts. Divide the left division into five equal parts each representing 20 meters.

7. *Contours.*

1. *Definition.* — "The representation of an imaginary line running along the surface of the ground, at the same height above mean sea level throughout its length."

Only a certain number of these lines are drawn on the map, and the heights of intermediate points must be estimated. Generally, on our maps of 1/10000 and 1/20000, contours show each vertical distance of 10 meters, which is called the Vertical Interval between the contours.

2. *Examination of a map.* — (*a*) Contours indicate the relative steepness of slopes.

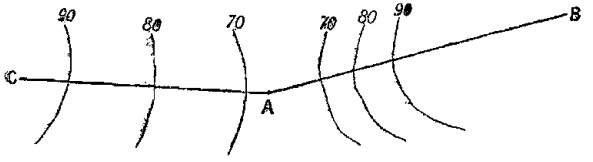


Fig. 23.

The closer the contours, the steeper the slope. Thus the slope along BA will be steeper than that along CA.

(*b*) Contours indicate the form of the surface of the ground.

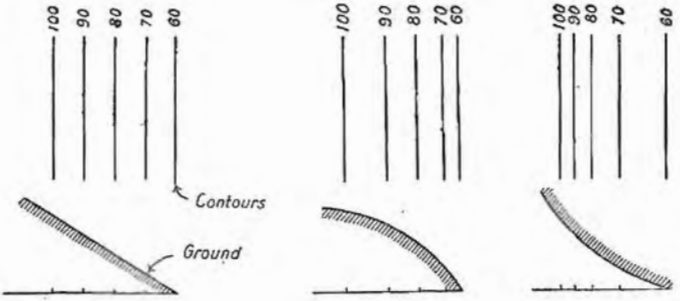


Fig. 24.

(*c*) From contours the gradient, or steepness of slope, can be calculated.

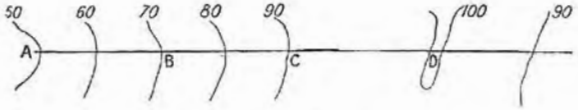


Fig. 25.

(AB = 500 meters)

Example. — The slope A to B is required.

Suppose AB = 500 meters (= ZY).

B is 20 meters above A (= XY).

Then the gradient is "20 in 500", or written as a

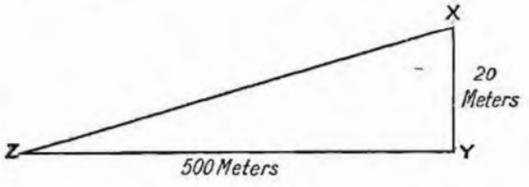


Fig. 26.

fraction $= \frac{20}{500} = \frac{1}{25}$. The steepness of the slope can also be measured by the angle XZY.

Angle XZY (in mils) $= \frac{XY}{ZY} \times 1000 = \frac{20}{500} \times 1000$ $= 40$ mils.

Practical uses.

(*a*) Knowing the gradient, it is possible to judge whether a road on a reverse slope in the enemy's territory will be used by transport or not; for it is very improbable that a gradient greater than 1/10 (i. e., 100 mils) will be used. From this we can decide whether to fire on the road or not.

(*b*) The steepness of a slope will decide in the selection of routes for transport.

If the gradient is 1/20 (i. e., 50 mils) even on a good road, time must be allowed to rest the horses.

On a gradient of 1/10 (i. e., 100 mils) a horse can only draw one quarter of the load it can draw on the level.

(*c*) Knowing the slope of the ground fired on, several deductions can be made of probable fire effect. (See "Fire effect in relation to slope of ground", page 121.)

(*d*) From contours, one can find whether two points are mutually visible.

Example. — See Fig. 25.

Is the point D visible from the point A? C is the point likely to cause the obstruction.

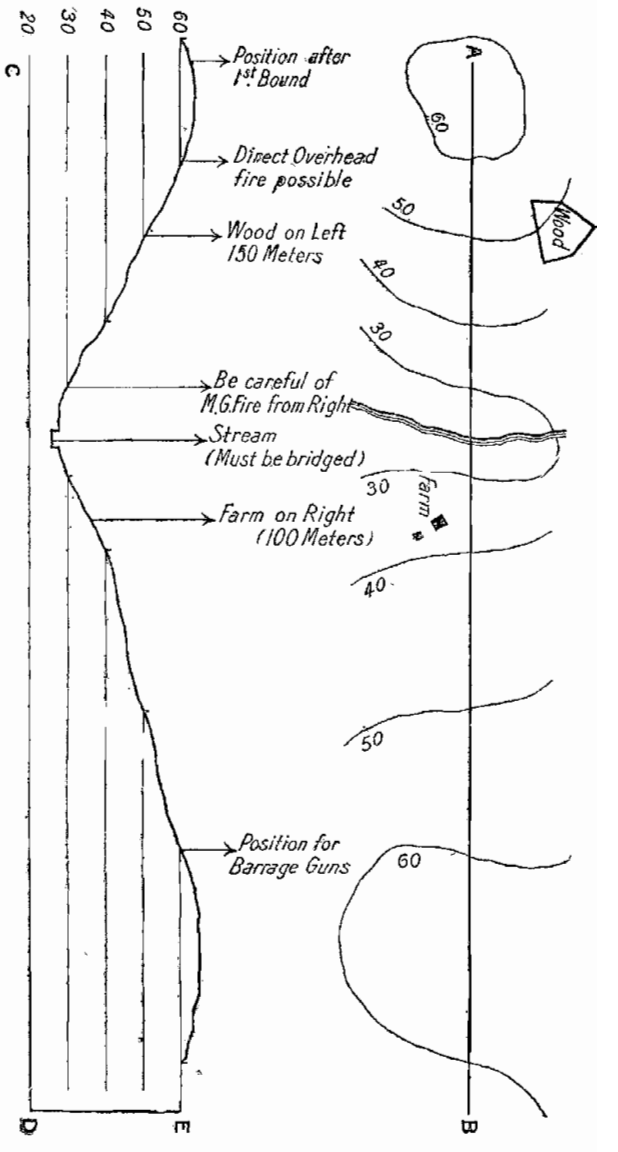

20
30
40
50
60
C
Position after 1st Bound
Direct Overhead fire possible
Wood on Left 150 Meters
Be careful of M.G. Fire from Right
Stream (Must be bridged)
Farm on Right (100 Meters)
Position for Barrage Guns
D
E
A
B
60
50
40
30
Wood
30
Farm
40
50
60

Fig. 27.

Now AC = 950 meters and AD = 1600 meters.

C is 40 meters above A, and D is 50 meters above A.

$\therefore$ the angle of site from A to C $= \frac{40}{950} \times \frac{1000}{1} = 42.1$ mils, and the angle of site A to D $= \frac{50}{1600} \times 1000 = 31.25$ mils.

Then, as the angle of site from A to C is greater than that from A to D, the point D is not visible from A.

The practical use of the above would be in selecting routes of advance either for troops of for transport. For instance in the previous diagram, suppose we hold C and the enemy holds A, it would be safe for troops to cross D, although D is the highest point in the vicinity, because D cannot be seen from A.

(*e*) From a contoured map, sections of the country (profiles) can be made.

In the above contours, to make a profile from A to B :

Join AB on the map.

Draw CD = AB, marking the points where each contour cuts AB.

Draw DE to some convenient scale to show the vertical intervals of the contours. Plot in the vertical section of the ground; and then insert details that are likely to be of practical value.

A profile thus constructed will be useful, for example, for showing troops the kind of ground over which they have to advance, especially if aeroplane photographs are difficult to obtain.

For purposes of study, the construction of such profiles is one of the best ways of understanding the different problems connected with contours.

MAPS OF FRANCE.

8. *Maps to the scale 1 to 80000.* — Maps drawn up on a scale of 1 to 40.000. Bonne projection; the center of projection is found at the intersection of the meridian of Paris and the parallel of latitude 50 G.

Each sheet is divided into quarters, each having the dimensions of 40 centimeters by 25 centimeters, or of 32 kilometers by 20 kilometers.

At each corner are indicated the longitude with reference to the meridian of Paris, the latitude expressed in grades, seconds, or tenths of seconds, as well as the rectangular coordinates with reference to the center of projection.

The map is printed in black. Slopes are represented by hachures normal to the contours.

Map to the scale of 1 to 50000, in black. — Exact reproduction of the 1 to 80000 map, enlarged by photography; also printed in black. This is the map which is laid off in quadrangles of the adopted system of projection (Lambert).

Maps to the scale 1 to 10000 and 1 to 20000. — The maps to the scale 1 to 10000 are obtained from accurate maps drawn up on the ground to the scale of 1 to 10000 " Polycentrique " projection.

The elevations are adjusted to the general elevations of France.

The contours are at 5 meters interval, with intermediary contours at intervals of 2.5 meters in very flat areas.

Each sheet of the 1 to 10000 map covers a distance of 5 minutes, centesimal, of latitude and longitude.

The maps, 1 to 20000, are obtained by photographic reduction from those of 1 to 10000; each sheet of the 1 to 20000 contains four sheets of the 1 to 10000 not joined, but simply placed by the side of one another, with an interval separating them.

It results from this that the maps can not be used in the ordinary manner in every case, especially in taking angular measurements and distances from them.

The sheets, 1 to 10000, are printed in black.

Maps 1 to 50000, in colors. — Prepared by means of maps 1 to 10000 for the plains and country of average roughness, and from maps 1 to 20000 in mountainous country.

" Polycentrique " system of projection. Each sheet represents a surface 20 minutes, centesimal, in latitude and 40 in longitude, which corresponds for the northern zone to a dimension of about 40 centimeters by 50 centimeters. (8 sheets for 1 to 20000, or 32 sheets, 1 to 10000.)

The topography is shown by contours at intervals of 10 meters touched up with a stump. (Short and thick roll of paper, cut to a point, by which colored crayons may be distributed or colors toned down.)

Printed in eight colors; maps in course of preparation; there are only a very limited number of these sheets in existence. (See index map.)

Maps to the scale 1 to 200000. — Derived from the 1 to 80000. Each sheet corresponds to 4 sheets of the 1 to 80000 (128 kilometers by 80 kilometers).

Topography is represented by contours at 40 meter intervals, with intermediary contours at 20 meter intervals for the plain areas, and heavier contours at 200 meter intervals, the whole touched up with a stump.

Printed in six colors. A new type (1912) shows the following improvements :

Localities shown in detail, indication of mills, factories, isolated buildings, chateaux, etc.

Highways and coach roads alone are shown in red, dirt roads and paths are shown in black.

The population of communes is indicated by the number of hundreds of inhabitants.

Bridges and stream crossings are shown by a special conventional sign.

Topography is represented by contours at intervals of 20 meters, with heavy contours at intervals of 200 meters.

MAPS OF BELGIUM.

Maps to the scale 1 to 20000. — Drawn up from the cadastral maps reduced to 1 to 20000, checked up and completed on the ground.

They are based on the Bonne projection, on the meridian of Brussels, and the parallel of 50g.

Topography is shown by contours at intervals of 1 meter on the left bank of the Meuse and at intervals of 5 meters on the right bank.

Printed in black.

Certain important parts have been enlarged to 1 to 10000.

Maps to the scale 1 to 40000. — Maps constructed by

assembling and reducing sheets of the 1 to 20000. Each sheet comprises four sheets of the 1 to 20000 map.

Contours are spaced at intervals of 5 meters.

Printed in black (a new edition is published with streams in blue and highways in red).

Maps to the scale 1 to 100000. — Reduced from the 1 to 40000. Each sheet comprises two sheets and two half sheets of the 1 to 40000.

Contours are spaced at 10 meter intervals.

Printed in six colors.

MAPS OF GERMANY.

Maps to the scale of 1 to 25000. — These are reproductions of original maps to the scale of 1 to 25000, prepared with a view to the establishment of the general map to the scale of 1 to 100000.

Polyhedric projection; origin of longitudes is the meridian of the island of Fer, 20°, sexagesimal, to the west of that of the observatory at Paris.

Area of each sheet is 6 minutes, sexagesimal, in latitude and 10 minutes in longitude (144 square kilometers, approximately).

Topography is shown by contours at intervals of 10 meters in very broken area, and of 5 meters in rolling country, with intermediate contours at 2.5 meters, and even 1.25 meters on very gentle slopes. Heavy contours are shown at every 20 meters. The contours are numbered along the borders and at various points along the curves themselves.

They are printed in black, with water in blue. These sheets, usually referred to as "planchettes" (small boards), have been published for a large part of Germany. They have been prepared for Alsace-Lorraine and the Rhenish Provinces.

Maps to the scale of 1 to 100000. — These are prepared by the reduction of the sheets to the scale of 1 to 25000. Each sheet covers 15 minutes, sexagesimal, in latitude and 30 minutes in longitude.

There are numerous conventional signs and details.

Relief is shown in hachures normal to the contours.

There are two scales along the lower border one in meters and paces; the other in geographical miles.

They are printed in black.

MAPS WITH SQUARES LAID OFF ON THEM.

The Geographical Service makes special prints of maps to the scale of 1 to 50000, with quadrangles laid off in the Lambert system, of the whole of northeastern France, Alsace-Lorraine, and Germany, and prints of maps to the scale 1 to 40000 of Belgium likewise laid off in quadrangles of the Lambert system.

CHAPTER III.

FIRE DIRECTION.

Theory of fire.

9. *Technical terms.*

Axis of the bore. — An imaginary line following the center of the bore from breech to muzzle.

Line of aim. — The straight line passing through the sights and the point aimed at.

Trajectory. — The curved path taken by the bullet in its flight to the target.

Cone of fire. — The figure formed in the air by the trajectories of the outermost shots of a burst of fire.

Culminating point. — The highest point of the trajectory above the line of aim.

Its position is approximately 6/10 of the range.

First catch. — The point where the lowest bullet has descended sufficiently to strike the head of a man, whether mounted, standing, kneeling, lying, etc...

First graze. — The point where the lowest bullet, if not interfered with, will first strike the ground.

Beaten zone. — The area of ground beaten by a cone of fire.

(1) The length is great compared with the width.

(2) The dimensions of the beaten zones of the Hotchkiss gun have never been satisfactorily measured.

Effective beaten zone. — The area of ground beaten by the best 75% of the shots.

Drift. — The term used to express the lateral deviation of the bullet, brought about by its gyroscopic action, after it has left the barrel. Experience indicates that for purposes of machine gun fire drift need not be taken into consideration.

Angle of site. — The angle contained between the line of aim and the horizontal plane.

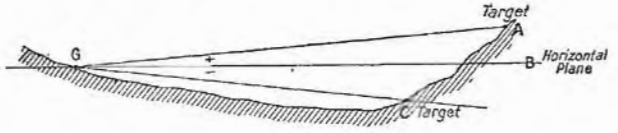


Fig. 28.

Angle AGB = angle of site for target A.

Angle BGC = angle of site for target C.

By convention, the angle is said to be positive (+) when the target is above the H. P., and is negative (—) when the target is below the H. P., through the gun position.

Angle of tangent elevation. — The angle between the axis of the bore and the line of aim.

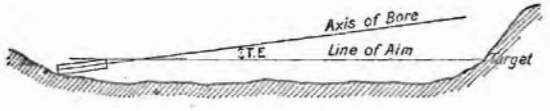


Fig. 29.

T. E. is the angle of tangent elevation.

Angle of quadrant elevation. — The angle between the axis of the bore and the horizontal plane.

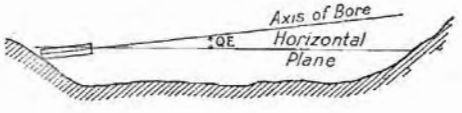


Fig. 30.

Relation between angle of quadrant elevation (Q. E.), angle of tangent elevation (T. E.), and angle of site.

(*a*) Target above gun.

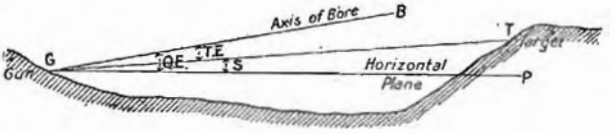


Fig. 31.

By definition :

Angle BGP = angle of quadrant elevation.
Angle BGT = angle of tangent elevation.
Angle TGP = angle of site.
Then Q.E. = T. E. + S.

i. e., when the target is above the gun, the angle of quadrant elevation is equal to the angle of tangent elevation, plus the angle of site.

(*b*) Target below gun.

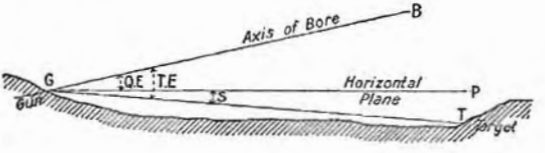


Fig. 32.

By definition :

Angle BGP = angle of quadrant elevation.
Angle BGT = angle of tangent elevation.
Angle PGT = angle of site.
Then Q. E. = T. E. — S.

i.e., when the target is below the gun, the angle of quadrant elevation is equal to the angle of tangent elevation minus the angle of site.

Generally then, the relation can be expressed by the following formula : Q. E. = T. E. ± S.

Angle of fall. — The angle which the tangent to the trajectory, at the point of impact, makes with the line of aim.

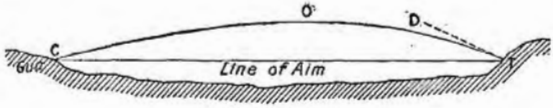


Fig. 33.

GT = line of aim.
GOT = trajectory
T = point of impact
DT is the tangent to the trajectory at the point of impact.

Then angle DTG = Angle of fall.

For all practical purposes, this can be calculated in the following manner:

OBT is the trajectory.

AT = line of aim.

DT = tangent at point of impact,

Then if AT = 100 meters the trajectory BT will be practically coincident with the tangent DT, and we can assume that the angle BTA = DTA.

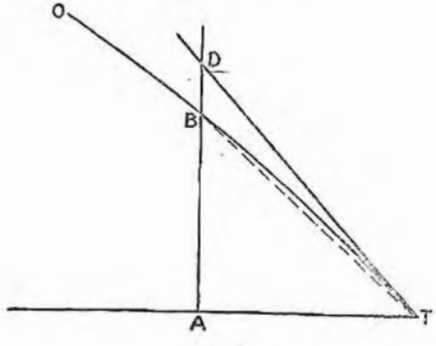


Fig. 34.

The distance BA can be found for any range, from the Table of ordinates. (Appendix 3, table 6.)

Then angle BTA = $\frac{BA}{AT} \times 1.000$ = angle of fall in mils.

Example: Find the angle of fall for 1800 meters.

From table of ordinates find the height BA, i. e., the height of the 1800 meters trajectory at 1700 meters. This equals 8.7 meters.

Then angle of fall $= \frac{BA}{AT} \times 1000 = \frac{8.7}{100} \times 1000$ $= 87$ mils.

Danger space. — For one bullet the danger space is the distance between the first catch and the first graze. In a burst of machine gun fire the danger zone is an area equal to the beaten zone, plus the area formed by the danger space for each bullet.

10. *Fire effect in relation to slope of ground.*

On level ground the length of the beaten zone varies considerably with the range; but also at any particular range the length of the beaten zone varies with the inclination of the ground to the line of aim.

The reverse slope.



Fig. 35.

Suppose AB is the length of the beaten zone along the line of aim GAB. Then it is clear that if the reverse slope AC be engaged, the beaten zone produced along this reverse slope by the same cone of fire will be AC, and will exceed AB.

Suppose, also, that DA represents the length of the danger space when firing along GAB, then EA will represent the length of the danger space when firing on the reverse slope.

Along the line of aim, therefore, fire effect will be produced for a distance DB, but on a reverse slope fire effect will be produced for a distance EC, and this distance (as will be shown later) will greatly exceed DB.

On a reverse slope the ratio of the length of AC to that of AB at any range can be found as follows :

$$\frac{AC}{AB} = \frac{\text{Angle of fall}}{\text{Angle of fall} - \text{Angle of slope of ground}} = \frac{FBA}{FBA - BAC}$$

Example : Range 2000 meters. Slope of ground 1 in 14.

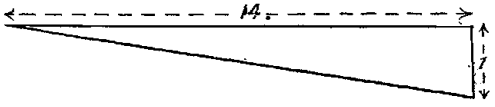


Fig. 36.

NOTE. — If the ground slopes 1 in 14, the angle of slope $= \frac{1}{14} \times 1000 = 71.4$ mils.

Also angle of fall at 2000 meters = 106 mils.

$$\frac{AC}{AB} = \frac{106}{106 - 71.4} = \frac{106}{34.6} = 3.07$$

Therefore, AC is 3.07 times the length of AB at 2000 meters when the ground slopes 1 in 14.

The forward slope.



Fig. 37.

Again let AB represent the length of the beaten zone along the line of sight GAB. Then AC will represent the length of the beaten zone produced by the same cone of fire along the forward slope AC.

Also, if DA represents the dangerous space along the line of sight, EA will represent it along the forward slope.

In all cases on a forward slope, the length of ground effectively engaged (i. e., EC) will be less than on the line of sight (i. e., DB).

On a forward slope, the ratio of the length of AC to that of AB is found as follows :

$$\frac{AC}{AB} = \frac{\text{Angle of fall}}{\text{Angle of fall} + \text{Angle of slope of ground}} = \frac{CBA}{CBA + CAB}$$

Example : Range 1500. Slope of ground 1 in 12 (i. e., angle of slope = 83.3 mils).

$$\frac{AC}{AB} = \frac{57}{57 + 83.3} = \frac{57}{140.3} = .4$$

Thus AC will be less than half the length of AB, at 1500 meters, when the ground slopes 1 on 12.

Atmospheric corrections.

11. The following are the normal atmospheric conditions for laying of machine guns in elevation :

(1) Barometric pressure. 750 millimeters (sea level).
(2) Temperature. 15 deg. centigrade.
(3) Still air.
(4) A horizontal line of aim.

(A) *Atmospheric variations that affect elevation.*

When the barometer rises above 750 mm., more elevation than is normally required for the distance will be necessary, owing to the greater resistance offered to the bullet by the denser atmosphere. If the barometer falls below 750 mm. as is the case in damp weather, or at a height above sea level, less elevation will be required as the atmosphere will offer reduced resistance to the bullet. In the same manner the bullet meets with less resistance in hot weather when the thermometer is high, and greater resistance in cold weather when it is low.

(1) The following table for correction in case of variation in barometric pressure will be used with French 1898 ammunition or 1886 D (a m) ammunition :

RANGE in meters.	CORRECTION OF BAROMETRIC PRESSURE, in meters for a variation of 10 mm. Normal 750 mm.
1000	9.0
1200	11.0
1400	13.0
1600	15.5
1800	18.0
2000	21.0
2200	24.0
2400	27.0
2600	30.5
2800	33.5
3000	37.0
3200	41.0

(2) The following table for correction in case of variation in temperature will be used with the French 1898 ammunition or 1886 D (a m) ammunition :

RANGE in meters.	CORRECTION OF TEMPERATURE in meters for a variation of 5° centigrade. Normal 15°.	NOTE.
1000	13.0	Above 15° subtract.
1200	16.0	Below 15° add.
1400	19.0	Above 750 mm. add.
1600	22.5	Below 750 mm. subtract.
1800	26.5	
2000	30.5	
2200	34.5	
2400	39.0	
2600	43.5	
2800	48.0	
3000	53.0	
3200	59.0	

Example : 2200 meters. Temperature 10° centigrade. Opposite 2200 we see 34.5 meters (Add this). Corrected range = 2234.5 meters.

(3) The following table of correction for wind will be used with the French 1898 ammunition or 1886 D (a m) ammunition :

Table of Correction for Wind (1 meter per second).

RANGE in meters	IN DIRECTION	IN RANGE	IN DIRECTION	IN RANGE
	3 or 9 o'clock wind. Correction in meters	6 or 12 o'clock wind. Correction in meters	1 : 30, 4 : 30, 7 : 30 o'clock wind. Correction in meters	10 : 30 Correction in
1500	2.0	4.0	1.4	2.8
1600	2.2	4.5	1.5	3.1
1700	2.4	5.0	1.6	3.5
1800	2.8	5.6	1.9	3.9
1900	3.2	6.4	2.2	4.4
2000	3.7	7.2	2.5	5.0
2100	4.2	8.1	2.8	5.6
2200	4.7	9.2	3.2	6.3
2300	5.2	10.3	3.6	7.1
2400	5.8.	11.6	4.1	8.0
2500	6.5	12.9.	4.5	9.0
2600	7.2	14.3	5.0	10.0
2700	7.9	15.8	5.5	11.1
2800	8.7	17.4	6.1	12.2
2900	9.7	19.4	6.7	13.5
3000	10.8	21.6	7.4	15.1
3100	11.9	23.8	8.3	16.7
3200	13.3	26.6	9.3	18.6
3300	14.9	29.8	10.4	20.8
3400	17.0	34.0	11.8	23.8
3500	19.2	38.6	13.4	27.0

Example. — Wind from 12 o'clock blowing at 10 meters per second. Range 1700 meters.

Opposite 1700 we see 5.0.

$10 \times 5 = 50$ meters (Add this).

Therefore the corrected range is 1750 meters.

(B) *Atmospheric variations that affect direction.*

A side wind acts on the greater surface of the bullet, and has consequently more influence on its flight than a wind blowing from the front or rear.

One must also note that, owing to the increased time during which the bullet is exposed to the effect of wind,

and to the height attained in its flight, the allowance for wind at long range is out of all proportion to that necessary at short range.

Example. — Wind from 3 o'clock blowing at 5 meters per second.

Range 3000 meters.
Opposite 3000 we see 10.8.
$5 \times 10.8 = 54$ meters.

$$M = \frac{W \times 1000}{R} = \frac{54 \times 1000}{3000}$$

= 18 mils, the necessary deflection to take to the right to overcome the effect of the wind.

(C) *Effect of not having a horizontal line of sight.*

As previously stated, one of the normal conditions under which a machine gun is sighted is that the line of aim shall be horizontal. When this condition obtains, the forces acting on the bullet cause it to travel on its greatest curve, and the elevation for any given distance must therefore be given to the gun.

When firing up or down hill, the tangent elevation required gets less as the angle of site increases, until when firing vertically upwards or downwards no tangent elevation is required at all.

It is very improbable that it will be found necessary to engage a target at an angle of site of more than 250 mils (except hostile aircraft, which is provided for on the special sights issued); and it also happens that no allowance need be made for angles of site less than 175 mils owing to the rigidity of the trajectory.

12. *Results of recent experiments.*

Experiments made to examine the behaviour of the bullet at ranges of about 3500 meters proved that fire at over that range will be of very little value.

The shape and size of each beaten zone would appear to vary with each burst fired, and the area beaten is always very large. This is no doubt due to the fact that the bullets attain a great height, and are influenced by many varying air currents.

The bullet also appears to fall sideways, sometimes pointing to the right and sometimes to the left, indicating that it has ceased to rotate with its point foremost.

The power of penetration was also tested, and the bullet was able to penetrate into 1 1/2 inches of soft wood at a range of 2800 meters.

Barrage demonstrations at 3000 and 3500 meters prove that accurate and effective firing can be produced at these ranges.

For tables for U. S. Ammunition, see Appendix IV, Parts 1, 2 and 3.

Combined sights, searching and traversing.

13. *Permissible and probable errors in range finding.*

(*a*) *Permissible error in range finding.*

Suppose a target is being engaged which is 1000 meters away. Then if the center of the effective beaten zone



Fig. 38.

hits the target (T) the lowest shot of the E. B. Z. will hit the ground 70 meters short of the target, and the highest shot 70 meters beyond the target, because the length of the E. B. Z. is 140 meters.

If now the center of the E. B. Z. falls 70 meters short, the highest shot only will hit the target (T 1).

Or if the center of the E. B. Z. falls 70 meters beyond the target (T2), only the lowest shots will hit the target.

It is clear then, that if an error of more than 70 meters is made in obtaining the distance to the target (T), the whole of the fire effect will be lost, because the target will not be hit. Seventy meters can be called the permissible error, and it is half the length of the effective beaten zone.

In general, the length of beaten zone decreases, as the range increases, and consequently the permissible error decreases as the range increases.

(*b*) *Probable error in range finding.*

Whether the fire be direct or indirect, the range to

any given target can rarely be obtained with complete accuracy, and the magnitude of this probable error depends on the method employed in obtaining the range.

The following table will act as a rough guide :

(1) Using range-finding instrument . . 5 % error.

(2) Using a range card built up from key ranges, the key ranges being found by instrument, and the intermediate ranges by judging distance . . . . . 10 % error.

(3) Judging distance (by eye) ranges . 15 % error.

(4) Using 1/10000 map (by eye) ranges . within 5 %.

(5) Using 1/20000 map (by eye) ranges . within 5 %.

This means that we can never look upon our target as a point, for there will always be a certain length in which the target may lie.

For example. — Suppose with a range-finding instrument we decide that the range to a certain target is 1000 meters.



Fig. 39.

Then as an error of 5 % may have been made either way, the target may be anywhere between the points A and B ; and to ensure hitting the target, we must produce fire effect on the whole of the line AB.

AB in this case is twice the probable error, and = 2 × 5 % of the range.

It is clear that the greater the range, the greater the probable error will be. For example, in the case considered above, the probable error is 50 meters, but if the range had been 2000 meters, the probable error would have been 100 meters.

To consider the permissible and probable errors together :

Example. — Range 2000 meters, using range-finding instrument.

Ground to be searched = 2 × 5 % of range = 200 meters.

Permissible error = 35 meters.

Example. — Range 1500 meters, using key ranges.

Ground to be searched = 2 × 10 % of range = 300 meters.

Permissible error = 40 meters.

Example. — Range 1000 meters, using judging distance method.

Ground to be searched = 2 × 15 % of range = 300 meters.

Permissible error = 70 meters.

Therefore, in practically all cases, it is necessary to increase the depth of the beaten zone considerably in order to ensure fire effect.

There are two methods of doing this :

(*a*) Combined sights.

(*b*) Searching.

14. *Combined sights.*

Definition. — The method of engaging any required depth of ground by applying simultaneously overlapping zones of fire from *two or more* guns.

The depth of the beaten zone is increased by ordering different elevations to be used by each gun, while each uses the same aiming mark.

In direct fire these different elevations are put on by ordering each gun to fire with a different elevation on the tangent sight. In indirect fire the same effect is produced by ordering a different quadrant elevation for each gun.

Rule for combined sights.

" Always use as many guns as possible, with 100 meter differences if the error in range finding is probably considerable, and with 50 meter differences if the error in range finding is probably small. "

Explanation of the result produced.

Example. — Range 1500 meters (as found by range-finding instrument) 3 guns available.

50 meter differences will be used (Rule above).

Then for direct fire, the order will be :

" Range 1450 — 50 meter differences. "

For indirect fire, the order will be :

" Up 33 — Add 2. "

(The angle of site is assumed to be zero; the tangent elevation for 1450 meters = 33 mils, and that for 1500 meters 35 mils.)

In each case the result at the target will be as follows :

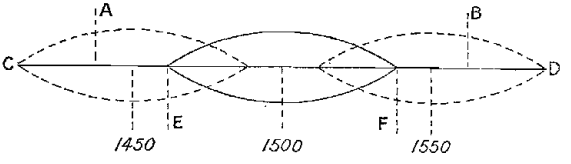


Fig. 40.

AB = 150 meters = ground to be searched = (2 × 5 % of range).
CD = Depth of E. B. Z. produced = 180 meters.
EF = Length of each E. B. Z. = 80 meters.

From this diagram it is clear that the likelihood of hitting the target (which lies between A and B) is greatly increased, but, as the fire is spread out, the density will be greatly diminished. Consequently, whenever observation of fire can be obtained, the controller must cease using combined sights, and fire with all the guns at the correct elevation to hit the target.

" Combined sights " is specially useful when surprise effect is desired, because each portion of the ground in which the target probably lies is beaten simultaneously.

NOTE. — When the target is itself a depth of ground e. g., a wood, combined sights will be maintained, even though fire effect on a particular part of the target has been observed.

15. *Searching.*

Definition. — The method of engaging any required depth of ground by applying successively overlapping zones of fire from *one* gun.

On comparing this method with combined sights, it

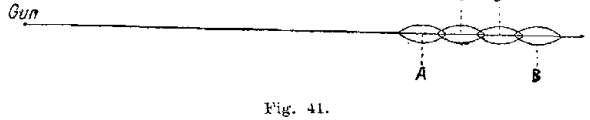


Fig. 41.

will be seen that searching is of little value when surprise effect is desired, because, whereas in combined sights each part of the target is engaged simultaneously, in searching each part of the target is engaged successively.

Suppose the target lies somewhere between the points A and B; then to ensure hitting it, the whole distance AB must be engaged.

The firer places a burst on A, then elevates his gun and places another on C, then on D, and continues until the whole line has been covered.

It requires much skill on the part of the firer to avoid gaps between bursts, and proficiency can only be obtained by constant practice on the 1000 inch range.

The firer is taught on the 1000 inch range to turn the elevating wheel after firing a burst, so that the next burst of fire is two inches above the first. This is the "Normal" or "Two-inch" turn.



Fig. 42.

G is the gun position. A and B the positions on the target of two bursts of fire, the necessary elevation being given to the gun after the first burst to raise the point of impact to B, which is two inches above A.

Using the mil formula :

$$\text{The angle BGA} = \frac{2 \times 1000}{1000} = 2 \text{ mils.}$$

i. e., the two-inch turn elevates the gun 2 mils.

Alterations in elevation are made by turning the elevating wheel, and it must be impressed on the firer, that the required turn is a very small one. (For the omnibus tripod, model 1915, it represents 1/5 of a turn of the hand wheel; for the Hotchkiss tripod, model 1916, 1/29 of a turn.)

For example, when firing at 1100 meters (tangent elevation 21 mils), an elevation of 3 mils will throw the beaten zone 100 meters forward (because the tangent elevation for 1200 meters is 24 mils). As one-third of a

turn of the wheel elevates the gun by 3 1/3 mils, the firer, if not properly trained, will probably elevate far more than this between bursts, and so leave gaps between the beaten zones on the target.

The firer should also be trained to apply his fire in suitable volume. Suppose the target is 1200 meters away and a burst of 5 rounds is fired. The length of the ground covered by that beaten zone may be 180 meters and the width is 8 meters, and it is clear that the effect of 5 bullets on such a large area will be very small. 20 or 30 rounds should be fired, or even more, if there is reason to suppose that the target is a dense one.

When searching is being employed to overcome errors in range-finding (the object at present under discussion) the following is the procedure :

The controller decides between what limits the target lies (say, between 1200 meters and 1500 meters).

He then orders range to near limit (i. e., 1200 meters).

Then he indicates the target.

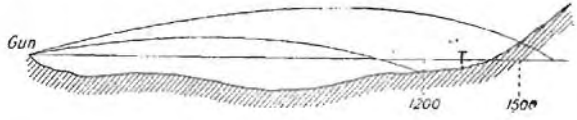


Fig. 43.

No. 1 aims at target with smaller range (1200 meters).

Controller then orders range to far limit (1500 meters).

No. 1 alters his sights to 1500 meters without elevating the gun.

No. 1 fires bursts and elevates until aiming at the target with 1500 meters.

Then, providing that the target lay between 1200 meters and 1500 meters, it will have been effectively engaged.

There is also another important use of combined sights and searching, which arises when the target is itself longer than the beaten zone which can be produced by one gun.

In this case, the total length of ground which must be searched can be found by adding the length of the target to twice the probable error.

When using combined sights, a point in the center of the target will be employed as an aiming mark (if the center is not visible, the near end), and the controller will decide from the number of guns available and from the length of the target, whether he should use 100 meter or 50 meter differences in order to cover the whole target.

If the target is on a forward slope, it will generally be advisable to use 100 meter differences, in order to counter-balance the shortening of the beaten zone which arises when firing on such a slope.

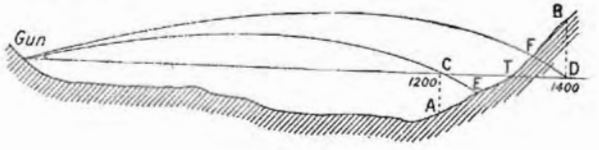


Fig. 44.

Example. — AB is a road, the near end being 1200 meters and the far end 1600 meters from the gun.

Then although a distance CD (400 meters) is covered along the line of aim (because all guns will have the same line of aim to T), only a part of the road AB will be covered, namely EF.

In order to cover as much of AB as possible, spread out the fire by ordering 100 meter differences.

If such a target be engaged by the method of searching, the existing rule needs modification. This rule states :

" The firer will aim at the near end of the target with the range to hit it. Then run his tangent sight slide to the range to the far end. Then fire and elevate until aiming at the near end. "

Such a process will only bring fire effect on the whole target when the far end of the target is on the prolongation of the line of aim to the near end.

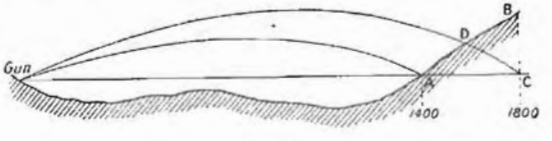


Fig. 45.

Example. — AB is a long target on a forward slope. A being 1400 meters and B 1800 meters from the gun. If the existing rule be followed, the firer will elevate until aiming at A with 1800 meters on his sights, but although his fire would, in the absence of ground at D, go to a point C, 1800 meters along the line of aim, it will not touch B the far end of the target.

In such an instance the rule must be altered; the firer should fire and elevate until aiming at the far end of the target.

16. *Traversing.*

Definition. — The method of engaging any required width of ground by distributing laterally against it the fire of one or more guns.

The normal way of engaging a wide target is to aim at one extremity, fire a burst and then traverse and fire alternately until the whole target has been covered.

The firer is taught on the 1000 inch range the required amount to traverse to cause the horizontal distance between bursts to be two inches on the target at 1.000 inches. It is equivalent to a traverse of 2 mils.

If the object in view is to bring fire effect on a belt or an area of ground (as in a barrage) this method is very

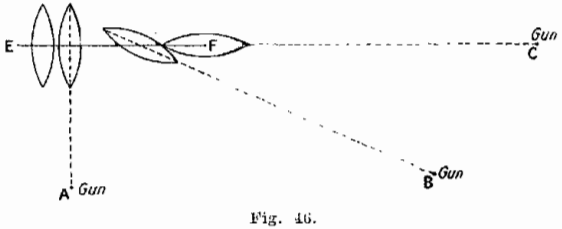


Fig. 16.

effective. But if the target is a thin line of extended infantry, or a trench running at right angles to the line of fire, traversing is wasteful. In such cases the best fire effect is obtained by firing in enfilade, or as obliquely to the target as possible.

EF is a line of extended infantry at 1000 meters.

The E.B.Z. is 115 meters long and 2 meters wide.

Then if EF is engaged from A (i. e., frontally), *only* the width of the E.B.Z. can be counted as effective (2 meters).

If EF is engaged from C (i. e., in enfilade), the whole length of the E.B.Z. (i. e., 115 meters) can be counted as effective. The fire effect produced will then be 57 times as effective from C as from A.

From B (i. e., obliquely) the fire effect will be greater than from A, and the effect will increase the nearer the fire approaches to enfilade.

It will also be seen that the time taken to cover the whole target EF will be much less from B than from A.

Every endeavor, therefore, should be made to reduce traversing to a minimum, and to engage targets from oblique or enfilade positions.

NOTE. — In the above example EF is looked upon as one single target, which it is better to engage from C than from any other position.

If, however, the object in view is to make a certain line EF impassable to the enemy, it is better to engage

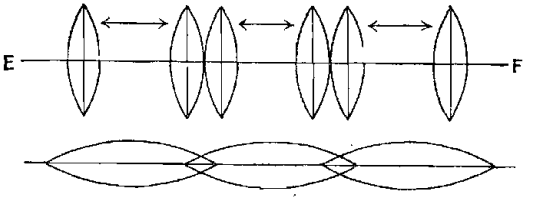


Fig. 47.

it frontally, provided sufficient guns are available to do this effectively, because then the enemy will be bound to pass through a deep belt of ground beaten by machine gun fire, whereas if the same object is attempted by enfilade guns, only a very narrow belt of ground is effectively engaged.

17. *Oblique traversing.*

Consider a target such as AB, running obliquely to the line of fire. Such a target is very often likely to demand attention (a road, hedge, or trench), and it is one of the most difficult to engage.

The best way is to use a combination of combined sights, searching and traversing.

For example, with four guns, order:
Range 1100, add 100.

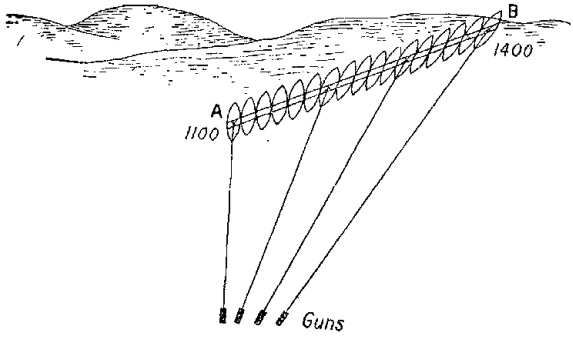


Fig. 48.

Target hostile column on road, 12 o'clock.
Fire at will.

Each No. 1 will then traverse and search along his own portion of the target, keeping his line of aim on the target.

It will then be unnecessary to order any one gun to use different elevations.

18. *Swinging traverse.*

This is a method of engaging a wide target by firing continuously, and at the same time distributing the fire along the whole target.

The swinging traverse should not be used except at dense targets which are not more than 500 meters distant.

Direct overhead fire.

19. It is an accepted principle of infantry tactics that, whenever the ground permits, an advance should be assisted by fire directed at the enemy over the heads of the assaulting troops.

For this type of fire action, in which the safety of the troops whose advance is being covered is the primary consideration, the machine gun, by reason of its fixed mounting and the close grouping of its fire, is characteristically fitted.

The safety of the attacking troops is ensured by the employment of a "safety angle", the magnitude of which depends on the range to the target.



Fig. 49.

Suppose the safety angle shown above is that for the range GT. Then it is safe for the firer at G to fire on the target until the advancing troops meet the line GB.

20. *Rules for direct overhead fire.*

(1) If the range to the target is 1000 yards or under, the safety angle is 8 mils.

If the range to the target is between 1000 and 1500 yards, the safety angle is 15 mils.

If the range to the target is over 1500 yards, the safety angle is 20 mils.

NOTE. — If the ground is comparatively flat between the gun and the target, closer support may generally be given by using the methods of indirect fire, if it is possible for these methods to be used.

(2) Use only machine guns — not automatic rifles.

(3) Use new barrels; have the tripods mounted on T's well dug in and settled; see that there is no lost motion. Do not use barrels that have fired more than 14000 rounds.

(4) Have the very best firers at each gun.

(5) Direct overhead fire must not be employed if the attacking troops are more than 1800 meters from the gun.

(6) Notify our own troops that the machine guns are going to fire over them.

(7) Block the elevation of each piece.

(8) If uncertain of the location of our own troops, don't fire.

(9) The range to the target must be known to within 5 %.

(10) Fire in short bursts and verify the laying frequently.

NOTES on the preceding rules.

(1) The calculation of the safety angles given in rule (1) is based on the following allowances :

(*a*) That a maximum error of 5 % of the range may have been made in range finding.

(*b*) That the lowest bullet may fall short an additional 10 % of the range on account of bad holding, aiming, worn barrel or defective ammunition.

(*c*) Over and above the allowance for errors in range finding and firing, allowance is also made for the known distance of the lowest shot of the cone below the center shot.

(2) In rule (5) there is no limit to the range from gun to target.

(3) The other rules are practical precautions for minimizing the errors allowed for in rule (1), and thus making the safety of the attacking troops absolute.

(4) In addition, the controller will allow for climatic conditions, especially for head winds.

21. *Methods of applying safety angles.*

Method I. — By musketry rule or field glasses.

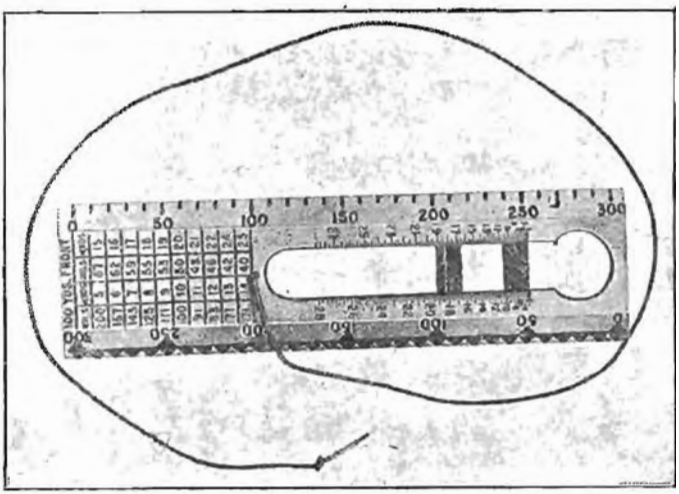
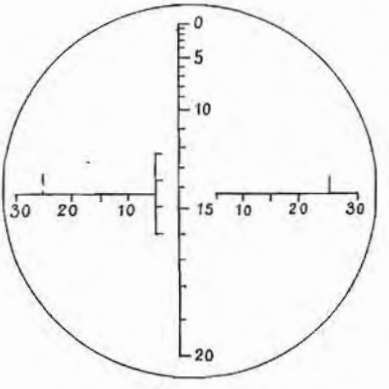


Fig. 50.

With the mil scale of the musketry rule or EE field glasses, measure downward from the line of aim the 8, 15 or 20 mils, depending upon whether the range to the



View through Type EE glasses.

Fig. 51.

target is under 1000 yards, between 1000 and 1500 yards, or more than 1500 yards. Observe where this line cuts the ground. Fire until the attacking troops touch this line.

Method II.

An objection to the previous method is that only three

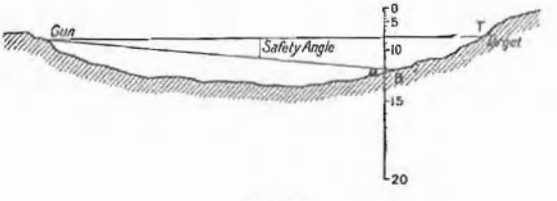


Fig. 52.

safety angles are permissible. This is unsound because the safety angle varies with every variation in the range.

This difficulty is overcome by the following method :

The glass or the musketry rule is so held that the line on the scale marking the range to the target cuts the target. The observer then determines the line on the ground that is cut by the scale at a range 400 yards greater than that to the target. This is the safety limit and firing must cease when the heads of friendly troops appear on this line.

Example. — Range to target 800 yards.

Place the 800 line of the range scale on the target T.

Observe where the 1200 yards line of the range scale cuts the ground.

Fire until attacking troops cut this line.

NOTE. — The trajectories of the American and French ammunition are so nearly the same that the musketry rule and EE glass can be used for both.

Method III. — Tangent sight method, or *Automatic sight correction.*

In the methods given above, the controller alone knows how far it is safe to support the advance. If he should become a casualty, the firer will be in danger either of supporting the advance beyond the safety limit, or of ceasing fire too soon, in which case the attacking troops will lose the effect of his covering fire.

This difficulty is overcome by the following method :

Stage I. — The firer lays on the target with the range to hit it. Then, without moving the gun, he runs up his sights 400 meters higher, and finds at which point on the ground he is now aiming.

This position on his new line of aim becomes his aiming mark, and he continues firing, constantly checking his aim on it, until his line of aim is touched by the advancing troops, when he ceases fire. The fire up to the present will have been directed on the target, because initially the gun was laid on the target with the range to hit it.

Stage II. — The firer now elevates the gun, aims

at (i. .e., takes a line of aim on to) the target, and fires until the attacking troops reach the target which is their objective, when he ceases fire if our troops intend advancing further. By so doing, fire effect is produced on the ground beyond target, and this will help to neutralize the fire of the enemy's support.

Example. — Range to target, 800 meters.

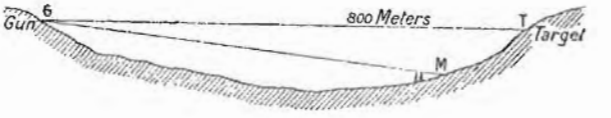


Fig. 53.

Lay on the target with 800 meters on the sights.

Alter tangent sight to 1200 meters (i. e., 400 meters higher), use the point M thus found, as aiming mark.

Fire until the attacking troops touch the line G. M.

Aim at the target, and continue firing until the advancing troops reach T. Then cease fire.

22. *Conclusion.*

In the absence of factors which obstruct the field of view (mist, smoke screens, the smoke and dust caused by artillery, etc.), the foregoing methods of direct overhead fire are technically reliable. But because one or other of these factors either is or may be present, arrangements for indirect fire should be made, and they should be of the following nature :

Once the gun has been laid on the target, an auxiliary aiming mark should be put out for the purpose of maintaining elevation and direction, and the maximum time during which the advance can be supported should be obtained either by estimating the rate of advance or by obtaining it from the artillery time-table. Thus, the point up to which the attacking troops can advance with safety being known, it can be decided how long fire may safely be directed on the target.

Note. — Owing to the fact that the musketry rule

and EE glass are graduated in yards and the Hotchkiss sight in meters the gunner and observer will not get exactly the point. The gunner will obtain a slightly greater angle of safety.

Indirect fire (General).

23. Indirect fire is fire directed by any other means than laying the gun over the sights on to the target.

Indirect fire may be carried out by guns controlled :

(*a*) Singly.

In this case the line of fire of each gun is laid out separately, and without reference to the line of fire of another gun.

(*b*) Platoons.

In this case the lines of fire of the guns constituting the platoon are laid out in parallel directions, and these form a basis from which the controlling officer can issue an order producing :

(*a*) Distribution of fire along any line.

(*b*) Concentration of fire on any locality.

Where possible, registration should always be carried out.

As this is often impossible, reliance must be placed upon the theoretical rules which underlie the application of indirect fire.

Unless these rules, their limitations and applications are clearly understood, accurate indirect fire is impossible, the safety of the troops, over whose heads the fire is being directed, may become endangered, and the expenditure of ammunition is not justified.

For example, unless the officer carrying out the fire has a knowledge of his probable errors in direction and elevation, he may either :

(*a*) By searching an area unnecessarily large (in order to obtain fire effect on the target) obtain a very small material result; or

(*b*) By searching an area too small, miss the target altogether.

If the necessary care is taken, accurate indirect fire

can be carried out with the present equipment of the gun.

In order to test this possibility, tests have been carried out over a period of six months. These have been undertaken by different squads of officers under instruction, under varying weather conditions.

The targets were six 4 ft. by 4 ft. screens placed one behind the other, but on the side of a hill, so that one shot could not hit more than one target. The map location of the targets was given to the officers carrying out the test.

In all cases elevation was placed on the gun by the gun level and two strips were fired.

No traversing was allowed, as the tests were designed to show the errors in direction.

The results show that with care the degree of error in direction should not exceed 8 mils, therefore, a total traverse of 15 mils, 2 divisions, should include the target.

To carry out indirect fire with accuracy and rapidity entails a high standard of professional efficiency on the part of the officer. He must have a thorough knowledge of :

(*a*) Maps.

(*b*) The compass and its "characteristics".

(*c*) The tables and graphs which give :

(1) Angles of elevation and fall.

(2) Dimensions of cones and beaten zones.

(3) Methods of determining quadrant elevation.

(4) Methods of determining clearances.

(5) Allowances for atmospheric conditions.

(*d*) Methods of laying and fire control.

(*e*) The technical equipment in use.

(*f*) Probable errors.

24. Indirect fire will be dealt with under the following headings :

Indirect fire of guns controlled singly.

I. Without the map (i. e., where a 1/20000 or larger scale contoured map is not available).

(*a*) By graticules.

(*b*) By angle of site instrument or goniometer.

II. With the map (i. e., where a 1/20000 or larger scale contoured map is available).

(*a*) To obtain direction.

(*b*) To obtain elevation.

Indirect fire of guns controlled in platoons.

I. With the map.

II. Without the map.

Maintaining laying.

Clearances.

Night firing.

Searching reverse slopes.

Errors.

Barrage fire.

Indirect fire of guns controlled singly.

25. *Indirect Fire without the Map.*

A. By use of auxiliary aiming target. (See page 228.)

The following instruments are required :

(1) Bausch and Lomb 80 cm. base range finder.

(2) Type EE Field Glasses, in which range scale is cut across the focal plane, or Musketry Rule.

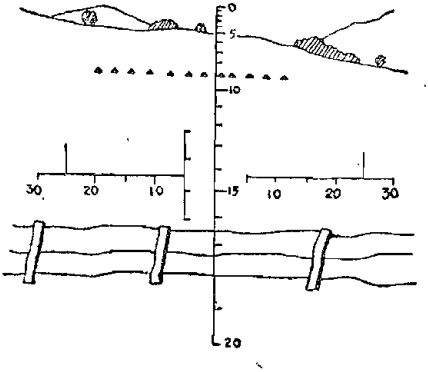


Fig. 54.

Procedure.

(1) Move to a position from which the target can be observed. (This should not be more than 2 meters

above the gun, and at approximately the same range from the target.)

(2) Obtain range to target.

(3) Select a suitable aiming mark, visible to the gun, which is vertically above or below the target, and in alignment of gun and target.

(4) Observe the target so that the graticule representing the true range falls across the true target.

(5) Note which graticule cuts the auxiliary aiming target and the corresponding range.

(6) Order the No. 1 of the gun to put this range on his rear sight and lay on the auxiliary aiming target.

If the observer is not provided with a EE glass or musketry rule, but has a mil scale or angle of site instrument, the auxiliary aiming target may be used as follows :

(1) Obtain the range to the target.

(2) Measure the vertical angle between the target and the auxiliary aiming target.

(3) Add this angle, if positive (subtract, if negative), to the tangent elevation of the range to the target. Determine the range corresponding to the sum.

(4) Lay the gun on the auxiliary aiming target with the range determined.

(5) The rear sight of the Browning is so made that turning the nut gives a click for each change of a mil. With this sight instead of carrying out three and four, proceed as follows :

(*a*) Set the range to the target on the sight.

(*b*) By means of the nut move the sight up or down the number of mils corresponding to the vertical angle between the target and the auxiliary aiming target, and lay the gun on the auxiliary aiming target.

These methods give accuracy of direction but not great accuracy of elevation. The fire effect is greatly enhanced when observation can be obtained.

(In open warfare these methods are of very great importance as machine guns can obtain cover from view with no loss of fire power if the observer is competent.)

NOTE. — Where a suitable auxiliary aiming target can be seen above or below the target, this method is

useful to bring fire to bear on a target which is visible through glasses, and is difficult to indicate to the No. 1.

B. By the TOG method.

The figure shows the :
Gun position, G.
Target position, T.
Observation station, O.
The following instruments are required :

1. Bausch and Lomb 80 cm. base range finder.
2. Goniometer, Brunton transit or some means of measuring the angle TOG and angles of site.

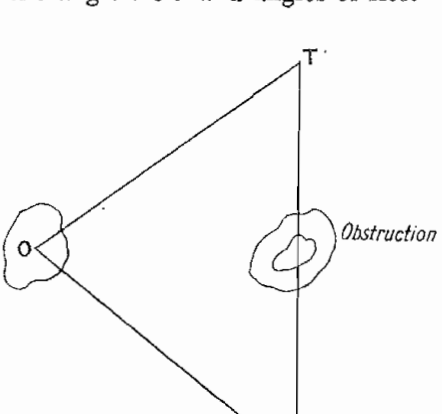


Fig. 55.

Procedure.

To obtain direction :

After selecting the gun position the controlling officer goes to a position from which he can see both the gun and the target, and :

(1) Takes ranges to the gun and to the target with the range finder.

(2) Measures the angle TOG.

This is done :

(*a*) With a goniometer, by laying it on G and T in turn, and noting the angle swung through.

(*b*) Without a goniometer, by taking bearings to G

and to T, and then the difference between these bearings is the angle TOG.

The ranges OT, OG, and the angle TOG being known, it is now simple to find the range GT, and the angle TGO. This is done as follows :

Draw a line to represent the range OT, set off the angle TOG with a protractor, and mark off the point G, so that OG represents the range OG. Measure the angle TGO with the protractor.

Order the gun to be laid on the observation station and lay off the angle TGO. An aiming post is now set out, and the gun is laid for direction.

To obtain elevation :

Take the angle of site from O to T $= t$ mils.
O to G $= g$ mils.

This is done with a goniometer.

To find the angle of site from G to T = S mils, use the formula :

$$S \text{ (in mils)} = \frac{t \text{ (in mils)} \times OT - g \text{ (in mils)} \times OG}{GT}.$$

The angle of site to a point is positive where that point is above the position of observation, negative where it is below.

Having found the angle of site S, find the tangent elevation (angle of departure) for the range GT and the angle of quadrant elevation from the formula :

$$Q.E. = T.E. \pm S.$$

Order this quadrant elevation to be placed on the gun.

The gun is now laid for direction and elevation. Where observation can be obtained, fire can be corrected by ordering "10 mils left", etc. — "up 10 mils".

The fire control is best carried out by telephonic

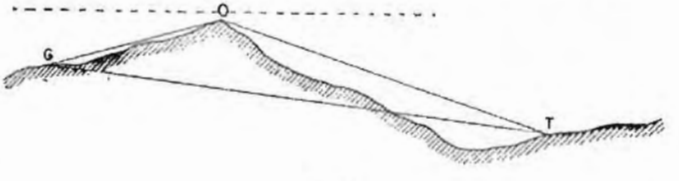


Fig. 56.

communication from O to G—or where this is not possible, by visual signalling.

Where the observation post is in the direct line from the gun to the target, direction can be obtained by placing posts, and elevation as follows :

Let :

OT = Range from crest to target.
OG = Range from crest to gun.
t = Angle of site from crest to target, in mils.
g = Angle of site from crest to gun, in mils.

Then angle of site from gun to target = S in mils.

$$S = \frac{t \times OT - g \times OG}{GT}$$

and GT = OG + OT approximately.

This "TOG" method can be easily adapted to guns employed in a platoon.

26. *Indirect Fire with the Map.*

The map must be at least 1/20000 and contoured.

A. To obtain direction.

Method 1. — By map and compass.

(1) The position of the gun on the ground must be accurately fixed on the map.

This is done either :

(*a*) From the detail on the ground and comparing this with the detail on the map; or

(*b*) If this is not possible, by resection.

Any of the methods described in "Locating positions by resection", may be used.

Where time permits greater accuracy is ensured by employing one method and checking with another.

It may be possible to obtain the aid of an Engineer Company where a very accurate location is necessary.

The use of oblique aeroplane photographs has been found helpful when moving guns forward to positions already sited in territory previously hostile.

(2) The magnetic bearing from the gun to the target must now be found.

To do this :

(*a*) Draw a line on the map from the gun position to the target.

(*b*) Using the protractor, measure the bearing this line makes with any North and South Grid line. This is the grid bearing from the gun to the target.

(*c*) Add the magnetic variation of the compass from the North and South Grid lines. The result is the magnetic bearing from the gun to the target.

NOTE 1. — (*c*) applies only to places where the magnetic variation is West.

If the variation is East, subtract instead of add.

NOTE 2. — The variation of the compass must be determined for each compass for the particular map in use, and should be constantly checked.

(3) To lay the gun on the magnetic bearing so obtained.

This can be done in the following ways :

(*a*) Place a post (not more than 6 inches high) in the gun position and place the compass on the top of the post. Rotate the compass until the card reads the required bearing.

Align an aiming post on this bearing, using the hair line on the compass. Place the gun with the center of the cross at the bottom of the socket, immediately over the post, and lay on the aiming post.

(*b*) It may often be impossible owing to the presence of iron to use a compass from the gun position itself. Take the compass out more or less in the required line of fire, either in front of, or behind the gun.

Two cases now occur :

1. Compass in front of gun.

The figures show :

1. CG the bearing from compass to gun.
2. CD the back bearing.
3. CT the bearing on which the gun is required to fire.
4. G*g* the line of fire obtained by laying off the angle *g*GC, which = the angle TCD.

NOTE. — Since the angle *g*GC = the angle TCD, *g*G is parallel to CT, and the gun is laid on the bearing required.

Rule :

1. Take the compass 30 to 50 meters in front of the gun more or less in the direction of fire. Lay the

gun on the compass. Take the bearing CG to the gun.

2. Obtain the back bearing CD.

3. Obtain the angle between this bearing and the one on which it is required to lay the gun (i. e., CT). This is the angle TCD.

4. The observer at C now turns his back on the

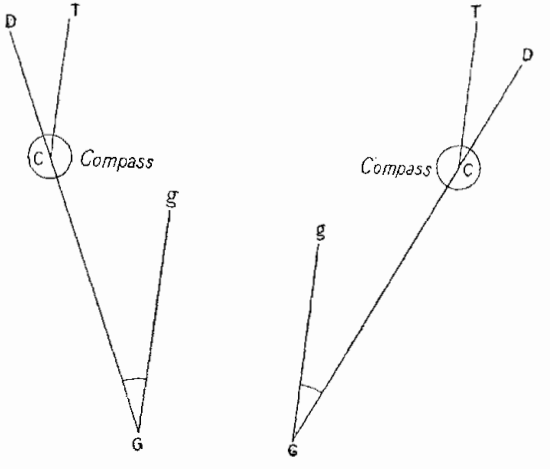


Fig. 57.

gun, and faces the direction CD—if the bearing on which it is required to fire the gun (i. e., CT) lies to his right, the gun lays off the angle TCD to the right—and if to his left, the angle TCD is laid off to the left.

The gun is now laid on the required bearing in the direction G*g*, which is parallel to CT ; and an aiming post is put out.

Example. — To lay a gun on a magnetic bearing of 7 deg.

Supposing :

(1) It is found that bearing CG = 170°.

(2) Adding 180° the back bearing CD = 350°.

(3) The difference between a bearing of 350° and 7° = 17°.

(4) Facing CD the bearing CT lies to the right. Therefore the gun lays off 17° to the right.

Or again, it may be found that :
(1) Bearing CG = 210°.
(2) Subtracting 180° the back bearing CD = 30°.
(3) The angle TCD = 30° — 7° = 23°.
(4) Facing CD the bearing CT lies to the left; therefore the gun lays off 23° to the left.

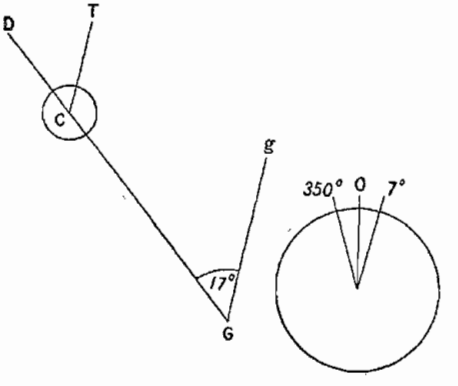


Fig. 58.

Compass behind gun.

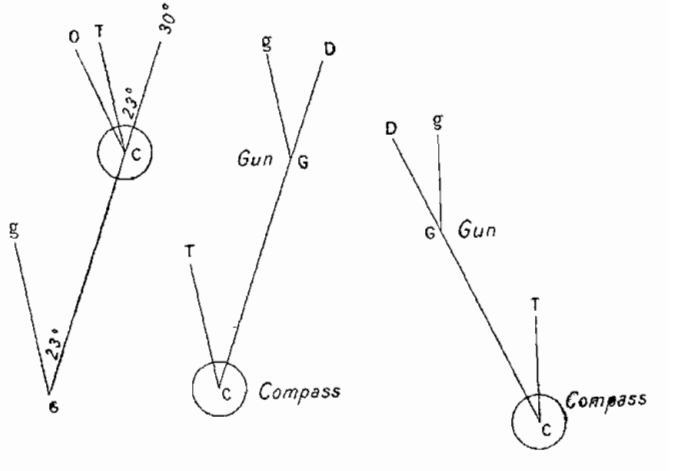


Fig. 59.

The figures show :

(1) CG the bearing from compass to gun.

(2) CT the bearing on which the gun is required to fire.

(3) Gg the line of fire obtained by laying off the angle gGD, which = the angle TCD.

NOTE. — Since the angle gGD = the angle TCD, gG is parallel to CT, and the gun is laid on the bearing required.

Rule :

1. Take the compass 30 to 50 meters behind the gun more or less in the prolongation of the line of fire,

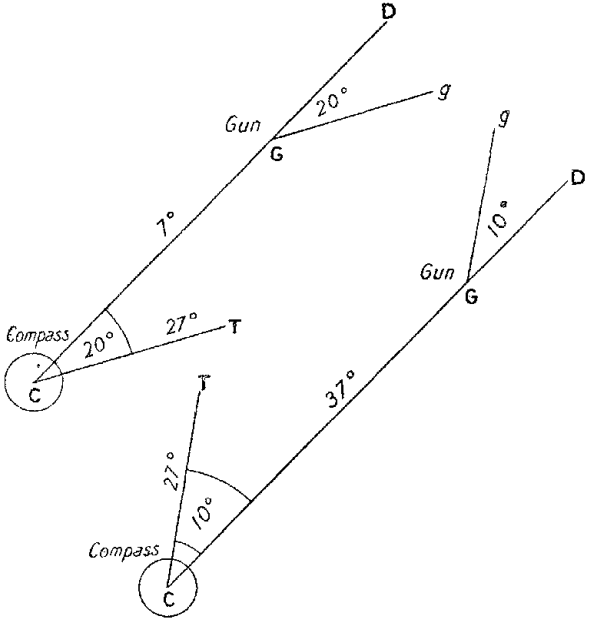


Fig. 60.

lay the gun back on to the compass from the foresight through the backsight.

Take the bearing CG on to the gun.

2. Obtain the angle between this bearing and the

one on which it is required to lay the gun (i. e., CT). This is the angle TCD.

3. The observer at C, now faces the gun. If the bearing on which it is required to fire the gun lies to his right, the gun lays off the angle TCD to the right — and if to his left, the angle TCD is laid off to the left.

The gun is now laid on the required bearing in the direction Gg, which is parallel to CT; and an aiming post is put out.

Example. — To lay a gun on a magnetic bearing of 27 deg.

Supposing :

1. It is found that bearing CG = 7 deg.
2. Difference between a bearing of 27 deg. (i. e., CT) and 7 deg = 20 deg.
3. Facing CD the bearing CT lies to the right, therefore, the gun lays off 20 deg. to the right.

Or again, it may be found that :

1. Bearing CG = 37 deg.
2. Difference between a bearing of 27 deg. (i. e., CT) and 37 deg. = 10 deg.
3. Facing CD the bearing CT lies to the left, therefore the gun lays off 10 deg. to the left.

Method 2. — By map and reference object.

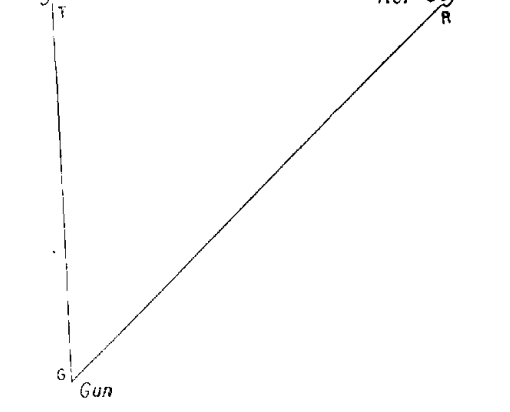


Fig. 61.

(1) The position of gun on the ground must first be accurately fixed on the map. (See page 100.)

(2) A reference object, which is both marked on the map and visible from the gun, is next selected. A line is drawn on the map.

(*a*) From the gun position to the target — GT; and

(*b*) From the gun position to the R.O. — GR.

The angle TGR is now measured with a protractor. The gun lays on the R. O. and turns off the angle TGR, and an aiming post is put out in the direction obtained. The gun is now aligned on the target.

NOTE 1. — The angle TGR may be measured with a protractor without drawing any lines—but these are an aid to accuracy.

NOTE 2. — Where the position of the gun can be found from the detail on the ground, all errors arising from the use of the compass are avoided.

Method 3. — By map, reference object, and compass.

A modification of Method 2 is necessary where no suitable reference object exists which is marked on the map and is visible from the gun.

Select a reference object on the ground, or, if necessary, place one out. Take the compass bearing from the gun position to the reference object.

Find from the map the bearing on which it is required to fire the gun. Find the difference between these bearings and lay off the angle obtained from the reference object.

NOTE. — Effect of atmospheric conditions on direction.

After the gun has been laid for direction by any of the methods given above, it is necessary to make the correction for wind. To find the allowance see wind tables.

This allowance is put on the gun by turning off the required angle on the "T" shaped aiming post.

B. To obtain elevation.

(1) On the map, measure the range from the gun to the target and note :

(*a*) The gun contour.

(*b*) The target contour.

The difference between the gun contour and the target contour is the vertical interval (V. I.).

(2) The quadrant elevation is now found by the formula :

$$Q.\ E. = T.\ E. \pm S.$$

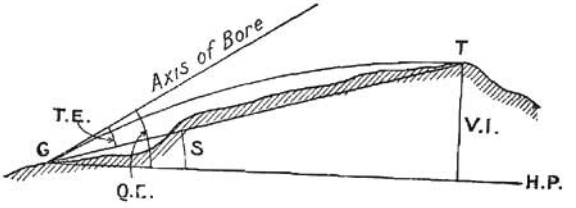


Fig. 62.

To obtain the angle of site use the formula :

$$\text{Angle of site in mils} = S = \frac{V.\ I.}{R} \times 1000$$

where V. I. = Vertical interval,
R = Range,
and both are measured in the same unit.

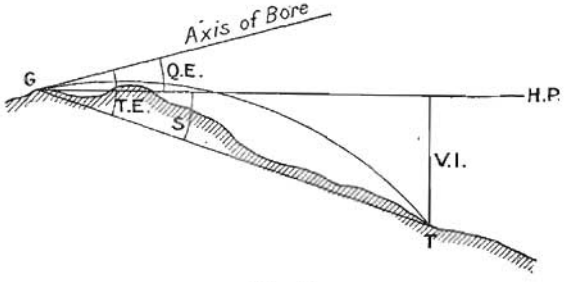


Fig. 63.

Example :

Range = 1700 meters and T. E. for 1700 = 45 mils.
Gun contour = 20 meters.
Target contour = 50 meters. Therefore V. I. = 30.

$$S = \frac{30}{1700} \times 1000 = 17.65 \text{ mils.}$$

Q. E. = T. E. + S =
45 + 17.65 = 62.65 mils.
or again if range = 1700 meters.
Gun contour = 50 meters.
Target contour = 20 meters.

$$S = \frac{30}{1700} \times 1000 = 17.65 \text{ mils.}$$

Q. E. = T. E. — S =
45 — 17.65 = 27.35 mils.

(3) In order to save calculating the angle of site and combining it with the tangent elevation to find the quadrant elevation, Tables 3A and 3B (Appendix III) have been compiled.

(These tables are compiled from the formula :

$$M = \frac{W}{R} \times 1000)$$

The Trajectory Graph in Appendix V allows the quadrant elevation to be read off without calculation of the angle of site.

(4) Before placing elevation on the gun the correction for atmospheric influences must be first made and the correction added to or subtracted from the Q. E., according as the correction is positive or negative.

To find the correction see Tables for Changes in Temperature and Barometric Pressure.

(5) To put the elevation on the gun.

Elevation is put on the gun, (*a*) with the gun level or clinometer; and (*b*) with the hand wheel.

(a) *Hotchkiss.* — Place the gun level on the rear sight at the range and bubble reading required by Table of Assimilation and elevate or depress the gun until the bubble is central. Hold down well on the pistol grip during the time the gun is being laid in elevation to insure that it will be the same as while firing.

Vickers—Browning.

1. Set the clinometer to the required reading.

2. Take the same hold as in firing, place the clinometer on the tangent sight base and elevate or depress the gun until the bubble is central. Move up the tan-

gent sight slide until the point of aim is on the auxiliary aiming mark.

(*b*) Level the gun barrel :

1. By means of the gun level : Range 1600, Bubble 4.
2. By a spirit level.
3. By sighting through the bore and putting up a paster on a stake some distance in front; then by reversing the gun and by back sighting through the bore, putting up a second paster on the stake. A point half way between the two pasters is on a level with the axis of the bore. Bring the bore in line with center paster and the gun is level.

Then set off the Q. E. in mils by means of the hand wheel.

Indirect fire of guns controlled in platoons.

Laying and fire control where 1/20000 or larger scale contoured map is available.

(To be read in conjunction with Barrage Drill.)

27. All the guns of one platoon are laid on parallel lines of fire initially, and zero aiming posts are placed in position. These lines are called the zero lines of fire of the platoon, and form the basis from which the line of fire of each gun is taken. The methods of obtaining parallel lines of fire are explained in par. 30, but where the nature of the ground admits, these lines should be checked by registration.

The guns are numbered from right to left, and the position of one gun is fixed as accurately as possible on the map. This gun is known as the directing gun, and is generally the left gun, to facilitate control. The choice of the zero line is arbitrary, but if the left gun is directing, it is generally the line from that gun to the left end of the first barrage line—or in the case of an S. O. S. barrage, to the left end of this S. O. S. line.

The zero line of the directing gun is laid out by any of the methods given in par. 26, and elevation is obtained as described in par. 26.

When a platoon engages a target, the fire of each gun is laid at equal intervals along it. Each gun traverses 15 mils either side of its line of fire, except :

(1) When concentrated fire is ordered.

(2) Where the concentration of guns is great, i. e., one gun to between 30 and 40 meters of front, when the total traverse is 15 mils.

(3) Where the concentration of guns is thin, and a traverse of 15 mils either side is insufficient to ensure that no gaps are left. In this case a traverse of twice the angle of distribution should be ordered.

This traverse prevents gaps by causing :

(1) The fire of neighboring guns to overlap.

(2) The fire of neighboring platoons to overlap.

At the same time, as the angle of traverse is small, different guns can have different quadrant elevations when the nature of the target demands it.

The fire is controlled by either :

(*a*) Shutter.

(*b*) Whistle and signals.

The former has been found the more effective method, especially when the platoon is all together.

28. *Distribution of Fire.*

Where the frontage of the target as viewed from the

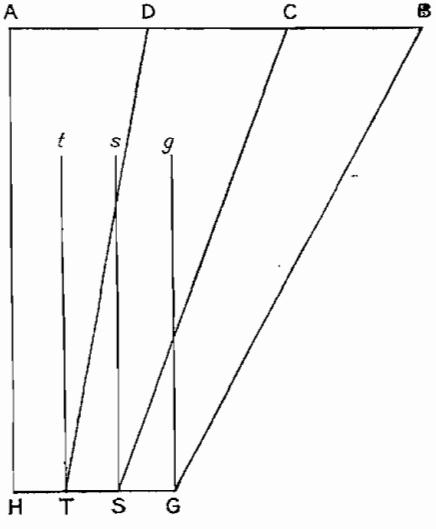


Fig. 65.

platoon, is greater than that of the platoon, it is necessary to distribute the fire of the guns from their parallel lines, in order to lay the fire of each gun at equal intervals along the target.

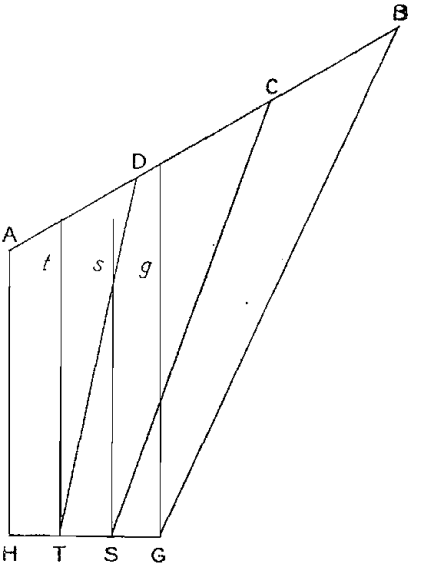


Fig. 66.

These figures show the lines of fire of a 4 gun platoon:

(*a*) On their parallel zero lines.

(*b*) After distribution of fire along:

(1) A frontal target.

(2) An oblique target.

The angle BG*g* = the angle of distribution of the platoon for the target AB.

The angle DT*t* = the angle of distribution for the gun at T.

The angle CS*s* = twice the angle DT*t*, or the angle of distribution for the gun at S.

The angle BG*g* = three times the angle DT*t*, or the angle of distribution for the gun at G.

Example. — If angle DT*t* = 10 mils
angle CS*s* = 20 mils
angle BG*g* = 30 mils.

Measurements of this angle are taken to the nearest mil.

If the zero line of the left gun (i. e., directing gun), is

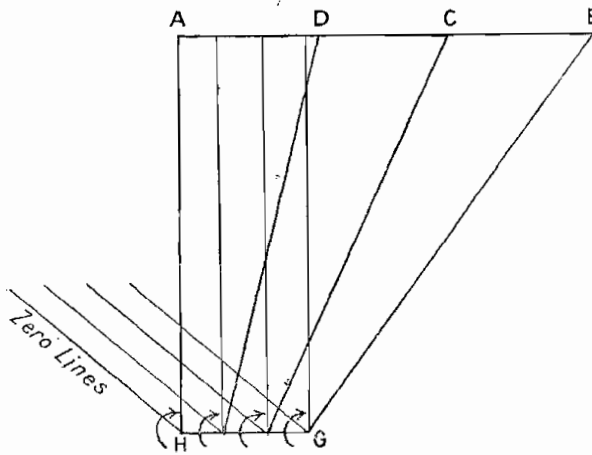


Fig. 67.

not directed on the left end of the target, this gun is

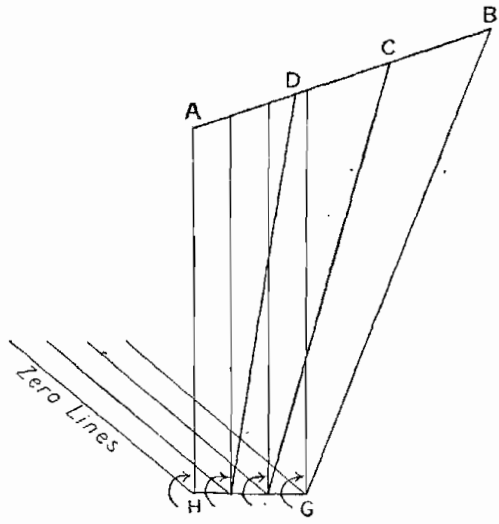


Fig. 68.

switched through an angle so as to direct its fire on to the left end of the target. This angle is called the "switch angle", and before distribution of fire along the target, all guns are ordered to lay off this angle, from their zero lines. This angle is measured by a protractor, or read from the fighting map.

These figures show the lines of fire of a 4 gun platoon :

(*a*) On their parallel zero lines.

(*b*) After all guns lay off the "angle of switch" from their zero lines.

(The guns are still on parallel lines of fire.)

(*c*) After distribution of fire along :

(1) A frontal target.

(2) An oblique target.

To obtain the distribution angle.

Case I :

Frontal barrage. — Where the angle HAB is between 1330 mils and 1870 mils.

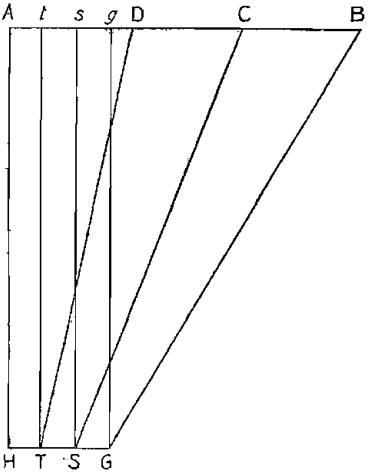


Fig. 69.

The figure shows the guns of a 4 gun platoon.

(*a*) On parallel lines before distribution.

(*b*) After distribution on the target AB.

Rule I :

1. Subtract the frontage of the platoon from the line to be fired on.

(Since GH = A*g*, this gives the length *g*B.)

2. Find from the mil formula what angle this length subtends at the range HA.

(Since HA = *gG*, this gives the angle of distribution BG*g* for the entire platoon.

3. Divide this angle by the number of gun intervals. The angle obtained is the distribution angle for the gun at T.

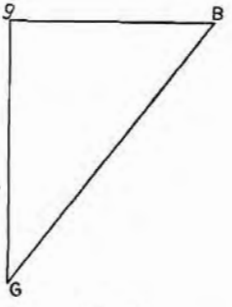


Fig. 70.

NOTE. — (1) The mil formula should not be used if the angle BGg exceeds 270 mils.

(2) The angle BG*g* can also be obtained by measurement with a protractor. No lines need necessarily be drawn, but errors are easily made in measuring the angle BG*g*.

Example. — A platoon of 8 guns, 10 meters apart, engages a target 320 meters long at a range of 2100 meters. To find the angle of distribution proceed as follows :

Applying Rule I.

1. AB = 320
   GH = 70
   AB — GH = 250

2. Using mil formula 250 meters at 2100 meters subtends an angle of 119 mils.

3. Dividing 119 mils by 7 (since there are 7 gun intervals) = 17 mils.

Check calculations by measuring angle on the map with the protractor. This requires that all lines be drawn with a sharp pencil and all angles be accurately measured.

Therefore:

(1) As the angle HAB is between 1330 mils and 1870 mils this is a frontal barrage.

(2) Order "Open 17 mils".

(3) On the order being given : "Open 17 mils",

No. 1 of No. 8 gun repeats "Open 17 mils".

No. 1 of No. 7 gun repeats "17 right, open 17 mils".

No. 1 of No. 6 gun repeats "34 right, open 17 mils".

No. 1 of No. 5 gun repeats "51 right, open 17 mils", etc. (See Barrage Drill.)

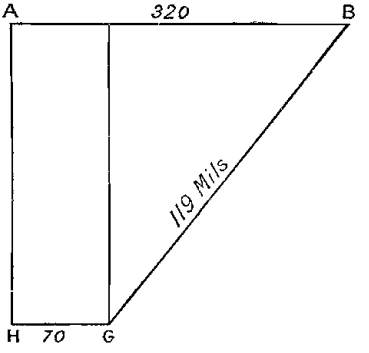


Fig. 71.

Case II:

Oblique barrage. — Where angle HAB is not between 1330 and 1870 mils.

(NOTE. — Enfilade barrage is only a type of this.)

The figure shows :

(*a*) The parallel lines of fire of the flank guns of a battery before distribution.

(*b*) The lines of fire of the flank guns after distribution on an oblique target.

It is obvious that if Rule I is applied, the distribution would be inaccurate owing to the foreshortening of the target when viewed from the battery. To overcome this apply Rule II.

Rule II :

Draw AX at right angles to HA. This is called the "working base", and is used instead of AB to determine the angle of distribution.

To find AX :

(*a*) Measure it from the map by drawing.

(*b*) Obtain length from Graph. Appendix VII. Pro-

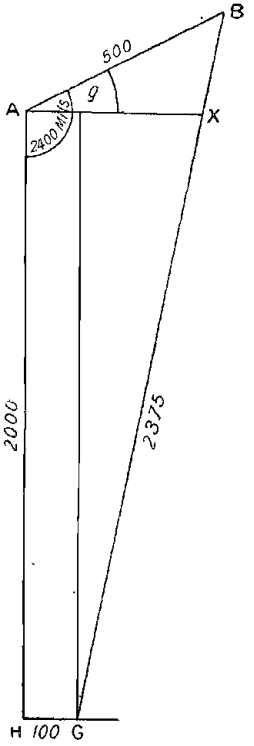


Fig. 72.

ceed now as in Rule I, using AX instead of AB from which to subtract the platoon frontage.

NOTE. — As the ranges HA and GB are different, combined sights are used.

Example. — An 8 gun platoon on a front of 100 meters engages a target 500 meters long, where the angle HAB = 2400 mils and the range HA = 2000 meters. (See fig. 72.)

To find the angle of distribution. — Apply Rule II.
By drawing, the working base AX = 320 meters.
By calculation with the mil formula:

$$\text{Angle } BGg = \frac{AX - HG}{AH} \times 1000 = \frac{320 - 100}{2000} \times 1000 = 110 \text{ mils.}$$

Dividing 110 mils by 7 (as there are 7 gun intervals) $= 15\frac{5}{7}$ mils. Order "Open 16 mils".

Check calculations by measuring angle BG*g* with a protractor. To find elevation:

Range GB = 2375. Q. E. = 85.25 mils.
Range HA = 2000. Q. E. = 60 mils.
Therefore, difference = 25.25 mils.

Dividing by 7 (i. e., the number of gun intervals).
Result = 3.6 mils.
Take 3.5 mils, order "All guns horizontal", then "Up 60, add 3 1/2".

29. *Concentration of fire.*
Where the frontage of the target as viewed from the platoon is less than that of the platoon, it is necessary to concentrate the fire of the platoon from their parallel lines.

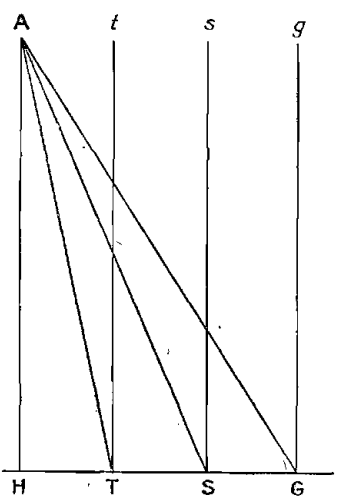


Fig. 73.

This figure shows the lines of fire of a 4 gun platoon.

(*a*) On their zero lines.

(*b*) After concentration on the target A.

The angle *t*TA = the angle of concentration for the gun at T.

The angle *s*SA = twice the angle *t*TA, or the angle of concentration for the gun at S.

The angle *g*GA = three times the angle *t*TA, or the angle of concentration for the gun at G.

The assumption in each of the above cases is that the gun at H is the directing gun and that the gun intervals are all equal.

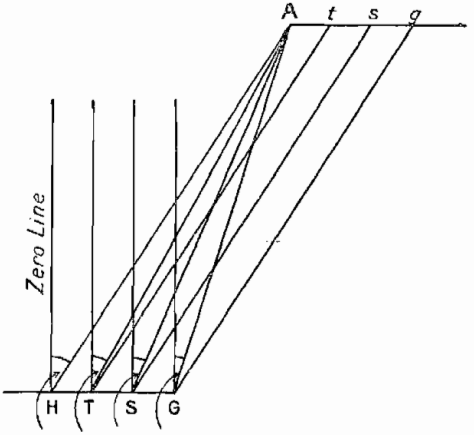


Fig. 74.

This figure shows the lines of a 4 gun platoon.

(*a*) On their zero lines.

(*b*) After all guns lay off the "angle of switch" from their zero lines.

(*c*) After concentration on to the target A.

To find the angle of concentration.

Rule III.

Subtract the frontage of the target from the frontage of the platoon, and proceed exactly as in Rule I, but substitute concentration for distribution.

Example. — A platoon of 8 guns on a frontage of 120 meters desires to engage a target whose frontage is 40 meters at a range of 2100 meters. To find the angle of concentration.

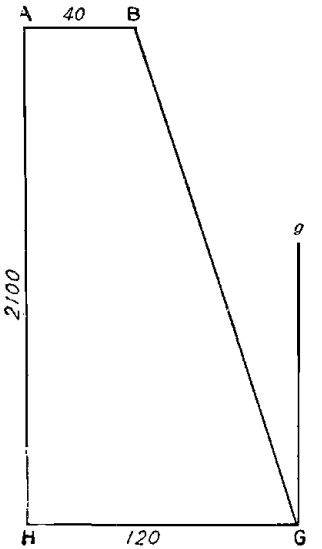


Fig. 75.

(1) GH = 120 meters
AB = 40
GH — AB = 80
(2) 80 meters at 2100 subtends an angle of 38.1 mils
(3) Dividing by 7, result = 5.44 mils.
(4) Order "Close 5 1/2 mils".

NOTE. 1. — On the order being given, "Close 5 1/2 mils" :

No. 1 of No. 8 gun repeats, "Close 5 1/2 mils".
No. 1 of No. 7 gun repeats, "5 1/2 left, close 5 1/2 mils"
No. 1 of No. 6 gun repeats, "11 left, close 5 1/2 mils"
No. 1 of No. 5 gun repeats, "16 1/2 left, close 5 1/2 mils" etc. (See Barrage Drill.)

NOTE 2. — It will often be found that for flank barrages the working base, as found by the use of Rule II,

will be less than the platoon front, and it will then be necessary to use Rule III and concentrate the fire.

NOTE 3. — It will generally be sufficient, in order to engage a target such as an enemy concentration, to switch the fire of the platoon on parallel lines without concentration or distribution of fire.

Example. — Showing distribution of fire along a target, after a switch.

A platoon of eight guns on a frontage of 100 meters

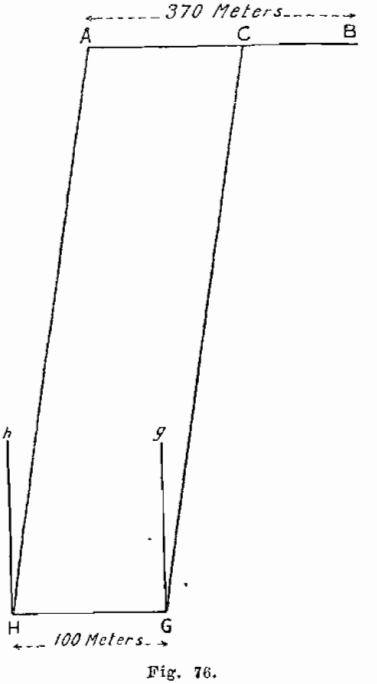


Fig. 76.

is ordered to engage a target 370 meters long at 2200 meters range.

To find the complete fire order :

The figure shows the flank guns.

(1) On their zero lines Gg and H*h*.

(2) After laying off the "angle of switch" (i. e., angle AH*h* = CGg).

(3) After distribution of fire along AB.

Suppose angle AH*h* = 90 mils, and gun and target on same contour so that Q. E. = 73 mils.

Applying Rule I (since the angle HAB is between 1425 mils and 1775 mils).

1. AB = 370
   GH = 100
   AB — GH = 270.

2. Using graph 270 meters at 2200 subtends an angle of 122.7 mils, which is the angle of distribution for the platoon.

3. Dividing by 7 = 17.5 mils, which is the angle of distribution for No. 7 gun.

The complete orders by the platoon commander would be :

Posts.
All guns on zero.
All guns 90 mils right.
No. 8 directing gun.
Open 17 1/2 mils.
Range 1750, Bubble 6, or
All guns horizontal.
Up 73 mils.
Load.
Rate — 75 per minute.
Fire at will.

If this target formed part of a previously arranged barrage, the platoon commander would place the results of his calculations in the platoon chart as follows. (See Appendix II, Part 2).

The lower part of the chart above mentioned shows the angle of deviation of each gun from its zero line. This is found by combining the angle of switch with the distribution angle of that particular gun.

It will be noticed that the angle of deviation of the directing gun equals the angle of switch.

From this part of the table the gun charts are compiled.

NOTE. — Where the situation does not permit the passing of orders, the platoon commander will employ the most suitable means of conveying the fire orders to

his guns; for example, by giving orders himself to each gun commander in turn, or sending the orders by runner to the gun commanders.

Frontage of platoon.

Definition :

The frontage of a platoon is the perpendicular distance between the parallel lines of the flank guns.

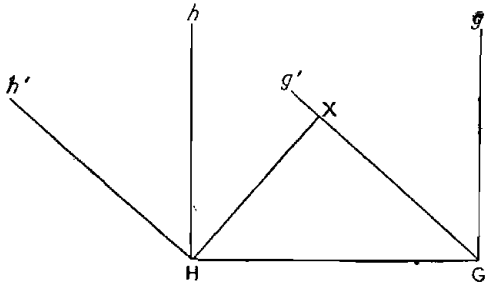


Fig. 77.

The figure shows :

1. Zero lines of flank guns of a platoon, H *h* and G*g*

As the angle *h*HG = 1600 mils the frontage of the platoon = GH.

2. Parallel lines H*h'* and G*g'* after a switch.

The frontage of the platoon is now HX, not GH.

This is only equal to the distance between the guns when the angle (*h*HG) between the line of fire of the directing gun and the line of guns is a right angle.

The error arising from considering the platoon frontage as the distance between the guns may be always neglected where the angle *h*HG is between 1950 mils and 1250 mils.

In other cases greater accuracy will be ensured if the frontage HX is used rather than the distance between the guns GH.

To obtain HX :

(*a*) Measure it on the map.

(b) Obtain length from graph B. Appendix V.

30. *To obtain parallel lines of fire.*

(*a*) It is very important that the lines of fire of the

guns of a platoon should be parallel when first laid out, and every effort should be made to attain this object. The platoon commander will then have a definite condition from which to make his calculations, and can switch his guns from one target to another without losing parallelism, distribute his fire correctly over a given front, or concentrate it on a given point, by means of the methods given above in par. 28 and par. 29. Any of the methods given below may be used, and the platoon commander will choose that most suited to the situation. In general, the method depending on the distant R. O. is the quickest and most accurate, the compass the slowest and most inaccurate.

(*b*) Methods depending on use of compass.

Each gun is laid on the same bearing by compass. This bearing is the bearing of the zero line. The methods can be any of those given in chapter III, par. 26.

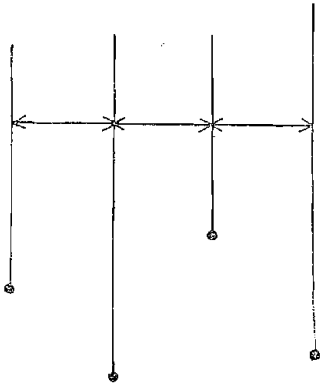


Fig. 78.

The lines of a platoon may be laid by compass when the ground renders it impossible to place the guns approximately in a line and there is no R. O. at a great distance.

The figure shows a 4 gun platoon in shell holes with parallel zero lines of fire.

This may occur after the forward move of platoons to new shell hole positions, from which to create an

S. O. S. barrage line. When firing in this direction the gun intervals should be as nearly equal as possible.

(*c*) Methods depending on the use of a goniometer or a gun used as a director.

The zero line of the directing gun is laid out by any of the methods described in chapter III and is marked by two posts.

The director is now placed in line with the two aiming posts at least 50 meters in front or rear of the platoon, with the foresight towards the target and clamped at zero.

If a gun is being used the reading on the traversing dial is noted.

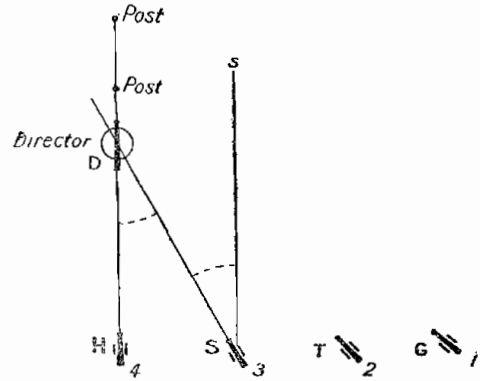


Fig. 79.

The figure shows : the director

(1) In line with the two aiming posts;

(2) Laid back on No. 4 gun;

(3) Laid back on No. 3 gun;

(4) No. 3 gun lays off the angle *s*SD = angle HDS, and is now on its zero line.

All guns now lay on the director.

The controlling officer now faces the platoon and lays back over the director (front sight over rear sight) on to each gun in turn.

The angles swung through are noted and given to the guns. Each gun lays off the angle given to it, and an aiming post is put out. The guns are now on parallel zero lines.

Where the director is behind the platoon, the procedure is the same, except :

(1) Guns are laid back on the director from front sight to rear sight.

(2) Director is laid on guns from rear sight to front sight.

The figure shows : the director

(1) In line with the two aiming posts;

(2) Laid forward on No. 3 gun;

(3) No. 3 gun laid back on the director;

(4) No. 3 gun lays off the angle *s*SC = angle HDS, and is now on its zero line.

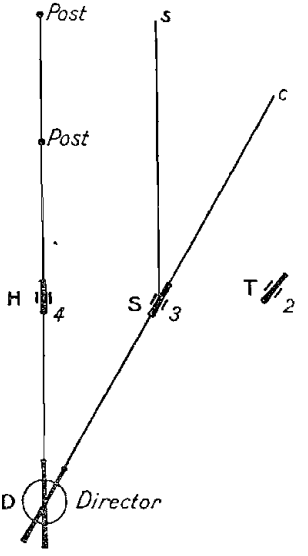


Fig. 80.

The lines of a platoon may be laid in this way when the ground renders it impossible to place the guns approximately in a straight line and there is no R. O. at a great distance.

(*d*) Methods depending on the use of an R. O., either on the map or put out.

When all the guns of the same platoon are laid off

the same angle from the same R. O., the lines of fire will not be parallel unless :

(1) The R. O. is at an infinite distance.

(2) The R. O. is in direct prolongation of the line of the guns.

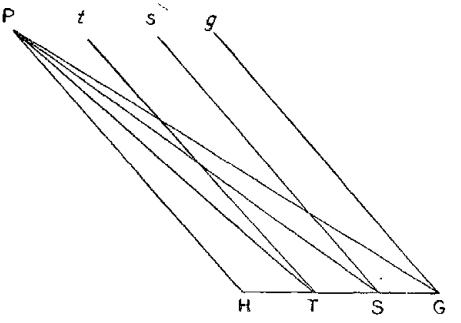


Fig. 81.

The figure shows the guns of a 4 gun platoon :

(*a*) Laid on the R. O. at P.

(*b*) After distribution to obtain parallelism.

The angle of parallax for the platoon = angle *g*GP = angle HPG.

The angle *t*TP = the angle HPT, the parallax for the gun at T.

The angle *s*SP = twice the angle *t*TP.

It also = angle HP*s* = twice angle HPT, the parallax for the gun at S.

The angle *g*GP = three times angle *t*TP.

It also = angle HPG = three times angle HPT, the parallax for the gun at G.

To obtain the parallax for any gun, measure the angle HPG and divide it by the number of gun intervals; then multiply the result by the number of the gun from the directing gun.

This is done by ordering flank guns to lay on each other and on R. O.; each gun notes the angle swung through. This measures angle PHG and PGH.

Add these angles together and subtract their sum from 3200 mils. The result is angle HPG. Divide this

angle by the number of gun intervals and this is the parallax for the gun nearest the directing gun.

NOTE. — The three angles of a triangle added together equal 3200 mils.

Example:

Angle PHG = 2100 mils.
Angle PGH = 1010 mils.
Adding = 3110 mils.
3200 mils — 3110 mils = 90 mils.
Dividing by number of gun intervals (3)
Result = 30 mils.

As the zero lines are unlikely to be the lines obtained above, it will be necessary to switch the parallel lines once these are obtained. In practice it is found better to order the angle of parallax first and the switch angle second. (See Barrage Drill.)

The result obtained is the same and the angle of parallax is independent of the switch angle.

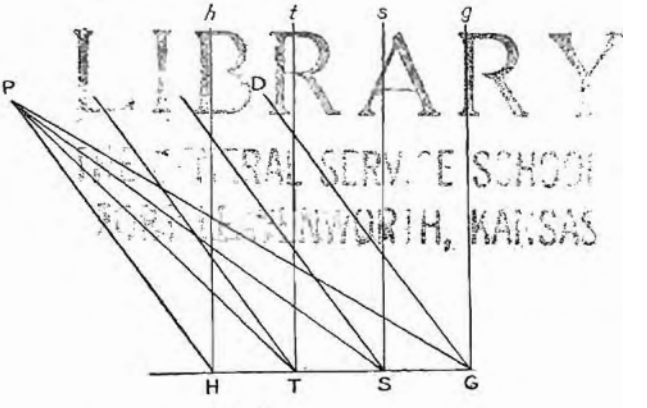


Fig. 82.

Draw GD parallel to HP.

The figure shows the lines of fire of a 4 gun platoon.

(*a*) Laid on R. O. at P.

(*b*) On parallel lines after distribution.

(*c*) On parallel zero lines.

Then in order for the gun at G to fire on its zero line Gg, it must lay off the angle :

gGP = angle gGD plus angle DGP
= angle hHP plus angle HPG
= switch angle plus angle HPG.

Therefore, measure angle HPG as described above and divide this angle by the number of gun intervals.

Example:

If switch angle = 1050 mils.
Angle of parallax = 15 mils.
Order All guns on R. O.
All guns 1050 mils right.
No. 4 directing gun.
Open 15 mils.

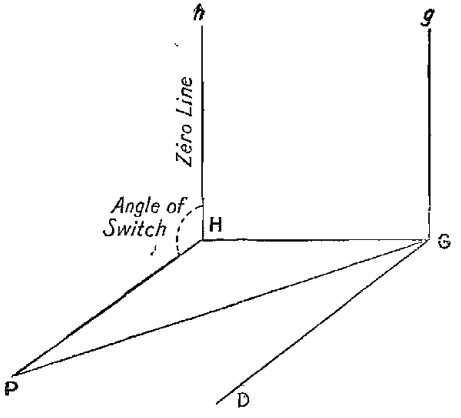


Fig. 88.

Case II. — R. O. behind guns.

The figure shows the flank guns of a platoon :

(*a*) Laid on R. O.;

(*b*) On parallel zero lines.

Draw GD parallel to HP. Since Hh and Gg are parallel, and HP and GD are parallel, therefore angle hHP = angle gGD, and angle HPG = angle PGD.

Now the gun at G lays off the angle gGP
= angle gGD — angle PGD
= angle hHP — angle HPG.

Therefore, proceed as in Case I, order all guns to lay off the switch angle and concentrate instead of distribute.

NOTE. — The angle of concentration for the gun nearest the directing gun is obtained by dividing the angle HPG by the number of gun intervals.

It may happen that no suitable R. O. exists which is marked on the map, but some object may be used which is not on the map, and by taking a bearing to this, the angle of switch necessary to obtain the zero line can be obtained.

This object can then be used to obtain parallelism as described above.

The R. O. must be as far away as possible, and it is sufficient if the guns are approximately in line.

If there is no suitable R. O. one must be put out in the line of the guns at a distance of at least 400 meters, if possible; and the guns should be in line as accurately as possible.

Here the bearing to the R. O. is taken from position of the directing gun.

It may happen that the R. O. is invisible from one of the gun positions or that the gun is out of line.

In this case its line can be laid :

(*a*) By compass;

(*b*) By laying on any gun which has obtained its zero line.

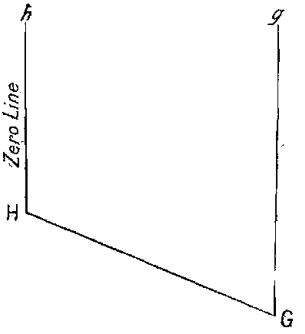


Fig. 84.

The figure shows H*h* the zero line of a gun already obtained, G*g* the zero line of a gun obtained as follows:

The guns lay on each other.

The gun at H records the angle *h*HG.

The gun at G subtracts this from 3200 mils and lays off the result from the gun at H. It is now on the parallel line Gg.

NOTE. — Since H*h* and G*g* are parallel, angle *h*HG plus angle *g*GH equals 3200 mils.

Indirect fire by machine gun platoons where a 1/20000, or larger scale map is not available.

31. In order to deal with some tactical situations arising in open warfare, provision must be made in the training of machine gun units for applying the indirect fire of platoons without the use of contoured maps.

The principles of distribution and concentration of fire from parallel lines and the methods of obtaining parallel lines remain unchanged, but modifications are required in the method of laying out the zero line of the directing gun and obtaining its elevation.

In the following, the word "director" will be taken to mean either a "goniometer", Brunton compass or some means of improvising a director, for example: a machine gun, a compass in conjunction with an angle of site instrument, or a sextant.

Two cases now arise :

Case I.

Where the target can be seen from the vicinity of the platoon position.

The line to the target is marked by two aiming posts.

The director is then placed in line with the two aiming posts at least 50 meters in front of, or rear of, the line of the platoon, and the guns are laid for direction as described in par. 26.

Elevation is obtained as in par. 26.

Case II.

Where the target can only be observed from some distance to a flank.

The line of fire of the directing gun :

(1) Is laid out by the method described in par. 26.

(2) The platoon commander orders :

All guns parallel to No.....gun.

(This being the directing gun.)

This is done by one of the methods described in par. 30. In either case the platoon commander is now in a position to distribute or concentrate his fire as occasion arises.

This type of fire should not be carried out over the heads of troops in the open, unless they are moving to a definite time table, and the clearances can be found.

Maintaining Laying.

After a gun has been laid for direction and elevation by any of the means heretofore described, an aiming post is put out in order to maintain direction and elevation. The rear sight slide is run up until the sights are aligned on the bulls-eye on the aiming post, and the laying is maintained by relaying on the bulls-eye between bursts.

In addition the elevation should be frequently checked by the gun level or clinometer. The appendix describes two types of aiming posts in use.

Inaccurate laying on the auxiliary aiming mark can only be avoided by training the personnel. Too much stress cannot be laid on this part of the machine gunner's training, as failure to realise the importance of accurate aiming may lead to fire becoming dangerous to our own troops, and consequent loss of confidence by the infantry.

Machine gunners should be tested in aiming from time to time by the "triangle of sighting" method.

NOTE. — Where no form of artificial aiming mark is available, some natural object on the ground may be selected. This should only be regarded as a makeshift, and not taught as a general practice.

Safety Clearances.

The clearance at any point over which fire is being directed is the vertical distance of the centre of the cone above that point.

32. When indirect fire is carried out over the heads

of our own troops the following rules must be adhered to in order to ensure the safety of the troops :

(1) The following minimum clearances of the centre of the cone are required :

RANGE TO FRIENDLY TROOPS	MINIMUM CLEARANCE	
	Meters	Mils
550 meters and under	11	
550 meters to 900 meters		20
900 meters to 1400 meters		27
1400 meters to 1800 meters		40
Over 1800 meters.	Don't fire.	

(2) Steps must be taken to prevent such extremes of traversing and searching as would violate (1). This is best done by using traversing and elevating stops or blocks.

(3) Calculations must be carefully checked and atmospheric conditions allowed for.

(4) The rigidity of the firing platform is essential. This is obtained by the use of the "T" base.

(5) Elevations must be frequently checked by the use of the gun level.

(6) The personnel must be highly trained in accurate aiming and relaying.

(7) The maps used must be accurate and the scale not smaller than 1/20000.

(8) Worn barrels and tripods should not be used.

(9) Our own troops should be warned when firing is going to take place.

(10) Gun levels or clinometers should be frequently tested.

The following table shows the various causes which may result in fire becoming dangerous, and how these causes may be avoided :

CAUSES	HOW AVOIDED
(1) Worn barrels, which include those that have fired over 14000 rounds.	Replacement by new barrels, but the life of a barrel is increased by care in oiling and pulling through.
(2) Worn mountings.	Replacement by new tripods or by the use of washers.
(3) Bad holding.	Training of personnel.
(4) Bad laying on auxiliary aiming mark.	Training of personnel.
(5) Extremes of traversing and searching.	Training of personnel and use of traversing and depression stops or blocks.
(6) Error in calculation.	Practice in the use of the Tables and Graph.
(7) Failure to allow for atmospheric conditions.	
(8) Inaccurate gun level.	Constant testing.
(9) Tripod sinking.	Use of "T" bases and care in construction of firing platforms.

The importance of the rigid platform may be better realised if it is remembered that a change of elevation of 5 mils is caused if the front legs sink 1/3 inch while the rear leg remains fixed, and vice versa if the rear leg sinks while the front legs remain fixed. As this error is neutralized by relaying on an auxiliary aiming mark, the necessity for constant and accurate relaying is again emphasized.

NOTE. — The safety clearances are based on :

(1) A possibility of 5 per cent. error in range on the map.

(2) A possibility of 10 per cent. error in range due to worn barrel, bad holding, etc.

(3) A possible error of 11 mils, in the play of the tripod.

(4) Allowance for the lowest shot of the cone.

33. (A) (To find the clearance over the friendly troops, using Table 6, Appendix III.)

Definition of equivalent range.

The range at which the centre of the cone would strike the horizontal plane through the gun position.

It is found by using table of tangent elevation and is used to determine the heights of the trajectories above the horizontal plane by means of the Table of Ordinates.

NOTE. — There is no equivalent range if the Q. E. is negative.

Example 1.

Target above gun.



Fig. 85.

The figure shows the trajectory to hit the target at T and GB the equivalent range on the horizontal plane through the gun position.

If GT = 1600 meters.

And target is 10 meters *above* gun.

Table 2 and mil formula give Q. E. = 46.25 mils.

Table 2 shows equivalent range = 1725 meters.

i. e., GB = 1725.

Example 2.

Target below gun.



Fig. 86.

The figure shows the trajectory to hit the target at T and GB the equivalent range on the horizontal plane through the gun position.

If GT = 2400 meters.

And target is 55 meters *below* gun.

Table 2 and mil formula give Q. E. = 64.1 mils.

Table 2 shows equivalent range = 2070 meters.
i. e., GB = 2070, approximately.

Procedure to find clearance.

Determine Q. E. and, when possible, the equivalent range.

Note the gun contour.

Note the friendly troops contour.

And so obtain the V. I. between the gun and our own troops.

The following two cases may arise :

Case I.

Where the trajectory, as it passes over our own troops is *above* the horizontal plane through the gun position.

Rule :

Find the height of the trajectory at the range to our own troops above the horizontal plane through the gun position.

(This is done by finding the equivalent range and using the Table of Ordinates.)

If the friendly troops are above the gun, *subtract* the V. I. between the gun and our own troops from the trajectory height.

The result is the clearance in meters.

If our own troops are below the gun, *add* the V. I. to the trajectory height.

The result is the clearance in meters.

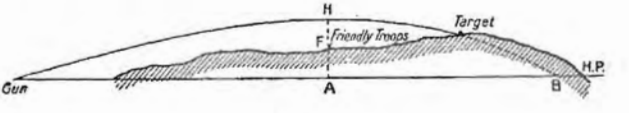


Fig. 87.

HA = height of trajectory above HP.
FA = V. I. between our own troops and gun.
Clearance = HA — FA.
= HA — V. I.

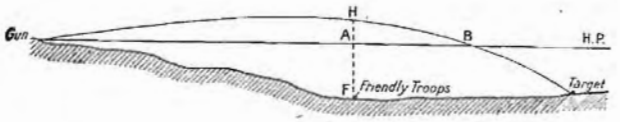


Fig. 88.

HA = height of trajectory above HP.
FA = V. I. between our own troops and gun.
Clearance = HA + FA.
= HA + V. I.

Case II.

Where the trajectory as it passes over our own troops is *below* the horizontal plane through the gun position.

Rule :

Find the depth of the trajectory at the range to our own troops below the horizontal plane through the gun position.

(This is done by finding the equivalent range and using the Table of Ordinates.) Table 6, Appendix III.

Subtract the depth of the trajectory from the V. I. between the gun and our own troops.

The result is the clearance in meters.



Fig. 89.

HA = Depth of trajectory below HP.
FA = V. I. between our own troops and guns.
Clearance = V. I. — HA.

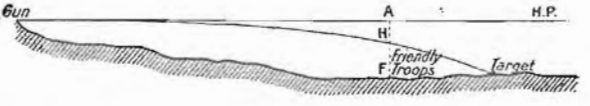


Fig. 90.

HA = Depth of trajectory below HP.
FA = V. I. between our own troops and guns.
Clearance = V. I. — HA.

Clearance may also be found by using the Trajectory Graph. (See Appendix V, part. 3.)

This method is much shorter and mistakes are less liable to be made.

(B) Where fire is being carried out as described in paragraph 26, clearances can be found as follows :

(1) Determine the range and Q. E. to our own troops.

(2) Obtain the range, V. I. and Q. E. to the target.

(3) Find the clearance of the center shot of the trajectory over the friendly troops *in meters* by the following formula :

$$\text{Clearance} = \frac{\text{Range to FT} \times (\text{Q. E. to target} - \text{Q. E. to FT})}{1000}$$

Clearing Obstructions.

34. In all cases where an obstruction exists between the gun and the target, it is necessary to ensure that the shots will clear the obstruction before opening fire.

Case I.

When the obstruction is visible and close to the gun. This method can be used when the obstruction is not more than 100 meters from the gun. Lay the gun with the correct elevation to fire on the target and look through the bore. If the axis of the bore clears the obstruction it is possible to fire on the target.

Case II.

When the obstruction is visible but is more than 100 meters from the gun. Lay the gun on the target. Set the sight at the range to the obstruction. If the line of aim now clears the obstruction it is possible to fire on the target. If the line of aim passes very close to the obstruction the lower shots of the cone of fire will strike the obstruction.

Case III.

When the obstruction is invisible.

(*a*) By profile. Construct a profile along the line of fire on the same scale as the trajectory chart. Superimpose the trajectory chart on the profile and see if the required trajectory clears the obstruction.

(*b*) By determining the height of the ordinate of the trajectory at the range of the obstruction by methods given on pages 183 and 184, substituting obstruction for our own troops. The clearance must be equal to at least one half of the height of the cone.

The Table of Ordinates is the trajectory table for positive quadrant elevations. It is compiled as follows

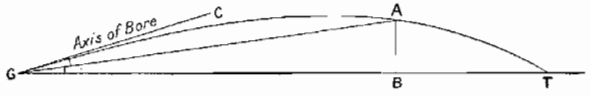


Fig. 91.

To find the height of the trajectory at a distance GB when firing at a range GT.

By definition, angle AGC = T. E. for range GT.

Assuming the rigidity of the trajectory.

By definition, angle AGC = T. E. for range GA
= T. E. for range GB

(since GA = GB approximately the angle AGB being small).

But angle BGA = angle TGC — angle AGC.
= T. E. for range GT — T. E. for range GB.

Now applying the mil formula :

$$M = \frac{V.\ I.}{H.\ E.} \times 1000 \text{ and so } V.\ I. = \frac{M \times H.\ E.}{1000}$$

and remembering M = angle BGA
V. I. = AB
H. E. = GB

the clearance AB

$$= \frac{(\text{T. E. for range GT} - \text{T. E. for range GB}) \times GB}{1000}$$

Example : To find height of 1700 meters trajectory at 1000 meters.

T. E. for 1700 = 45
T. E. for 1000 = 18

$$AB = \frac{(45 - 18) \times 1000}{1000}$$

$$= \frac{27 \times 1000}{1000}$$

= 27 meters.

Table of Ordinates gives 26.7 meters.

To find the depth of the trajectory below the horizontal plane through the gun position at a distance GB when firing with a quadrant elevation = angle BGC.

By definition, angle BGC = Q. E.

By definition, angle AGC = T. E. for range GA
= T. E. for range GB

(since GA = GB approximately).

But angle BGA = angle BGC + angle AGC.

Now applying the mil formula :

$$M = \frac{V.\ I. \times 1000}{H.\ E.}$$

and remembering M. = angle BGA
V. I. = AB
H. E. = GB

$$\text{Then AB} = \frac{(Q.E. + T.E. \text{ for range GB}) \times GB}{1000}$$

Example:

Supposing a negative angle of Q. E. of 20 mils.

To find depth of trajectory below horizontal plane at a distance of 1000 meters.

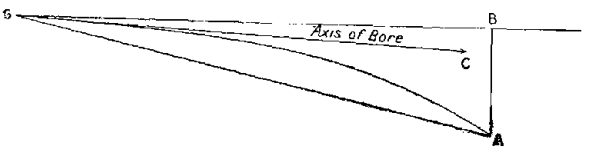


Fig. 92.

Then T. E. for 1000 meters = 18 mils.

$$AB = \frac{(20 + 18) \times 1000}{1000}$$

$$= 38 \text{ meters.}$$

This value is not computed in the Table of Ordinates.

In addition, all graphs and other aids to determine clearances without calculation are based on these Trajectory Tables. (See Appendix III and Appendix IV.)

Night Firing.

35. In trench warfare harassing fire by machine guns takes place usually at night, special emplacements being prepared and used for this purpose. Firing at night is done for two reasons :

(a) *Because the enemy is more vulnerable at night.* — His working parties are mending their barbed wire entanglements which have been broken down by our patrols or our artillery; their ration parties are on the move; relief generally takes place at night; and in fact, everyone is taking advantage of the possibility that cover from view may be cover from fire.

(b) *At night, though the flash of the machine gun is more visible, it is harder to locate.* — No reference objects can be seen, and ranging is practically impossible. So the enemy can only get direction roughly, and the first intimation that he will get that his range is correct is the silencing of his adversary's gun.

Shoots. — Two or three times a week, usually during the occasion of an enemy relief, the artillery carries out organized shoots on certain areas in the enemy's lines. Machine guns co-operate in this and make it their duty to see that every nook and cranny is heavily searched with fire. The artillery program extends over four or five hours, bursts of fire being opened at irregular intervals. Machine guns fire for longer intervals, and not necessarily only at the same time as the artillery. The object of this is to catch those who venture out between bursts and cause others to stay down under cover during the period of the shoot.

The moral effect of these shoots seem to be very great. As many machine guns as possible should co-operate; eight guns should be considered as an absolute minimum in a *brigade* sector.

Preparations. — For firing at night careful preparation should be made a day or two beforehand in getting everything ready. The maps of the enemy's positions must be closely studied; all necessary observation for locating reference objects and targets should be done by day; ammunition and other supplies that are neces-

sary should be gotten up and placed near at hand. Machine gun officers commanding organizations should keep in close touch with the artillery and co-operate with them on every possible occasion. Unless machine gun commanders do this, they will not know all of the plans of the artillery, and sooner or later they will be called upon to do something for which they have not planned, and disaster will result.

Targets. — In planning for and in carrying out night firing, attention should be paid to the following points :

(*a*) Sweeping fire should be brought to bear upon wire entanglements and parapets of a trench at short and medium ranges so as to catch working parties and sentries. Special attention should be devoted to those parts that have been damaged during the day.

(*b*) Search places where the enemy is digging roads, tracks and tramways. Pay special attention to new work. Concentrate on enemy dumps, crossroads and headquarters.

(*c*) At distant ranges where the gradient of the bullet is 1 in 4 or less, communication trenches can be fired into very effectively

(*d*) Where it is possible, always engage enemy artillery, especially sniping guns pushed well forward.

(*e*) Do not engage enemy aircraft at night unless you are especially detailed for the purpose.

Apparatus Used. — When machine gun fire is carried out by night, the gun position must be fixed by day, and a post at some known direction from the gun position must be placed in the ground by day, at dawn or at dusk; it is usually impossible to do these things with accuracy after dark. After dark, the post must be replaced by some illuminated aiming mark.

Experiments with aiming marks covered with luminous paint have not proved successful. Even on a dark night such aiming marks require very frequent exposure to artificial light in order to retain the necessary luminosity, and even then afford no definite point of aim. Another objection is that such aiming marks cannot be seen at all in the "half-light" of dawn or dusk, or on a moonlight night.

Lamps containing oil burners or candles are a con-

stant source of trouble because the lamp must be lighted before, and extinguished after each target is engaged. If this is not done, the mark becomes obscured by the smoke of combustion, and in the case of a candle, the lamp becomes hot and the candle melts.

The most satisfactory aiming mark is an electric box as described in Appendix VIII. The light can be switched on from gun position and can be put out as soon as the firing is completed. The box is easily carried and is not likely to break during transport. The aiming mark is 12 inches wide, and therefore, when placed 100 inches from the gun, gives a traverse of four divisions approximately on the Hotchkiss machine gun. This is a great advantage over "point" aiming marks where the limit of traverse has to be guessed. With this aiming box, used in conjunction with a luminous front sight and a luminous rear sight, such as we have on the Hotchkiss gun, any type of indirect fire, including barrage fire can be performed by night with accuracy.

An electric torch is essential at the gun for reading divisions on the traversing scale and bubble readings on the gun level, when laying the gun. The torch must be dimmed so as not to cause the position to draw hostile fire. The best way to dim the torch is to paint it with red enamel. When dry, scratch the surface of the enamel just sufficiently to allow a faint glow of light; just enough to read print in the dark when the bulb is held three inches away from it.

Elevating and traversing clamps, when set correctly, automatically ensure the safety of our own infantry, and thus diminish the strain on the firer.

Flash arrestors have been produced which effectively conceal the flash from view, but they invariably disperse the cone to some extent.

On the other hand, it has been proved experimentally that screens of wet canvas or wet sand bags have no effect on a cone which is fired through them, and yet effectively screen the flash. Care should be taken to screen the flash at the sides as well as at the front. The British use a canvas screen with an additional curtain of canvas which can be placed at the part through which the shots pass. This is so that it can be replaced when the curtain is riddled. Flaps extend out on either side

of the gun. One form is as follows : ten feet long, four feet high at one end tapering down to three feet at the other. It is held upright by four stakes, the distances between the two center ones being two feet. When firing through the screen the lower side flap is placed up-hill and away from the enemy, so that the light will not be reflected toward him. Before dawn the screen must be taken down so the position will not be discovered.

The prismatic compass should be used when no other

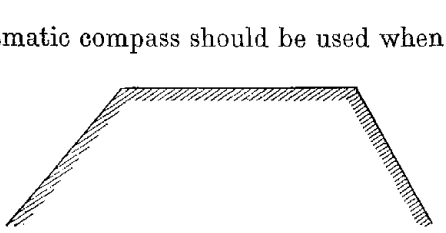


Fig. 93.

means for finding direction is available, as it is only accurate to within 10 or 20 mils. For marking the position of the axis of traverse of the gun, when the gun and tripod are removed a flat topped peg is driven so as to allow a compass reading to be taken from the gun position. In the British service a compass tower is placed upon the tripod and the compass rested upon this in order to get the direction of fire. Care is taken that the compass is more than 14 inches directly above any iron which would otherwise deflect it.

Methods of Laying. — Three cases will usually occur:

(1) The gun is brought up and laid at dusk; then left in position ready for firing at night.

(2) The gun is brought up and laid at dusk; removed for other work, and brought back again after dark.

(3) The gun is brought up for the first time by night; and therefore laid during darkness.

Case I.

Procedure by day. — (*a*) Obtain range to target and lay gun on it. If the target is not visible indirect means must be employed to lay the gun.

(*b*) Put a sentry over the gun to ensure that it is not touched.

Procedure by night. — (*c*) Send out a spare number with an auxiliary aiming mark or night-firing box. Adjust the rear sight and the position of the auxiliary aiming mark until the sights are aligned on it, taking care that *the direction and elevation of the gun are not altered.*

It may be possible to put out an auxiliary aiming mark by day unseen by the enemy. If it is not possible to set an auxiliary aiming mark at all, maintain direction and elevation by the traversing scale on the tripod and the gun level.

If several targets are to be engaged, a separate auxiliary aiming mark must be used for each, and the respective readings of the rear sight noted for each auxiliary aiming mark.

An alternative, if no auxiliary aiming mark can be put out, is to lay the gun on each target in succession by day, and note the respective readings of the traversing scale on the tripod and the gun level. At night the gun can be laid on any desired target by means of the traversing scale and the gun level, using the dimmed electric torch to get accurate settings.

(*d*) Adjust screen so flash is hidden and aiming mark visible.

(*e*) Direction and elevation are maintained by relaying on the auxiliary aiming mark providing one is at hand. Otherwise the readings on the traversing scale and gun level must be frequently checked between bursts.

Case II.

Procedure by day. — (*a*) Obtain range to target and lay gun on it. If target is not visible indirect means must be employed to lay the gun.

(*b*) Put out an auxiliary aiming mark. Take care not to alter the direction or elevation of the gun. Adjust the rear sight and the position of the auxiliary aiming mark until the sights are aligned on it.

In soft ground it is advisable to place the auxiliary aiming mark some distance from the gun, say 1000 inches, so that errors in elevation due to possible sinking of the gun during replacements may be corrected. If no auxiliary aiming mark can be put out, note the reading on the traversing scale and the gun level. At night lay the gun at these corresponding readings.

(*c*) Assuming that the auxiliary aiming mark is in position, next note the reading on the rear sight.

(*d*) Mark the exact position of the tripod feet on the ground, and note the height of the tripod.

The height of the tripod can be measured by driving a peg in the ground under the pivot and measuring the height of the top of the pivot above the ground.

(*e*) The gun and tripod can now be removed.

Procedure by night. — (*f*) Mount tripod in exactly the same position, and at the same height as before and replace the gun.

(*g*) Adjust the rear sight to the reading noted in (*c*) and lay the gun on the auxiliary aiming mark (which must be illuminated).

(*h*) The gun is now laid on the target. Direction and elevation can be maintained by relaying on the auxiliary aiming mark.

(*i*) Adjust the screen so that the flash is hidden but the aiming mark visible.

Case III.

Procedure by day. — (*a*) Drive in a peg, about six inches high, to mark position over which tripod will be mounted at night.

(*b*) Put in a second peg to give direction. This can be done by direct alignment if target is visible or by compass bearing.

The peg should be put out to a flank, or even in rear of the gun position if desirable. It would then be used in the same way as a reference object and direction obtained by use of the traversing scale.

(*c*) Obtain angle of Quadrant Elevation.

Procedure by night. — (*d*) Mount tripod over peg (*a*); pivot of tripod must be exactly over the peg.

(*e*) Place a luminous auxiliary aiming mark or night firing box on peg (*b*); this will give direction.

If a reference object is sufficiently near or distant enough to be visible to the gunner by moonlight or by dropping a "Very" light beyond it, this may be used if peg (*b*) has not been placed. Otherwise the direction must be gotten by compass.

(*f*) Put on Quadrant Elevation by most convenient method.

(*g*) Put up screen so as to obscure flash but still leave aiming mark visible.

(*h*) Maintain direction and elevation by auxiliary aiming mark.

Use of above methods during relief. — The above methods can be adapted to the relief, during darkness, of a gun laid on a definite target, by another gun to be laid on the same target.

If the outgoing gun has been maintaining direction by the traversing scale alone, an auxiliary aiming mark must be placed out before the gun is removed. The incoming gun can then obtain direction from the auxiliary aiming mark, which may be put either inside or outside if the emplacement is a closed one.

If the tripod of the outgoing gun can be left in its place, and the tripod of the incoming gun turned over in exchange, an auxiliary aiming mark need not be placed out, as the incoming gun can be laid on the same traversing scale reading.

Instruction in night firing. — In order to get accurate results in night firing, all of the methods described above should be practiced as a drill many times in the training areas in rear of the trenches. Firing at night should then be done at machine gun targets from time to time so as to note the progress which is being made in the instruction. Accuracy and great care in all the details are necessary in order to get successful results in this class of firing.

Until an organization is familiar with how to lay the guns for indirect fire by day, satisfactory results in night firing cannot be looked for.

Notes on night firing. — (*a*) Belts should be filled as emptied, and all the usual rules for firing by day carried out.

(*b*) Sentries on duty are responsible for the firing of the gun during their tour. They should be given a definite number of rounds to fire. When it has been impossible to put out illuminated aiming marks, a non-commissioned officer should superintend the firing.

(*c*) Any distraction, such as the sending up of a

"Very" light, or a burst of artillery or machine gun fire should be taken advantage of to hide the flash, or sound, of the gun.

Artillery cannot accurately locate a gun at night; they can only search for it. It will deceive them, to cease firing when shells fall some distance from the gun position, and to fire faster if they get near.

(*d*) Where an S. O. S. signal only indicates a raid, the gun should continue firing as before. But, at the least sign of an attack developing, the gun should be taken back to its "battle position" and laid ready to fire. Guns taken from positions within 800 meters from the front line must always be in their "battle position" during morning and evening posts.

(*e*) Always tell a firer what kind of a target he is engaging, so that by using his imagination properly he may make his indirect fire as effective as possible.

(*f*) Illuminated aiming marks placed at long distances from the gun are likely to be accurate; but the extra illumination necessary is liable to make them visible to the enemy. For this reason aiming marks should never be placed more than 10 or 20 meters from the gun. Illuminated aiming marks should always be switched off when not in use, or when hostile aircraft are overhead.

(*g*) When the firing is done from positions some distance behind our front line, and especially when it is reached by overland routes, special precautions must be taken against endangering friendly troops who are passing near the gun position.

This is done by posting sentries or by wiring in the danger area. The safety of working parties and patrols in No Man's Land must be secured by liaison with battalion headquarters.

(*h*) Records of all night firing must be kept on the sheets provided for this purpose and turned in to the company headquarters by the time designated in regimental and company orders.

Searching Reverse Slopes.

36. In order to search a reverse slope effectively, the gun must be placed at such a distance from the crest

that the fall of the bullet is steeper than the slope of the ground.

To determine the position at which the gun must be

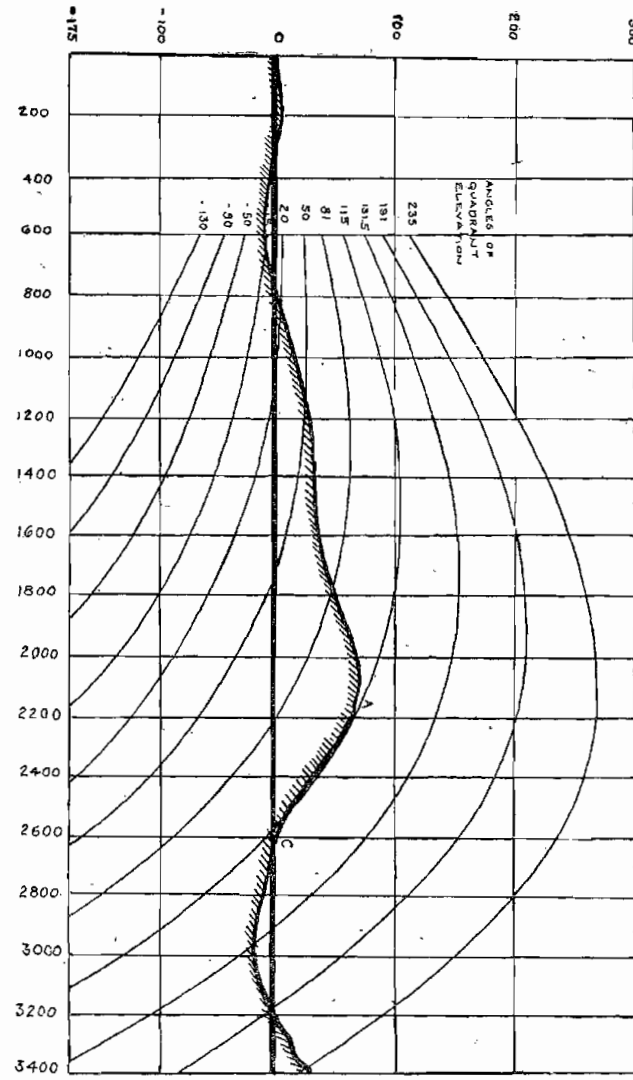


Fig. 94.

placed to search a reverse slope, make a profile of the ground from the reverse slope back through such a position where it is believed that a gun can be satisfactorily placed. The profile must be made on transparent tracing paper with the same horizontal and vertical scale as the trajectory graph which is issued to machine gun organizations. Place the profile of the ground over the trajectory graph and move it about until a point is found on the profile where the gun can be placed and the trajectories strike the reverse slope at an angle greater than the slope of the ground. Mark this point on the profile. Referring back to the map from which the profile was taken, the point can then be located where a machine gun may be placed to fire on the reverse slope effectively.

Knowing the gun position O, and the position and height of the top of the slope A, find by the ordinary methods of indirect fire, the direction and elevation necessary to hit the top of the slope A C.

As the searching of reverse slopes is just a special type of indirect fire, searching and traversing will be employed as usual, with the exception that searching will be very restrained.

If AB represents the length of the beaten zone on the horizontal plane, AC will represent the length of beaten zone on the slope AC. In all cases AC will greatly exceed AB, and consequently two or three turns of the elevating wheel will cover a target several hundreds of yards in length.

$$AC = AB \times \frac{\text{angle of fall}}{\text{angle of fall} - \text{angle of slope}}.$$

The final gun position may be an impossible one, say,

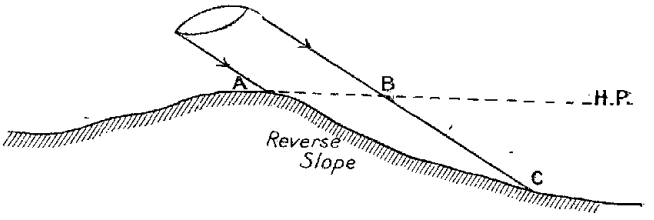


Fig. 95.

in a river or marsh. In such a case a gun position should be selected further away from the slope rather than nearer to the slope.

By moving further back the range is increased, and consequently the angle of fall of the bullet, but by going nearer to the crest the angle of fall is decreased, and it may become impossible to search the reverse slope at all.

Fire should be directed at the top of the target, which may, or may not, be the crest of the hill. If the top of the target is not the top of the hill, calculations should be made to see if the hill will be cleared or not. If the crest is not cleared, the gun should be taken back to such a range that the obstruction will be cleared.

Graph for Searching Reverse Slopes.

(For graph see Appendix VII.)

The foregoing procedure of searching a reverse slope assumes that a gun can be moved about on the terrain to engage a particular target. It is more probable that a machine gunner will be called upon to determine whether various reverse slopes within range of a gun already in position can be searched with effect.

The Graph for Searching Reverse Slopes enables one to approach the problem from either standpoint.

The graph comprises a series of curves representing various reverse slopes of from 1 in 100 to 15 in 100. Ranges are represented by vertical lines. The points at which the slope curves cut the thick central horizontal line indicate the ranges at which an angle of impact of 45 mils is obtained on the various slopes with the gun and target on the same level. The diagonal lines represent the angle of impact when firing at any range at any vertical interval on any slope.

The best angle of impact for effective searching is one that approximates 45 mils (150 min.). Any angle between 30 mils and 60 mils (100 and 200 min.) is suitable, and angles between 60 mils and 75 mils (200 and 250 min.) also give good results.

When reading the graph it should be borne in mind that the slope curves represent an angle of impact of

45 mils throughout their length *reading along the curves.* Also, the diagonal lines, representing the angles of impact, give the angle when *reading along the vertical range lines.*

(a) *To determine the searching powers of a gun in position.*

(1) Find the point at which the slope curve crosses the vertical range line.

(2) Then if the gun is below the crest of the target move *down* the range line from this point to the required vertical interval. If the gun is *above* the crest move *up* the range line.

(3) The angle of impact obtained by firing at that range with that vertical interval on that particular slope can be read off along the diagonal lines.

Example : Hotchkiss Machine Gun, Ball D Ammunition.

A reverse slope of 4 in 100 is 2000 meters from a gun, the crest of the slope to be searched is 40 meters above the gun. Can the slope be successfully searched from this gun position?

Find the vertical line representing the range and note where it is cut by the "4" slope curve. From that point (the gun being 40 meters below the crest) move down the *vertical line 40 meters.*

The angle of impact (60 mils) can then be read off along the diagonal lines. The angle of impact being within the searching limits, this target can be engaged with success.

(b) *To find the best position from which to search a reverse slope.*

(1) Find the point at which the particular slope curve cuts the central horizontal line. This gives the best range from which to engage the slope if gun and crest are on the same level.

(2) From the map find the vertical between the crest and the gun.

(3) If the crest is above the gun move up the *curve* to the required vertical interval and read off the range along the vertical lines.

Example : Hotchkiss Machine Gun, Ball D Ammunition.

To search a reverse slope of 5 in 100.

The graph shows 1825 meters to be the most suitable range from which to search the slope.

Measuring back 1825 meters on the map, the crest of the slope is found to be 27 meters above the gun. So move up the *curve* to this vertical interval and the final range at which the gun should be placed is found to be 1930 meters.

The quadrant elevation should then be determined in the usual manner.

Errors.

37. The most probable errors which affect indirect laying have been described in the preceding analysis. These errors are now summarized in order to assist the Machine Gun Company Commander to draw up his training program.

Errors on the part of officers.

(1) Inaccurate map work.

(2) Inaccurate compass work, which may affect both the fixing of the gun position and laying out the line of fire.

(3) Choice of reference object too near the gun position.

(4) Inaccurate calculations and failures to allow for atmospheric changes.

(5) Use of instruments such as clinometers, angle of site instruments, when not in accurate adjustment, and of worn-out material, such as barrels, etc.

Errors on part of personnel.

(1) Inaccurate aiming.

(2) Inaccurate placing of elevation on the gun.

(3) Inaccurate use of traversing dials, zero stakes, aiming stakes and aiming marks.

(4) Failure to "oil up", etc., during a barrage.

(5) Firing too many cartridges in a burst.

Modification in Equipment.

38. 1. *Safety Devices.*

In order to secure the safety of the troops, over

whose heads fire is being directed, it is most important to ensure the rigidity of the mounting.

Without this, traversing and elevating blocks do not prevent fire becoming dangerous if the tripod sinks, because these form part of the tripods. This rigidity is obtained :

(1) By careful construction of firing platforms.

(2) By the use of "T" bases.

The latter is much preferable.

In the Appendix is shown a type of "T" base easily made, but which must be adjusted to each tripod.

A type of "T" base is shown which is :

(1) Collapsible and therefore more easily carried, and less likely to render the carrier conspicuous.

(2) Adjustable.

After the tripod has been placed on the "T" base, which in soft ground should be reinforced by a layer of sandbags underneath, a few sandbags are placed across the legs.

Provided that a rigid tripod bas been obtained, traversing blocks prevent the firer swinging his gun beyond the prescribed limits of traverse.

At the same time elevating blocks prevent the fire becoming dangerous by depression of the gun.

2. In order to obtain the accuracy of direction now required for indirect fire, it is necessary to be able to lay off to 3 mils. This cannot be done by the graduation plate, and is done by :

(1) The "T" shaped zero stake. (See Appendix VI, Plates 1 and 2).

This is graduated in inches, and, when placed 9 1/4 yards from the gun :

1 inch represents a traverse of 3 mils.

At this range the zero stake gives a traverse of 54 mils on either side. It cannot be used at night.

3. Signalling shutters have been often used for controlling the fire of a battery.

4. The introduction of a rotatable dial much simplifies laying off angles, as it overcomes the difficulties of addition and subtraction, over which mistakes have been easily made in the past.

5. The necessity of accurate indirect fire by a large

number of guns renders necessary gun levels or clinometers on a scale of one per gun.

6. Some form of large protractor in the shape of a sector of a circle with an angle of 500 to 800 mils.

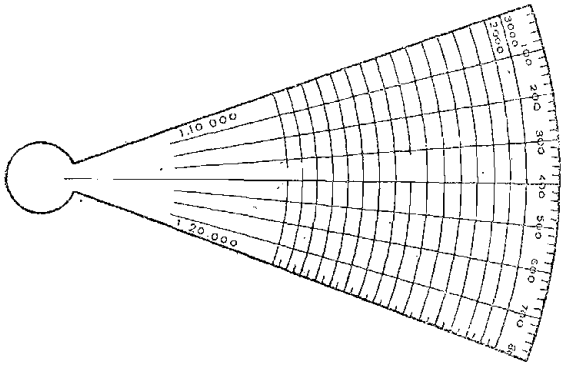


Fig. 96.

Barrage Fire.

39. Barrage fire by machine guns is the fire of a large number of guns acting under a centralized control, directed on to definite lines or areas, in which the frontage engaged by a gun approximates 40 meters.

Barrage fire is carried out by :

(1) Artillery.
(2) Trench Mortars.
(3) Machine Guns.

The best results in any operation can only be obtained by conceiving the barrage plan as a whole and allotting to the different weapons tasks which their characteristics render them most fitted to carry out.

There are four types of barrage fire :

(1) Preliminary bombardment.
(2) Creeping barrage.
(3) Standing barrage.
(4) Back area barrage.

The "harassing fire" of machine guns forms an integral part of the preliminary bombardment, and the object of the fire is to :

(1) Lower efficiency of enemy working parties.
(2) Increase difficulty of transport of munitions and supplies.
(3) Cause deterioration of enemy morale.

This object can be obtained by engaging the following targets :

(*a*) Targets previously engaged by the artillery more especially wire-entanglements and defenses that have been damaged.

(*b*) Communication trenches which can be taken in enfilade.

(*c*) Routes, tracks taken by ration parties and reliefs, dumps, tramways, etc.

(*d*) Certain field battery positions which may have been erected within range of machine gun fire.

By close cooperation between machine guns and other arms it is possible to drive the traffic from overland routes into the trenches, thereby causing :

(*a*) Congestion and delay.

(*b*) Casualties from the artillery fire on the communication trenches from their enfilade guns.

During the period more closely approaching zero day when the enemy defenses have been knocked about and the morale of the garrison has been shaken, the plan of concentrating the guns of one battery on to carefully chosen centres of activity, and opening rapid fire for a short period is effective. This type of fire is known as "area shooting". This treatment should be applied to different points at irregular intervals.

40. The objects of barrage fire on zero day are to :

(*a*) Prevent the enemy manning his parapets and installing his machine guns.

(*b*) Interfere with the effective use of machine guns in rear.

(*c*) Prevent supplies of food and ammunition being brought up.

(*d*) Prevent reinforcement of the garrison.

(*e*) Destroy morale.

(*f*) Place a protective barrage at every definite stage of an advance.

(*g*) Save our own troops at all times from casualties

by keeping down the fire of the enemy infantry, machine guns, etc.

By these means Infantry Battalions are enabled to :

(*a*) Advance and seize objectives previously allotted.

(*b*) Organize for defense ground won during the delicate period when troops are suffering from nervous and physical strain, the loss of leaders and men, and the unfamiliarity of their surroundings.

These objects are obtained by creeping, standing and back area barrages carried out by artillery, trench mortars, and machine guns in conjunction.

41. In order to enable the machine guns to carry out the rôle allotted to them in the barrage scheme, the machine gun barrage must fulfil the following conditions :

(1) It must be equally applicable to the "set piece" where the "time factor" is relatively unimportant, and to the later stages of large operations involving the forward movement of platoons to new positions from which to create a barrage, in which case the "time factor" becomes of paramount importance.

(2) It must apply also to conditions of semi-open and open warfare, becoming relatively more important as the troops get out of range of the bulk of their artillery.

(3) It must be flexible, i. e., it must be possible to create a zone of intense machine gun fire on any area with accuracy and rapidity.

(4) It must be capable of being taught and carried out as a drill.

These conditions can only be obtained by simplicity of :

(*a*) Organization.
(*b*) Laying.
(*c*) Fire control.
(*d*) Drill.

42. *Organization of Guns for Barrage Fire.*

(*a*) Guns for barrage fire are organized into groups and platoons. The group normally consists of between 12 and 24 guns. If the group is considerably larger, it will be necessary to divide it into sub-groups, each

under a sub-group commander. The group is commanded by the Group Commander, who is a Battalion Commander.

His normal position is at the Brigade Headquarters in whose area he is operating. He is assisted by an officer. Generally each Brigade has one group of barrage guns.

The group is divided into platoons of 4 guns.

Platoons are lettered from the right A, B, C, etc., throughout the Division front; in the case of a forward move these become A2, B2, C2, etc., for the first move; A3, B3, C3, etc., for the second move, and so on.

(*b*) The duties of the Group Commander are :

(1) To carry out the orders of the Division Machine Gun Officer.

(2) Distribute the platoons of his group.

(3) To make all preliminary preparations, which include estimates of small arms ammunition, oil, water, etc.

(4) To make preparation for the formation of dumps and communications.

(5) Issue operation orders which deal with the location and tasks of each platoon. The task is in the form of a table showing the times, targets, rates of fire for each lift, and any moves. These orders must be issued in ample time for the Platoon Commander to make his calculations and send these to the Group Commander to check.

(6) To provide himself with a fighting map showing zero lines and tasks of each platoon. (See Appendix II, Part. 5.)

(*c*) The duties of the Platoon Commander are :

(1) To lay out the zero lines of his platoon in the position ordered by the Group Commander.

(2) To carry out orders of the Group Commander detailed above in (3), (4), and (5).

(Specimen of Fire Organization Orders, See Appendix II, Part 2.)

(3) To issue a Barrage Chart to each Gun Commander. (See Appendix II, Part 3 *a*, *b*, *c*.)

(4) To provide himself with a fighting map showing zero lines and tasks of his platoon. (See Appendix II, Part 4.)

(5) To see that every "Commander" in his platoon, including himself, is provided with an understudy.

(6) To supervise the fire of his platoon.

(*d*) The duties of the Gun Commander are :

(1) To control the fire of his gun as ordered on his gun chart.

(2) To control the fire as taught in "Barrage Drill".

(3) To see that the correct elevation and direction is *placed* and *maintained* on his gun.

(4) To watch for signals from the officer controlling the fire.

(5) In the event of a barrage not on the chart being ordered, to see that the correct fire order is passed down, and that his gun is correctly laid before repeating "No. ... gun, ready".

These duties can only be performed in toto when the tactical situation permits. It will often be impossible to prepare elaborate fighting maps and charts.

43. *Laying and Fire Control.*

Although machine gun barrage fire can be carried out by controlling the fire of each gun singly, experience has shown that the barrage so produced is not flexible, that calculations are laborious, and control difficult.

The introduction of the Platoon System has rendered it possible to produce a flexible barrage, easily controlled and obtained by the aid of extremely simple calculations. This is the normal method of producing machine gun barrage fire.

44. *Rates of Fire.*

(1) To prevent waste of small arms ammunition, to ensure time for relaying and oiling (thereby prolonging the life of the gun), and to enable estimates of small arms ammunition to be made in advance, rates of fire must be laid down for rigid observance by each gun.

(2) Normal rates of fire are :

(a) *Slow fire.* — 60-75 rounds per minute fired in bursts of 5 to 10.

This is the rate for long period barrage fire.

(b) *Medium fire.* — 125-150 rounds per minute. This is the rate that can be used to speed up slow fire for short periods. It can be maintained for about half an hour, and should not be attempted for a longer period.

The gun barrel should be frequently cooled by wet sand bags or by immersing the end of the barrel in a pail of water, care being taken that escaping steam will not give away the gun position.

(c) *Rapid Fire.* — 250-300 rounds per minute. This rate is used in response to S. O. S. calls, but should only be maintained for a few minutes, after which the fire should be reduced to medium or slow rate.

(d) *Harassing Fire.* — 1000 rounds per hour. This may be carried out at slow, medium, or rapid rates.

(3) Before ordering rates of fire, the following factors must be considered :

(*a*) Tactical requirements of the barrage.

(*b*) Frontage per gun.

Obviously it will be necessary, if the concentration of guns is thin, to fire at a more rapid rate than if the concentration is thick, in order to produce the same result.

(*c*) Time during which the barrage is to be fired.

(*d*) Number of boxes of ammunition per gun available.

(*e*) Wear and tear of guns.

(*f*) Rate at which belts or clips can be filled if necessary.

It is the belt filling problem which imposes the "Slow Rate of Fire" for all long period barrages, and it is advisable to increase the number of belts per gun for large operations.

45. *Life of Barrels.*

The most important factors which affect the life of the barrel of a water-cooled gun are :

(1) The temperature of the water.

(2) Oiling.

(*a*) With the rate of fire approximating 1000 rounds per hour, fired intermittently, frequent oiling of the barrel, the water below boiling point or only boiling for short periods, the life of the barrel is 20000 to 25000 rounds.

This corresponds to "Harassing Fire".

(*b*) With a rate of fire exceeding 3500 rounds per hour, fired continuously, frequent oiling of the barrel, the water boiling for long periods, the life of the barrel it 12000 to 15000 rounds.

This corresponds to normal forms of barrage fire and S. O. S. calls.

(*c*) A failure to oil the barrel in both the above cases at regular intervals appears to decrease the life by 3000 to 4000 rounds.

The loss of range due to worn barrels is not at present definitely known, but experiments have shown that the lengths of the beaten zones become nearly twice those given in the tables, and that the loss apparently does not exceed 5 per cent of the range.

Communications.

46. No proper fire control is possible without a comprehensive system of telephonic communications. This necessitates the most careful co-ordination of the machine gun signalling personnel available.

System of communications.

(*a*) The machine gun companies attached to infantry battalions or regiments must be connected with the headquarters of these units.

(*b*) Machine gun battalion commanders must be connected with company commanders. The latter in turn must maintain communication with platoon commanders either by telephone or visual signals. The headquarters of the battalion commander will ordinarily be at brigade headquarters. He will have communication with Division Machine Gun Officer over the main line of communication to the division.

CHAPTER IV.

INSTRUMENTS

47. For the proper observation and control of the fire of modern arms, it is necessary to use certain instruments. The instruments discussed in these notes are those required for observation, direction and control of the fire of the rifle and machine gun. Conditions of field service require that these instruments be few in number, rugged in construction, and simple to use. In general, the field glass is required for observation of the terrain and the effect of fire; some form of instrument, such as the mil scale, is required for determining angles; and the range finder is required, for determining ranges.

Field Glasses.

48. The binocular glass consisting of two complete optical systems, connected by a rigid or hinged frame, is universally used for military purposes. However, if one of the two optical systems should be damaged, or if parallelism of the two systems should be destroyed by accident to the frame or displacement of the lenses or prisms, it is well to remember that the field glass can still be used effectively as a monocular.

The two types of field glasses in common use are the Galilean glass and the Porro prism glass.

The Galilean Glass.

A. The Galilean glass has convex objectives and concave eyepieces. It is of low power (magnifying from 2 to 5 diameters) but requires careful focusing. It is a comparatively inexpensive instrument.

The type A and type B glasses of the Signal Corps are examples of this form of field glass. Figure 97 shows diagramatically the arrangement of lenses in the Galilean glass.

In this field glass the rays from an object are converged by the object glass (O), and would normally focus at the focal plane (C), and there form the inverted image (*b a*) were it not that the double concave eye glass or ocular (D) is so located in the barrel of the glass as to intercept the pencils before they are focused. This double concave eye glass diverges these pencils and forms a magnified erect image *a' b'* apparently at E.

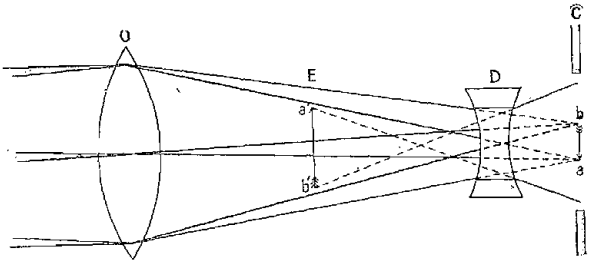


Fig. 79.

Due to the diverging action of this concave eye lens, the cone of the pencils entering the eye is larger than the pupil of the eye, and therefore only a small part of the field gathered by the object glass is utilized, which causes field glasses of this type to have comparatively small field of view.

In the Galilean type of field glass, the two optical systems are usually mounted rigidly and a single focusing screw moves both eye pieces in or out for adjustment of the focus only. The concave eyepiece lenses are quite large, and, for ordinary eyes, accurate adjustment for interpupillary distance is therefore unnecessary. This means that the two lens tubes do not have to be hinged so that their distance apart can be adjusted to correspond with the distance apart of the pupils of the eyes.

The optical principle of the Galilean glass makes is necessary to change the focus for maximum enlarge-

ment when viewing objects at different distances, unless these distances are several hundred yards or more. With this glass, the eye, by being strained can get a temporary focus with wrong adjustment of the eyepieces, but this is very hard on the eyes, and the glass may seem to go out of focus after a time, because of eye fatigue and inability to keep up the strain. For this reason, the focusing of Galilean glasses should be done carefully and in the following manner : start with the eyepieces well in; turn the focusing screw until the field is in apparent focus and then go on beyond about one turn of the screw. Then very slowly turn the screw back until the focus is obtained again. If the glass is the personal property of the user, it is well to put a mark on the barrel corresponding to the correct focus for a range of about 500 meters. It will then be correct for everything beyond that distance. If the user's eyes have markedly different optical characteristics so that the broad focus of this type of glass will not be approximately correct for each eye, he will have to obtain a glass of the prism type with separately adjusted eyepieces. However, there are glasses of the Galilean type, of foreign manufacture, with interpupillary adjustment and separately adjustable eyepieces and, if a glass of the Galilean type is preferred, it may be possible for one with abnormal eyes to obtain one of these foreign glasses.

The Porro Prism Glass.

B. The Porro prism glass has convex objectives and eyepieces and prisms for erecting the image and shortening the length of the glass. It can be built of the highest powers and has a practically universal focus.

In the astronomical telescope, which consists simply of a convex object glass and a smaller convex eyepiece, the image is magnified but is inverted. It is possible to erect this image by a system of erecting lenses, but this increases the length of the telescope and usually decreases the brilliancy of the image and the clearness of definition.

In 1850, Porro, a French engineer, discovered a combination of two prisms which, when inverted between the object glass and eyepiece of an astronomical telescope, showed the image erect or in its natural position. These prisms have an additional advantage; the ray is twice turned upon itself and the telescope can, in consequence, be shortened. Figure 98 shows the path of rays through the prisms, and the reason for the erection of the image is evident.

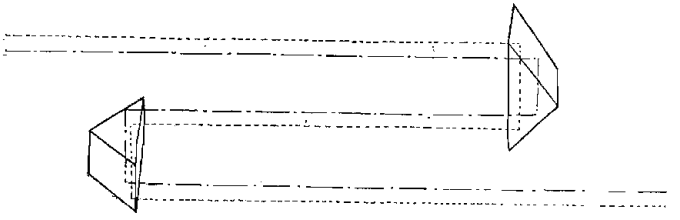


Fig. 98.

The Porro prism glass has two advantages inherent in the astronomical telescope. It is possible to get a large magnifying power combined with a large field of view. In addition, by the use of prisms, the glass can be reduced in size to very small dimensions. For these reasons, it makes the ideal glass for military purposes and most officer's glasses are of this type. The Signal Corps furnishes four glasses of this type, viz : Type C, 10 power; Type D, 8 power; Type E, 6 power; and Type EE, similar to Type E, but equipped with a mil scale in the field and with certain other constructional refinements. A special sight scale in addition to the mil scale has been applied to the type EE glass and will be discussed later.

The glasses of the prismatic type were, until a short time ago, invariably of foreign design. They are usually built with a jointed frame and can be adjusted so that the distance between the optical axes of the eyepieces can be made exactly that of the distance between the pupils of the user's eyes. There is a scale at the joint with figures 60 and 70 and intermediate divisions. The normal interpupillary distance is about 64 millimeters and this scale shows the distance between the optical axis of the eyepieces in millimeters. Many

glasses have an adjustable ratchet or stop which drops into a notch, and being once set for a certain interpupillary distance the glass can be opened until the stop drops into its notch and the interpupillary distance will be correct for the user. To determine interpupillary distance, point the glasses at the sky and open and close the joint until the field ceases to be two overlapping circles and appears to be one sharply defined circle. The interpupillary distance can then be read in millimeters from the scale at the joint. If you know this constant for your own eyes you can at once set it off on the joint scale of a strange pair of glasses, otherwise the determination must always be made and the glasses adjusted for interpupillary distance before attempting to use strange glasses.

All prism glasses have independent focusing arrangements for each eyepiece. In some types, both eyepieces focus with one screw and, in addition, one of the eyepieces has an independent adjustment. In other types, each eyepiece is independently adjustable and there is no common adjusting screw. An index is generally engraved on the barrel and the eyepiece screws in and out, a scale with a middle zero being engraved on its circumference. Each division of the scale corresponds to a movement in or out of 1/3 millimeter, the movement outward or lengthening the focus being indicated as + and the opposite movement being indicated as —. For a person with normal eyes a prism glass with eyepiece scales set at 0 is in focus for everything between about 16 meters and infinity. If the eyes are not normal, or, in any case with a new glass, each optical system should be focused separately on some object several hundred yards distant after the interpupillary distance has been carefully determined and adjusted. If the glass has the common adjusting screw and a scale on but one eyepiece, the eyepiece without the scale should be focused first and then the other eyepiece adjusted by turning it without touching the common adjusting screw.

A person with one or both eyes abnormal may instantly focus any prism glass if he remembers and sets off on the eyepiece scales the same readings that he uses on his own glasess.

Care and Preservation.

49. The ordinary military field glass is a rugged, serviceable instrument. Occasionally screws work loose, and all screws should be periodically tightened. In hot, moist climates there is a tendency for the Canada balsam cement between the lenses of the object glass to deteriorate, and this causes spots on the object glass but, unless the damage is extensive, the glass is still usable.

The majority of cases of damage to field glasses, especially those of the prism type, can be traced to the fact that they have been taken apart by their owners who have been unable to put them together again with the exact original adjustment. It is practically never necessary to open a pair of field glasses for cleaning or otherwise, and when it is necessary, the work should be done at a factory by an expert who has the proper tools to do the work.

If a glass has been damaged by a fall or blow, and a duplication of the image occurs, it is sometimes possible to correct this by seizing one of the lens tubes in each hand and, while looking through the glasses, cautiously twisting or turning the hands until the duplication disappears. It is never possible to entirely and permanently correct duplication by this means, and it is better to return the glasses to the makers for overhauling at the first opportunity.

The exposed surfaces of the object and eyepiece lenses should be kept clean by being occasionally wiped lightly with a soft clean cloth very slightly moistened with water or alcohol. The lenses can be scratched by dust or grit on the cloth if they are rubbed vigorously and, if alcohol is used, care should be taken not to get it on the lacquer of the frame and the lens holders.

Characteristics of a Good Field Glass.

50. The standards for comparison of field glasses are based on the capabilities of the unaided normal human eye. There are four properties, measurable by these

standards, that every field glass has, viz : power, light, field and definition.

Power. — The power of a field glass is defined as the ratio of the diameter of an object as seen through the glass to the diameter as seen by the unaided eye.

The power of a field glass can be determined with sufficient accuracy by focusing the instrument on a wall or, preferably, a range rod at least 200 yards distant. By looking at the object through the instrument with one eye and at the same time viewing the object with the other unaided eye, it is possible to make a comparison of the apparent length of height of the two images. The ratio of the two is the power of the glass.

The actual power of most glasses varies more or less from the power marked thereon, but it is in cheap glasses that the greatest discrepancy is found.

For the mounted man a glass of but 4 or, at most, 6 power can be used to advantage; on foot with free hand, instruments of not to exceed 10 power can be used. If more than 10 power is desired, a holder or tripod becomes necessary, and if the holder is intended to be portable a greater power than 30 is not practicable, as the movements of the air or the slightest touch of the hands sets up vibration that renders clear vision impossible.

Light. — The illumination of an object when observed with the unaided eye is impressed upon the retina with a brightness in strict proportion to that of the object itself. If an object be viewed under equal illumination conditions alternately with the unaided eye and with a glass, the brightness of the object seen with the naked eye may be represented by 1, while that of the image in the glass will generally differ, being more or less bright. Light is a function of the dimensions of the object glass, of the power of the instrument and of the dimensions and character of the media, such as prisms or erecting lenses, interposed between the object glass and eyepiece. There is no easy method of measuring this property except with special instruments but, in glasses of the same general type the light varies directly as the square of the effective diameter of the object glass and inversely as the square of the power.

Field. — The field of the human eye for perception only is at least 90°, but for *distinct* vision it is much smaller, say 45°. This corresponds to a field of 800 feet in diameter at 1000 feet but this field varies greatly with individual eyes.

The field of a field glass is always smaller and is, in any but very inferior glasses, sharply defined and capable of exact measurement. To measure the field of a glass, stake out a T on any convenient level ground. The stem of the T is, for convenience in obtaining results without calculation, laid out 1000 feet in length.

Figure 99 shows the arrangement and dimensions of the T in conventional perspective.

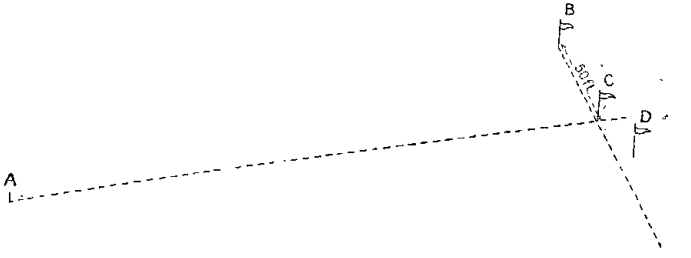


Fig. 99.

The observer with the glass stands at A and holds the glass so that the pole B is just visible at the left hand edge of the field. An assistant moves pole D until the observer notes that it is just visible on the right hand edge of the field. The assistant is then signaled to halt and make any fine adjustments of the position of the pole D as signaled from A. The assistant keeps pole D lined in on poles B and C. The distance B D is then measured with a tape in feet and is the field of the glass in feet at 1000 feet or in yards at 1000 yards or in mils. If the distance B C is laid out exactly 50 feet, the distance C D plus 50 feet equals B D. If it is desired to reduce this value to angular measure, we may use the formula

$$\frac{B\,D}{2\,A\,C} \text{ equals tan. } 1/2 \text{ "Visual angle."}$$

Definition. — The most important and essential quality of a field glass, and the quality most frequently neglected in choosing a glass, — is definition, that is, the sharpness, the clearness and the purity of the images seen through it.

To obtain good definition, it is necessary that spherical and chromatic aberration be overcome, that the polish of the lenses be as perfect as possible, that the lens cement possess noninequalities, that the lenses (and prisms, if any), be well focused and rigidly mounted with reference to one another and, generally, that the instrument be without optical defect.

Faults in this direction are discovered at once by examination of definition, whereas in determining the other constants they are hardly noticeable. In comparing the definition of any two instruments it is ordinarily necessary only to scan distant objects and observe to what extent details may be distinguished.

The following tests may also be used : Focus on printed matter at a distance just beyond that at which perfect clearness is given and gradually approach until the letters are distinctly defined. The instrument with which the print can be read at the greatest distance has the best definition. The best results are obtained with this test when large print (an inch or more in height) is used as test type and the distance is considerable.

An absolute measure of definition can be found by preparing and posting up, in a good light, a sheet of white paper ruled with black lines one-tenth inch wide and the same distance apart. The observer examines the test sheet with the glass, moving away from it until the lines are just on the point of appearing blurred. The distance is then measured and a simple calculation gives the definition in angular measure.

For example, suppose the distance at the blurring point were 38 yards. The calculation required is to determine the value in seconds of an angle subtended by a chord of one-tenth inch at a radius of 38 yards. The circumference of a circle whose radius is 38 yards is 238.76 yards or 85953.9 tenths of an inch. But a complete circle contains 360 degrees or 1296000 seconds. One tenth of an inch therefore equals 1296000″ divided by 85953.9 or 15. 1″. With this glass we therefore have

definition with objects subtending an angle 15.1", whereas the unaided eye only defines objects subtending angles of 40" or more.

Suggestions for Use of Glasses in the Field.

51. The eyes of a person unaccustomed to the use of field glasses soon tire when using glasses and his observation powers may be less than if he is using the eye alone. It is important that persons, required to use glasses, practice with them frequently and that the glasses be accurately focused at all times. In using the glasses they should be held with both hands, pressed firmly enough to the eye sockets to keep the relation with the eyes constant, but not so tight as to impress on them the beating of the pulse or the bodily tremors.

It must be remembered that, in using glasses, the eye is looking through a microscope at a tiny image of the distant objects. It is therefore working under entirely different muscular conditions from those when it is looking directly at distant objects. Long continued observation with glasses, even under the best conditions, is a decided strain on the eyes and may result in dizziness and headaches, particularly in a novice. Badly focused glasses or glasses with poor definition will produce the same effect.

The observer should use the glasses as little as possible consistent with the work in hand and take every opportunity to rest the eyes. Officers in charge of observing parties on work requiring continuous observation should see that observers are frequently relieved and should use consideration with men who complain of eye strain or headaches from the use of field glasses.

Machine gun platoons are equipped at present with a 6 power glass. Some men find it impossible to hold a glass of this power steady enough with the hands alone for proper observation. This is largely a matter of practice but, for those who have difficulty in the use of these high power glasses, a rest is recommended. This may consist of a simple rod with means of attaching it to the glass and permitting of a movement of the glass in azimuth and elevation. The rod may be forced into

the ground or merely rest on the surface. The rod should be adjustable in length to permit of use while standing or kneeling : its use in the prone position is unnecessary.

Instruments for Determining Angles.

52. A mil is the angular unit whose tangent is .001. For the computations required in the control of fire, the system of angular measurement in terms of degrees, minutes and seconds, would be very cumbersome. A much more satisfactory angular unit is the mil. Its value in the conventional angular measure is 3′ 26.2″. The mil used in the artillery is an angle of 3′ 22.5″, which is arrived at by dividing the circumference of a circle into 6400 parts. This is a sufficiently close approximation to the true mil and greatly simplifies the manufacture of the scales of such instruments as the Battery Commander's Telescope and Panoramic Sight.

The mil is used for target and sector designation and in estimating ranges and occupied fronts in terms of yards or men. An object one meter long at a distance of 1000 meters subtends an angle of one mil. The mental calculation of problems involving the solution of triangles is easy if the following equations are kept in mind :

(1) $$R = \frac{W \times 1000}{M}$$

(2) $$W = \frac{R \times M}{1000}$$

(3) $$M = \frac{W \times 1000}{R}$$

Where R equals range in meters; W equals width or height in meters; M equals number of mils subtended by W.

The following examples of the use of these formulae indicate their practical use :

Example 1. (Estimation of range.)

A certain tree is estimated to be 15 meters high. It

covers an angle of 25 mils. It is therefore 600 meters away, for :

$$R = \frac{W \times 1000}{M} = \frac{15 \text{ meters} \times 1000}{25} = \frac{15000}{25}$$
$$= 600 \text{ meters.}$$

The telegraph poles seen on a distant railroad running at right angles to our line of sight are known (from previous measurement of such poles), to be 44 meters apart; the distance between two adjacent poles is observed to be 40 mils; the range to the railroad is, therefore, 1100 meters, for :

$$R = \frac{W \times 1000}{M} = \frac{44 \text{ meters} \times 1000}{40}$$
$$= 1100 \text{ meters.}$$

Example 2. (Estimation of fronts.)

A line of skirmishers at about one man per meter of front covers 40 mils of the scale; the range is known to be 800 meters; the number of men is therefore 32, for :

$$W = \frac{R \times M}{1000} = \frac{800 \text{ meters} \times 40}{1000} = \frac{32000}{1000}$$
$$= 32 \text{ meters (or men).}$$

A column of infantry in "fours" is seen by a patrol at a range of 1200 meters. It is moving across his front. and covers 120 mils from head to rear of column. How many men are in the column?

$$W = \frac{R \times M}{1000} = \frac{1200 \text{ meters} \times 120}{1000} = \frac{144000}{1000}$$
$$= 144 \text{ meters.}$$

At 2 men per meter the column contained 288 men.

Example 3. (Determination of mils in distributing fire.)

A hostile force known to contain about 100 men is deployed in position 1000 meters away but so concealed that its flanks cannot be seen or determined definitely. The company commander decides to cover a front of 200 meters with his fire, 100 meters on each side of a visible group of heads in the hostile line. How many mils should be covered?

$$M = \frac{W \times 1000}{R} = \frac{200 \times 1000}{1000} = 200 \text{ mils.}$$

A machine gun platoon known to contain two guns is concealed at a range of 900 meters, with one of its guns visible through glasses. The company commander decides to cover a front of 50 meters on each side of the visible gun. How many mils should be covered?

$$M = \frac{W \times 1000}{R} = \frac{100 \times 1000}{900} = 111 \text{ mils.}$$

Where it is possible to measure off a distance D directly toward or away from an object which subtends a fairly large angle (50 to 300 mils), we may use a formula derived from formula (1) and which does not contain W; in other words, in this case the width of the object or its height does not have to be known. When the distance is measured toward the object, the formula is

$$R = \frac{D \times \text{2nd Mil Measurement}}{\text{2nd Mil Meas.} - \text{1st Mil Meas.}}$$

When the distance is measured away from the object the formula is

$$R = \frac{D \times \text{2nd Mil Measurement.}}{\text{1st Mil Meas.} - \text{2nd Mil Meas.}}$$

Example 4.

From this point a hostile trench measures 150 mils. A scout goes forward 330 paces (300 meters), and finds that the trench covers 200 mils. The range from this point to the trench is therefore 1200 meters.

$$R = \frac{300 \times 200}{200 - 150} = \frac{6000}{50} = 1200 \text{ meters.}$$

We have come to a river bank and a village across the river covers 150 mils. An observer walks back 200 meters keeping our party on the river bank in line with the village and finds that at that point the village covers but 120 mils. The range from the river bank to the village is therefore 800 meters.

$$R = \frac{200 \times 120}{150 - 120} = \frac{24000}{30} = 800 \text{ meters.}$$

53. Mils are conveniently measured : (*a*) with the Goniometer; (*b*) with the field glass fitted with the mil

scale; (*c*) with a mil rule; (*d*) with the machine gun "Sights".

The Goniometer is the most accurate instrument for measuring mils, but is very hard to obtain. For this reason, the most convenient instrument is the field glass fitted with a mil scale.

The type EE glass of the Signal Corps is so fitted. The mil scale is engraved on a thin glass reticule which is accurately placed in the focal plane of the left object glass. As a result the scale and distant field of view are in focus at the same time and the scale can be superimposed on any object in the field of view by a slight movement of the glass.

But for target and sector designation, it is essential that every man firing have some mil measuring instrument in order to interpret and carry out the orders of his superiors when these orders are given in mils. The Small Arms Firing Manual suggests the use of the finger held at arms length as a unit, but much more satisfactory units are the "Sights" of the Hotchkiss Machine Gun Model 1914. If the cheek of the gunner is placed against the rear of the handle block the rear sight slide (inside the plungers) subtends 50 mils, the front sight 7 mils. An even more accurate measurement of milscan be made by using the traversing scale of the Hotchkiss.

The service pistol, Cal. .45, can be used for measurement of angles in terms of "sights". The aperture of the trigger guard is 0.95 inch in width. If the pistol be held with barrel vertical and butt to the right at a distance of 19 inches from the eye, the aperture of the trigger guard subtends an angle of one "sight" or 50 mils. The distance of 19 inches may be obtained at first by use of a measured cord, one end of which is held in the teeth and the other in the hand grasping the pistol butt, but after a little practice, the pistol can be held at the proper distance without the use of the cord. An officer can, by this means, obtain the angular data for his orders and estimations in terms of "sights" and fractions thereof, even if not provided with a mil rule or a field glass with mil scale.

A short ruler with a cord 50 cm. in length forms a convenient mil measuring instrument. The graduations are calculated from Formula (2).

This ruler is held in one hand with the knot held in the other under the eye, the cord stretched and the graduated edge of the rule superimposed on the field under observation, one eye being used for noting space covered by the distant object on the scale. Another type of ruler will be considered later.

Range correction and sight setting for fire by means of auxiliary aiming points is best done with some device based on the scale of sight leaf graduation.

The theory upon which any such device is constructed will be understood by reference to Figure 100.

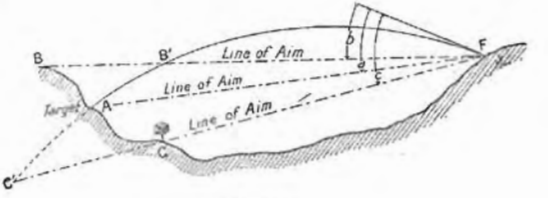


Fig. 100.

The figure shows a cross section through two hill features with the firer at F and the target at A (1000 meters distant from F). It also shows two possible aiming points at B and at C and the trajectory necessary to hit the target at A.

Case I :

The target at A is clearly visible. The rifle is therefore aimed directly at the target with sight setting 1000 meters. The line of aim is the line F A, the angle of departure is the angle *a* and the trajectory is the line F-B'-A which the bullet travels and so strikes the target at A as intended. No matter what auxiliary aiming point is used, the bullet will travel this same trajectory and strike at A when the appropriate sight setting is used. For example :

Case II :

The target A is invisible except through glasses. Aim cannot now be taken at the target and an auxiliary aiming point is necessary. At C is a well defined point. If the gun is aimed at C, the desired

trajectory will be produced when the angle of departure is *c*, the line of aim F-C and the "range" on the sight is equal to F-C′.

Case III :

The target at A is invisible and the skyline at B is chosen as an aiming point. If the gun is aimed at the point B with an elevation *b*, the line of sight will be F-B, the angle of departure will be *b*, and the bullet will travel along the trajectory F-B′-A, passing the line of aim at the range F-B′ and striking the target A as desired.

The angle of departure *c* used in Case II is made up of the angle of departure *a*, necessary to hit A when aiming directly, plus the angle of site A-F-C. To determine the total angle *c*, therefore, it is necessary to know the angle *a*, and to measure the angle of site A-F-C. The angle *a* is known by reference to a table of fire for the given rifle and ammunition, and the angle of site may be measured in the same unit (Mils), by an angle measuring device. A much simpler method, however, is to use the rear sight leaf of the gun held upside down at a distance from the eye equal to 56.2 cm.; for the angle *a* in terms of meters is marked on the leaf by the intercept between the zero of the scale and the graduation marking the true range to the target and the angle of site may be read on this improvised angle measuring instrument between the graduation marking the true range and the graduation opposite the auxiliary aiming point C when holding the sight leaf the proper distance from the eye with the true range graduation laid on the point A. With the leaf so held the auxiliary or artificial range to be used (angle *c*), may be read directly as shown in Fig. 101.

Thus, to fire at the target A, at a range of 1000 meters, we may use the skyline B as an aiming point with sight setting 500 meters or the foot of the tree C as an aiming point with sight setting 1650.

Instead of using the gun, held in an inconvenient position, for this measurement, the observer may have a detached rear sight leaf with a cord attached as in the mil scale previously described. The cord in this case

is of such a length as to bring the sight 56.2 cm. from the eye when making an observation.

A combination of the mil scale and device for range

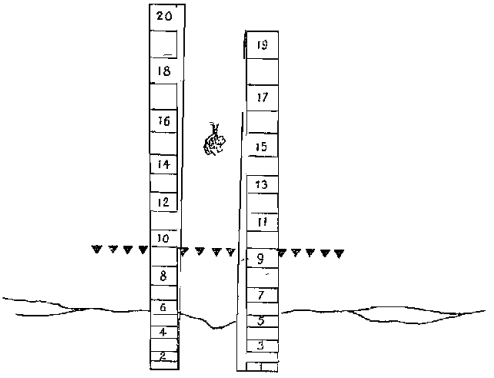


Fig. 101.

corrector and sight setting for fire by means of auxiliary aiming points is shown in Figure 102. This is the form now in use by the School of Musketry and manufactured and issued by the Ordnance Department. It is designated the "Musketry Rule"; its length over all is 4 3/4 inches and the scales are so proportioned that the rule is to be held 15 inches from the eye for measuring mils and using the inverted rear sight.

Choice of an aiming Target. — The choice of an aiming target depends primarily on the available features of the terrain that are immediately in line with the area that is to be covered with fire. At ordinary ranges care must be taken not to choose an aiming target so that a negative sight setting will result. Skylines are often not available on this account. Assuming that the enemy's line to be covered with fire is of the same length as ous line, there are three satisfactory aiming targets from a theoretical standpoint.

First, an aiming *point* so far in rear of the enemy's line (several kilometers), that our fire will be very slightly convergent. In this case, the distribution and accuracy of our fire ought to be excellent, but if the aiming point is too close the flanks of the enemy will not be covered.

Second, an aiming target consisting of a well defined horizontal *line* within a hundred meters or so of the enemy's line. In this case the accuracy of our fire ought to be excellent but the distribution will depend on the training of our troops since they must fire on the



Fig. 102.

part of the aiming target immediately to the front in order that the distribution be good.

Third, an aiming *point* half way between us and the enemy so that all our fire will cross at the aiming point and the fire of our right flank will strike the enemy's right flank. In this case the accuracy and distribution should both be excellent but here again if the aiming point is not exactly half way to the enemy our fire may cover too much or too little of his line.

Considerable judgment and experience is required in the choice of aiming targets. Excellent results may be obtained by their judicious use but they should rarely if ever be used if the real target is visible to the firing line.

A combination mil scale and reproduction of the rear

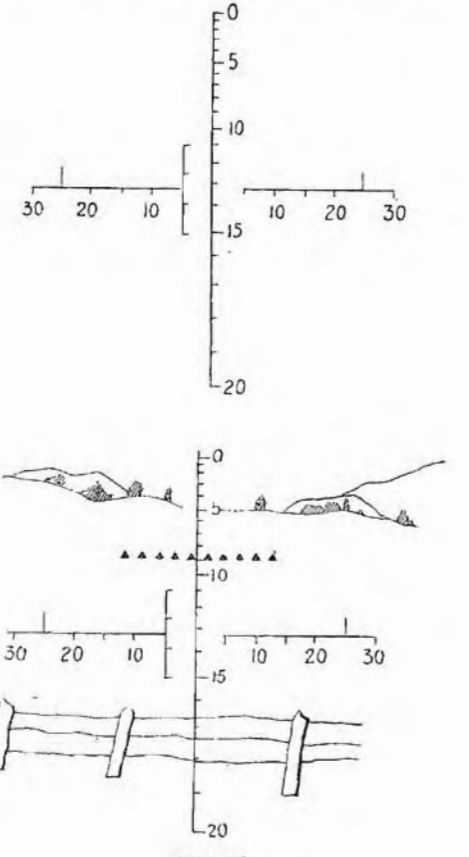


Fig. 103.

sight scale, placed on the reticule of a field glass makes the handiest angle measuring instrument for an officer.

The procedure with the gun, detached sight leaf or sighting rule is only as accurate as the process of aim-

ing the gun. Inaccuracies will occur in practice through holding of the leaf at an incorrect distance from the eye, through an inaccurate holding of the true range graduation on the target or aiming point and an inaccurate reading of the scale opposite the aiming point or target.

These inaccuracies disappear if an exact reproduction of the gun sight leaf scale be engraved on the reticule of a field glass. A glass with a scale like Figure has been produced and with it, the measurement of range for use with an auxiliary aiming point becomes an easy and accurate matter.

The horizontal scale is a mil scale.

In use, the graduation marking the true range is laid opposite the target, the selected aiming point will then fall opposite the sight setting to be used by the firers.

If, for example (See Figure 103), the target is a line of heads 900 meters away, the graduation 900 on the scale would be laid on the line of heads seen through the glasses. Any one of several aiming points will then be opposite the appropriate graduations on the scale to be used against this or that aiming point. The skyline for example crosses the scale at 500. If aim be taken at the skyline with 500 meters set on the rear sight, the bullets will hit in the line of heads at 900 meters as intended. The bottom wire of the fence immediately in front of the firers crosses the scale at 1800 meters. If the gunner aims at this lower wire with 1800 meters elevation the bullet will fall in the line of heads as before. In fact the entire landscape is available to the director of the fire who has but to choose that point or line, which, because of the color, shape or nearness would make the best aiming point in that particular field of view.

54. The Musketry Rule, or better, the field glass fitted with sight and mil scales, can be used in conjunction with an estimate in correcting ranging fire so as to get it on the target.

The correction of sights, as a result of ranging, is based upon the observation of the impact and the subsequent estimate as to its distance and direction from the objective.

In known distance practice, the strike of the bullet is on a vertical surface, and, when the position is shown by the marking disk, the sight is corrected accordingly.

In combat, however, the observation of impact is usually on a surface that is rising with respect to the line of aim. In such cases, the correction of the sight must compensate not only for the horizontal distance short or over, but also for the vertical distance above or below the objective.

Referring to Fig. 104, suppose VV′ to represent a vertical surface, and the point T to be the target. If a shot fired at T strikes at the point H, the sight correction to be applied corresponds to the vertical distance HT. If T be assumed to be on a horizontal surface AT,

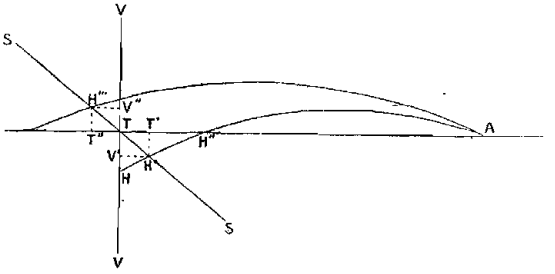


Fig. 104.

the same trajectory will cut the horizontal surface at H″ and the sight correction to be made will correspond to the horizontal distance H″T. If T be assumed to be on the surface STS, rising with respect to the line of sight, the same trajectory will intersect this sloping surface at the point H′. The required correction in this case embodies two elements, a correction for the horizontal distance short, H′V′, and a correction for the vertical distance below the target, represented by H′ T′.

In practice, the actual distance in meters of the center of impact from the target must, in most cases, be estimated. The vertical correction, however, may be measured with a fair degree of accuracy by using the

type EE field glass with the range and mil scale or else the Musketry Rule.

To measure the amount of this vertical correction with either the glass or the ruler, place the graduation of the range scale corresponding to the elevation actually used, in coincidence with the target. Then the graduation opposite the point where the impact was noted will be the elevation necessary to take, in order to correct for the vertical error. It is to be noted that this vertical correction gives the range (in terms of the sight) to the point of impact.

The vertical correction having been made, then the correction is completed by adding (if the impact is

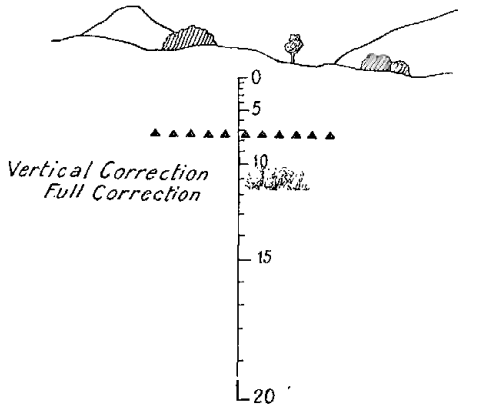


Fig. 105.

short) or subtracting (if the impact is over) a number of meters equal to the estimate of the horizontal distance from the impact to the objective and setting the sight accordingly.

Fig. 105 will illustrate this method.

Assume the range to have been estimated at 800 meters. Then with the 800 meter graduation held opposite the target, the splash of impact is observed opposite the 1100 meter graduation and is estimated to be 150 meters short. The full correction therefore would be 1100 meters (vertical correction) plus 150 meters (hori-

zontal correction) or a final elevation of 1250 meters as a result of this observation.

One other feature of the Musketry Rule remains to be mentioned. This is the simple device to obtain the sight settings when it is desired to use combined sights. Set both sliders at the range, estimated or measured, to the target. If two elevations are to be used, use the sight settings indicated by the mark numbered 2 on each slider. If three elevations are to be used, use the settings indicated by the mark numbered 3 on each slider and the sight setting corresponding to the true or estimated range, making three in all.

Machine Gun Sight.

55. The machine gun sight is primarily an instrument for the determination of small vertical and horizontal angles for the purpose of directing the angles of departure of the bullet from the gun so that its path may intersect the line of aim at the target.

Figure 106 shows diagramatically the necessary parts of a gun sight in elevation.

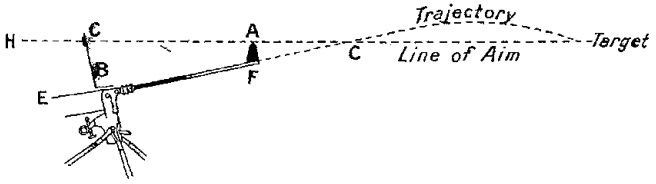


Fig. 106.

EF represents the axis of the bore of the rifle; A is the front fixed sight; B is the vertical leaf. The slide C can be moved up and down on the leaf B and an aperture in C together with the top of the front sight A fixes the line of aim H-A-*target.*

It is evident that the position of the aperture of slide C fixes the vertical angle AGE.

Without going into the theory of the trajectory, it may be stated that a bullet fired from a rifle behaves like a baseball thrown by a ball player. It is acted on

by three forces, viz. the force of projection, the force of gravity and the retarding influence of the air. Suppose a second baseman throws the ball to home plate; he may throw it easily and well up in the air or throw it hard and with a small vertical angle of departure. Similarly, if he fields the ball close to the pitcher and throws home with all his strength, the ball will apparently go on a straight line but really will have a slight downward curve, while if he fields the ball in center field and throws home with the same force the ball will go high in the air over second base.

In other words, with a variable velocity of projection (initial velocity), the less the velocity the greater the angle of departure, A G E, will have to be for a given distance covered and, with a constant velocity of projection, the less the angle of departure the less the distance traversed by the ball or bullet.

Now, with ammunition used in machine guns, the initial velocity is practically the same for every bullet. It follows then that there must be a certain vertical angle of departure corresponding to every range, if we assume the initial velocity to be constant. That is, if we are firing the gun over a perfectly level surface and want the bullet to strike the ground, say 2000 meters away, we must tilt up the barrel so that it makes quite an angle (60 mils), with the ground. If we want the bullet to strike 1000 meters away, the upward tilt of the muzzle need only be 18 mils.

Now, it has already been shown that the sights form an instrument for measuring small vertical angles. If we adjust the slide C (fig. 106), so that the angle AGE has a value of 60 mils, we may put a mark there and label it 2000 meters. Similarly, if the angle AGE is made 18 mils by adjustment of the slide C, we may put a mark there and label it 1000 meters. The whole of the graduation of the rear sight leaf may be mathematically calculated in this way if we know the initial velocity of the bullet and certain facts about its weight and shape. The rear sight leaf, so graduated, is said to be calibrated in meters of range.

If we have a gun with such a rear sight calibrated in yards of range and have the ammunition for which this calibration was made and wish to strike an object, say

1000 meters distant, it is merely necessary, theoretically, to set the sight at the 1000 meter graduation, get the distant object in line with the front sight and aperture of the rear sight and fire. The bullet will leave the rifle on an upward slope, curve gradually to the horizontal and then downward, finally crossing the line of aim at the range desired. See figure 106.

Range Finders.

GENERAL PRINCIPLES.

56. If in any triangle, we know the value of two of the angles and the length of one side, then we can determine the value of the other angle and the length of the other two sides. Range finders utilize this principle of trigonometry.

Case I.

(See fig. 107.) Suppose we have an apparatus by which we can lay off, on the ground, a right angle CAB and another angle CBA of a constant value such that CA = 3AB. We wish to know the distance of a

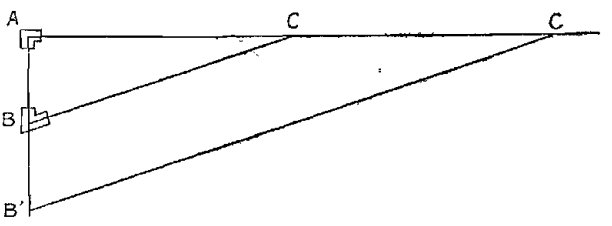


Fig. 107.

point C from the position of the observer at A. With the angle measuring instrument a right angle is laid off at A in the direction BB' and marked. A mark is left at A. The observer then proceeds along the line ABB' until, at a point B he finds that his other constant angle just fits on to the points A and C. He then measures the distance AB with a tape and $3A \times B' = AC'$. This is the principle of range finders with constant base angles and a variable base.

Case II.

(See fig. 108.) Suppose we have a base AB of fixed length and at A we have a line of sight AD permanently fixed at right angles to AB. At B we have a line of sight BE which can be rotated on B and make a variable angle with AB. Some means of measuring this variable angle ABE being provided, we may so calibrate the scale that when both lines of sight point to C the scale reads the distance CA; when both lines of sight point to 2C

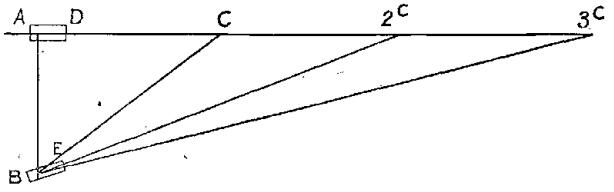


Fig. 108.

the scale reads the distance 2CA, and when they point at 3C the scale reads 3CA. Note that the angles increase by a smaller quantity each time although the distances are increased by equal increments. This is the principle of range finders with fixed base and one variable base angle, of which the Bausch and Lomb, Goertz, Hahn, Zeiss and Barr and Stroud are types. In these range finders, the base AB varies in length from 60 cm. (about 2 feet) to 5 meters (about 16 feet). Optical problems prevent the use of a shorter base, and constructional difficulties make a longer base undesirable. The base being so short, the variable angle ABC must approach its limit, 90° even for measurement of short ranges, so that a remarkable expedient must be adopted to measure the small changes in the value of this angle as the range varies. The optical and mechanical construction of fixed base portable range finders will be taken up later.

THE FIXED BASE RANGE FINDER.

57. This type of range finder comprises a base of fixed length with a line of sight at right angles thereto at one end and at the other end, a line of sight whose

angle can be varied. Some means of measuring the value of the variable angle in terms of the range is provided; the range is then directly read from this scale when both lines of sight point at the distant target.

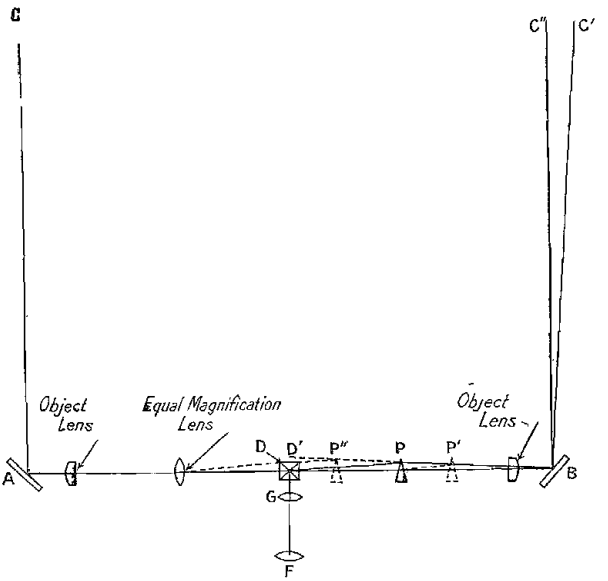


Fig. 109.

OPTICAL ARRANGEMENT.

58. A study of figure 109 will show that the fixed base range finder is equivalent to two telescopes. On the left side is a fixed telescope corresponding to AD'. In the left telescope the light traverses the objective lens, the coincident prism D and the eyepiece consisting of the lens G and the eyelens F. The line of sight of the left-hand telescope is turned through 90° by means of the reflecting prism A. At the right-hand side is the movable telescope corresponding to BD'. In the right-hand telescope the light traverses the objective lens, the angle measuring prism P, the coincident prism D', and the same eyepiece (G and F). As before the line of sight of the right-hand telescope is

turned through 90 degrees by means of the reflecting prism B.

Instead of moving BD′ at the right-hand side mechanically, in order to measure the angle C″BA (fig. 109), the line of sight is moved optically by means of the reflecting prism P. This prism is sometimes called the angle-measuring prism or wedge. The reflecting prism P carries a range scale which is graduated directly in meters of range. Thus, moving the reflecting prism P laterally along AB corresponds to a movement of the line of sight of BE and the angle which this line of sight makes with the line AB is read in terms of the range AC on the range drum attached to the reflecting prism.

Referring to figure 109, if CA and C′B are parallel rays of light from an object at an infinite distance, they will meet at the center D. If the object is at the finite C and C″, then CA will be reflected to D as before, but C′B will be reflected to D′. The angle D′BD is equal to the angle C′BC″ and varies with the distance of the observed object. The ray BD′ could be made to take the direction of BD by revolving the reflector B, but the amount of this revolution is so small for moderate changes in range and so difficult for accurate measurement that the same result is obtained by the use of the prism P, the reflecting angle of which is very small.

A position of the reflecting prism P can be found varying with the distance of the observed object where the reflected ray will pass through the point D, thus meeting the ray CAD. The two coinciding images of the same prisms are so placed at the point D that they reflect the light from both ends of the range-finder into the eyelens F, and the images are actually found at a point in front of the eyelens, the position of the images depending upon the type of the instrument. Since there is a certain position of the prism P which will bring the two halves of the object into coincidence, then a suitably graduated scale attached to the prism and moving with it will record the distance of the object corresponding to the position of the prism.

All the optical elements are inclosed in a tube. As the tube is liable to be distorted as a result of the effect of temperature changes, or of handling during the working of the instrument, it is necessary to adopt a type

of end reflector that will not alter the direction of the beams of light entering the range-finder even if its position were varied by small amounts. Nearly all, except the earlier range-finders, are made with a prism, known as the pentagonal or Prandl prism, to take the place of the reflectors A and B on figure 109.

A prism of this type, designed to bend the rays of light through an angle of 90 degrees, consists of a block of glass having two reflecting faces placed at an angle of 45 degrees to one another. It is necessary that these two reflecting faces should be silvered, as the angle of incidence is within the critical angle of glass. Any rotation of such a prism about an axis perpendicular to the column normal plane of the two reflecting surfaces does not affect the direction of the double reflecting beam of light, as the effect of the rotation of one reflecting surface is exactly balanced by the equal rotation of the two reflecting surfaces.

Instead of using an angle-measuring prism like P (fig. 109) which slides horizontally along the base of the range-finder, two rotating prisms are often used. These prisms are rotated in opposite directions by gearing connected to the range drum.

ADVANTAGES OF FIXED BASE RANGE FINDERS.

59. The more important advantages of the fixed base type of instruments are as follows:

Only one observer is required.

The ranges of moving objects can be continuously observed.

The accuracy of the determination is independent of the bearing of the object.

In the case of the smaller types, the range finder can be set in any position, horizontal, inclined, or vertical, to suit the nature of the object.

In general there are also the further advantages of greater convenience, simplicity and rapidity of operation.

TYPES OF FIXED BASE RANGE FINDERS.

60. For actually effecting the measurement of the angle subtended by the range finder base at the target,

there are available many methods of which several are described below :

(1) The two telescopes may be optically distinct from one another, each telescope being provided with its own eyepiece and cross-wire. In such a case the range finder is so directed that the image of the target falls upon the cross-wire of one telescope, and then the image of the target is made to coincide with the cross-wire of the second telescope by some optical or mechanical device, which thus provides a measure of the range.

(2) The eyepieces of the two telescopes may be so placed that the right eye can observe one of the pictures, and the left eye the other. In this case it is possible to employ the stereoscopic principle, first suggested for range-finding by Helmholtz, and developed by De Grousilliers in 1893. It is customary to substitute a mark for the cross-wire in the field of view of each telescope, and the operation of finding the range consists in making the mark and the target appear at the same distance, a suitable device being provided for the purpose.

(3) In stereoscopic comparison, it is possible to dispense with all movable parts by providing a series of marks A, B, C, in one field, and a corresponding series *a*, *b*, *c*, in another field; the pairs of marks A*a*, B*b*, C*c*, being so disposed that A*a*, seen stereoscopically together, appear to represent a single mark at, say, 1000 meters, B*b* one at 1100 meters, and so on.

The observer then sees in the field of view a series of marks which appear to lie at regular intervals between the near and distant portions of the landscape. By observing the image of the target stereoscopically, its position with reference to the index marks in the field can be determined, thus for example, the object may appear to lie between the two marks, 1000 and 1100 meters, and a rough guess may then be made as to its value between these limits.

(4) The two images of the target obtained from the two ends of the base may be brought to one eyepiece, say, the right. These images may completely, or partially, overlap one another, and the range of an object in the field of view is determined by adjusting the two images until the one lies exactly over the other. Other

objects in the field at different ranges will appear double, the displacement of the images of any particular object being dependent upon its distance.

(5) The two images in the field of view, instead of overlapping, may be separated from one another by one, or several, fine lines, or one image may be inset with the other. The image of an object on one side of the fine separating line is brought into coincidence, or alignment, with the corresponding image on the other side, by some optical or mechanical device, which indicates the range of the object. This method, is usually referred to as the "coincidence method".

(6) In the "Invert" system which is well adapted for field service, the optical arrangement is such that one of the images, separated as before by a fine horizontal line, is inverted, but not reversed right for left. It is

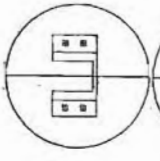


Fig. 110.

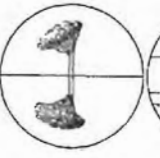


Fig. 111.

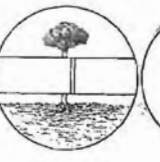


Fig. 112.

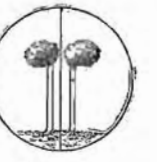


Fig. 113.

usually the upper image that is inverted, as indicated in figure 110, but under certain conditions the lower inverted arrangement illustrated in figure 111 offers some advantages. The appearance presented is that of an object and its reflection in the surface of a lake. This method is found advantageous when observations of range are being made upon ill-defined objects, such as bushes, stones, etc. It is commonly employed in infantry and artillery range finders, although not in naval range finders, where the targets are much better defined.

(7) A modification of the preceding method, known as the "inverted strip" or "double coincidence" system, is as follows :

The image in the main field is erect but right across this field extends a horizontal strip in which appears the inverted image from the other object glass. This image, although inverted, is not reversed, left for right. The effect is shown in figure 112. An object like a telegraph

pole may extend above and below the inverted strip and it is immaterial which edge of the strip is used in obtaining coincidence. The Hahn and Bausch and Lomb range finders have fields of this type.

(8) Another method, which has been employed for observing upon ill-defined objects, consists in arranging the two images of the target side by side, with a vertical line of separation, as indicated in figure 113. In this case each image is erect, but one is reversed laterally, so that the appearance presented to the eye is that of a picture and its reflection. This effect may be obtained with a range finder on the "Invert" system by holding the base vertical.

The range is determined by adjusting one of the images of the target until the vertical line of separation bisects the distance between the two images. In consequence, however, of the lateral reversion above mentioned, the rotation of the range finder in azimuth will cause one image to move to the right and the other to the left, and unless the range finder is held very steadily in azimuth — a condition that is difficult to satisfy in windy weather, or when the target is moving quickly — the accuracy obtainable by this method is not very great unless the object under observation is a skyline, a trench or something of that nature with good horizontal definition.

(9) The last method that will be referred to here consists in arranging that the magnifying power of the one telescope system is different from that of the other. In this case the images are generally separated by a fine horizontal line, and are viewed through a single eyepiece.

If an object at a particular range appears in coincidence in one part of the field, it will not appear in coincidence at other parts. By determining the position in the field at which the object appears in coincidence, an indication of the range can thus be obtained. This method is, however, inferior in accuracy to any of the other already described.

GENERAL PRINCIPLES OF ADJUSTMENT.

61. The three adjustments ordinarily required on fixed base range finders are : (1) adjustment of eyepiece

focus; (2) adjustment for halving; (3) adjustment for distance.

The fixed base range finder comprises two telescopes with a single eyepiece. This eyepiece is really a magnifying glass through which we examine the combined or superimposed images made by the object glasses of the telescopes. Observers whose eyes are not normal must have the eyepiece a little nearer or farther away from the images than those persons whose eyes are normal. The adjustment is individual and the criterion is a perfectly sharp and well defined field of view. The eyepiece focusing device is turned backward or forward until the field is sharp. Most range finders of this type have an adjusting arrangement like that on prism field glasses, with a scale and index.

It is essential for the proper operation of this type of range finder that one field of view begin exactly where the other stops, or that the division line between the erect and inverted fields cut the view at exactly the same place in each field. The adjustment by which this condition is obtained is known as the halving adjustment. With the Barr and Stroud, examine any well defined object with horizontal markings. If no markings are either duplicated or omitted at the division line in the field, then the instrument is in adjustment; if, however, there is any omission or duplication, the adjusting roller must be slowly turned until it disappears and the upper field of view seems to begin where the lower one stops.

Range finders of the invert type (Bausch and Lomb, Goertz, Hahn, Zeiss, etc.), are much easier to adjust for halving. Examine any object with a well defined horizontal edge, as the top of a chimney on the skyline or even the top of a telegraph pole. Bring the edge to the dividing line of the erect field by moving the range finder slightly; the inverted field should also show the edge of the chimney exactly at the dividing line if the instrument is in adjustment. If it is not in adjustment, slowly turn the adjusting device, watching the two fields, until an exact adjustment is obtained.

The last adjustment is that by which the instrument is made to read on the scale the correct distance to the object under observation. This is known as the distance adjustment. All these instruments are made with

such care that if the scale reads correctly the distance to any one object it will read correctly the distance to any point within the range of the instrument. The various methods of making this adjustment for distance will now be discussed; the fourth one, that using an infinity adjusting bar, will be found preferable if one is provided with the range finder.

DISTANCE ADJUSTMENT OF FIXED BASE RANGE FINDERS.

62. The distance adjustment of a fixed base range finder consists in setting the scale to indicate the known range of one object, the partial images of which have been brought into exact alignment in the field of view, and if the scale is correctly graduated it will then indicate the true range of other objects when the latter are brought into coincidence.

(A) *Adjustment upon a celestial body.*

As the range of any celestial body is from the range-finding point of view infinite, the sun, moon, or a star may be used for the adjustment of the infinity indication of the scale.

The sun is not usually a very suitable object unless partially obscured by mist or fog, and a bright sun at a considerable altitude is quite unsuitable, even if a dark glass be interposed between the eyepiece and the eye of the observer, because of the heating effect produced by the rays upon the optical parts of the instrument. The moon at low elevations is usually a very suitable object, provided the atmospheric conditions near the horizon are good, and the moon is to be preferred to a star owing to the fact that when working on the former it is not necessary to use the astigmatiser, which may introduce a small error owing to slight defects of adjustment of the optical parts in the process of erection of the instrument. In practice the weather and other conditions of observation are often such as to affect seriously the accuracy of night observations on the moon or stars, and if possible the adjustment should be made on a clear and calm night.

(B) *Adjustment upon an object at known range.*

This method is only suitable for occasional use in the field when a chart is available, and the position of the instrument and of some distant object can be located with sufficient accuracy. The method is, however, of special value for fortress range finders, because a pole or other suitable object can generally be erected at a considerable distance, and after that distance has been accurately determined it may be used at any time for adjustment purposes.

(C) *Adjustment upon infinity bar.*

This may be accomplished by having two marks mounted upon a board or other suitable frame at a distance from one another equal to the base length of the range finder.

The images of the right and left hand marks produced by the right and left hand telescopes respectively, are observed in the fields of view of the range finder, and when the image of one mark in the upper field coincides with that of the other mark in the lower field, the instrument is adjusted for "infinity".

In using the infinity adjusting bar, the bar should be set up at least 100 meters and preferably 200 meters or more from the range finder to be adjusted. The bar

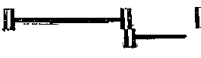


Fig. 114.

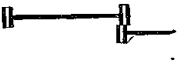


Fig. 115.



Fig. 116.

should be carefully set at right angles to the lines of sight of the range finder by sighting through the bar sight at the center of the range finder. The range finder should be set at the mark ∞ (infinity), which will be found well beyond the last numbers on the scale. Moving the range finder so that the bar is split horizontally by the dividing line between the fields, we should see through the eyepiece something like figure 114; if the images of the bar appear like figure 114 or 115, the instrument is out of adjustment and the distance adjust-

ing device must be turned carefully until the effect of figure 116 is obtained.

Now move the scale so that the infinity mark is away from the index and carefully bring it back until the effect of figure 116 is again obtained; the infinity mark will probably not be exactly at the index. Try this several times before attempting to improve the adjustment, throwing off the infinity mark alternately above and below the index. If it is found that the mean of the several positions of the infinity mark is close to the index, the adjustment is satisfactory; if, however, the mean is well off the index a readjustment should be made.

Always make the adjustments in the following order, (1) eyepiece focus, (2) halving adjustment, (3) distance adjustment. Test the adjustments, if possible, immediately before using the instrument. If it is in daily use or likely to be used daily, it should be adjusted the first thing in the morning. This takes but a few minutes and insures correct operation.

ACCURACY.

63. The accuracy of any range-finding operation in actual practice must depend largely upon the nature of the object under observation and upon the atmospheric and other conditions of working, but assuming that the object to be observed, such as a mast or pole, is clearly defined, and that the atmospheric conditions are favorable, the limit of accuracy attainable will depend upon the base length which determines the angle of parallax, and, further, upon the smallness of the angle the instrument is capable of detecting.

Thus, for example, if the smallest angle the range finder is capable of distinguishing is .0025 mils, a range finder having a base of 1 meter would be able to distinguish between two objects at distances of about 2000 meters and 2010 meters respectively, whereas with a base length increased to 2 meters the range finder could distinguish between two objects separated by 5 meters at the same distance of about 2000 meters. In practice the base length is limited

by such considerations as convenience, weight and constructional difficulties.

In figure 117 suppose AB represents the base length; that is, practically the distance between the centers of the reflectors at the ends of the instrument, and

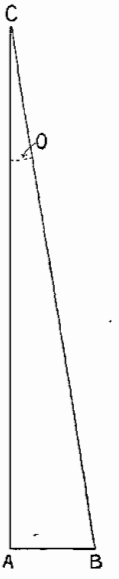


Fig. 117.

suppose C is an object situated at the minimum distance the instrument is arranged to measure, say, 450 meters.

Then since the base length AB is very short compared with the distance AC, the lengths AC and BC may be considered as practically equal, and the base length AB may be regarded as the arc of a circle described about the center C. The circular measure of the angle O is then equal to

$$\frac{AB}{AC} = \frac{\text{base}}{\text{minimum distance}}.$$

Assuming the distance of C is 450 meters, and the base length 80 cm., the angle O is 800 meters divided by 450 meters; that is, approximately 1.78 mils. For

a base length of 80 cm., this small angle is the total available for subdivision to indicate the whole series of distances between 450 meters and infinity

RESOLVING POWER AND MAGNIFICATION.

64. The unaided human eye is incapable of appreciating so small an angle as .0025 mils. From the results of many years of practical experience with range finders of the coincidence type it would appear that under the most favorable conditions the unaided eye can resolve angles of about .06 to .075 mils. A better average value is .15 to .2 mils.

Although the range finder may be able to measure an angle of .0025 mils, the eye can therefore only appreciate such an angle when it is sufficiently magnified. It would be necessary accordingly in the above instance to use a telescopic system having a magnifying power of about 30 diameters.

If the magnification of the telescopic system were 15 diameters, an angle of not less than .005 mils, measured by the range finder, could be appreciated by the eye, whereas if the magnification were 30 diameters, an angle of .0025 mils could be appreciated.

The accuracy of the range measurement under similar natural conditions is determined, therefore, not only by the length of the base employed, but also by the magnification of the telescopic systems.

ACCURACY OF COINCIDENCE METHOD.

65. The value of the resolving power of the eye, mentioned above as being .06 to .075 mils only applies to observations of the coincidence type in which the partial images of an object are separated by a fine line, and the adjustment is made by bringing the images into exact alignment at the separating line. The human eye, under such conditions is capable of distinguishing with great exactitude any discontinuity or want of alignment, even when the definition of the edges of the object is not perfect.

OVERLAPPING IMAGE METHOD.

66. In the case of overlapping images the smallest angle the eye can resolve is of more than twice the above mentioned value even under ideal conditions, and in practice when the definition of the edges of the images is not perfect, it is not possible with the necessary exactitude to determine when the images are correctly superposed.

STEREOSCOPIC METHOD:

67. In the case of stereoscopic vision the images are superposed on the retina of the observer's eyes by the involuntary working of the muscles which direct the eyes. The action is a physiological one and is dependent upon the physical condition of the observer.

It is generally agreed as the result of practical experience among the Armies and Navies of the world that so far as accuracy is concerned, stereoscopic methods are much inferior to coincidence methods.

INVERTED IMAGE METHOD.

68. Range finders of the invert type, already referred to as being often preferred for Army purposes, where the objects to be observed are usually of irregular form and ill-defined, are considered by some users to be more accurate upon such objects than range finders of the ordinary coincidence types.

When one of the images is inverted a coincidence error becomes evident as a want of lateral symmetry between the images above and below the separating line, and on ill-defined objects it is sometimes easier to detect errors of symmetry than errors of alignment. It is generally the upper image that is inverted, because in the case of the great majority of the objects that have to be dealt with, the most suitable parts of the objects for ranging purposes are directed upwards. The greater portion of the object remains therefore in view, not only in the lower field, but also in the upper as illustrated in figure 110. When the lower image is inverted,

the greater part of the object is generally invisible in either field (See fig. 111).

All range finders of the invert type have the disadvantage that a rotation of the instrument about its longitudinal axis causes the two partial images in the field of view to move in opposite directions at right angles to the separating line, and when the force of the wind is considerable it is difficult to keep an indistinct object under observation, as the object is lost from view if it is allowed to pass the separating line.

Goniometer.

69. The goniometer, figures 118 and 119, is a small and very portable angle measuring instrument of French manufacture, primarily intended for use in topographical operation. The French artillery later used it in their batteries as a "director" upon which they based their data for indirect fire. The instrument is so light, compact, accurate, and simple to operate that its use by machine gun organizations in our service has been very strongly recommended.

GENERAL DESCRIPTION.

The instrument comprises a telescopic sight with a large field of view mounted on trunnions on a dial over a prismatic compass. The compass box forms part of the upper of two circular dials, the lower of which is graduated into hundreds of mils completely about its circumference. The upper dial of the instrument can be revolved about the lower dial through very small arcs by means of a tangent screw. The instrument must be pivoted on a tripod for use.

The sight is a small prism telescope having a magnification of about 4; its eyepiece is provided with a focusing gear so that it may be adjusted for the use of each individual. By means of a screw the telescope can be elevated or depressed in a vertical plane approximately parallel to the axis of the magnetic needle in its zero position. The sight is also fitted with a level. The micrometer of the telescope comprises a vertical scale graduated in mils (— 100 to + 100 mils) for measure-

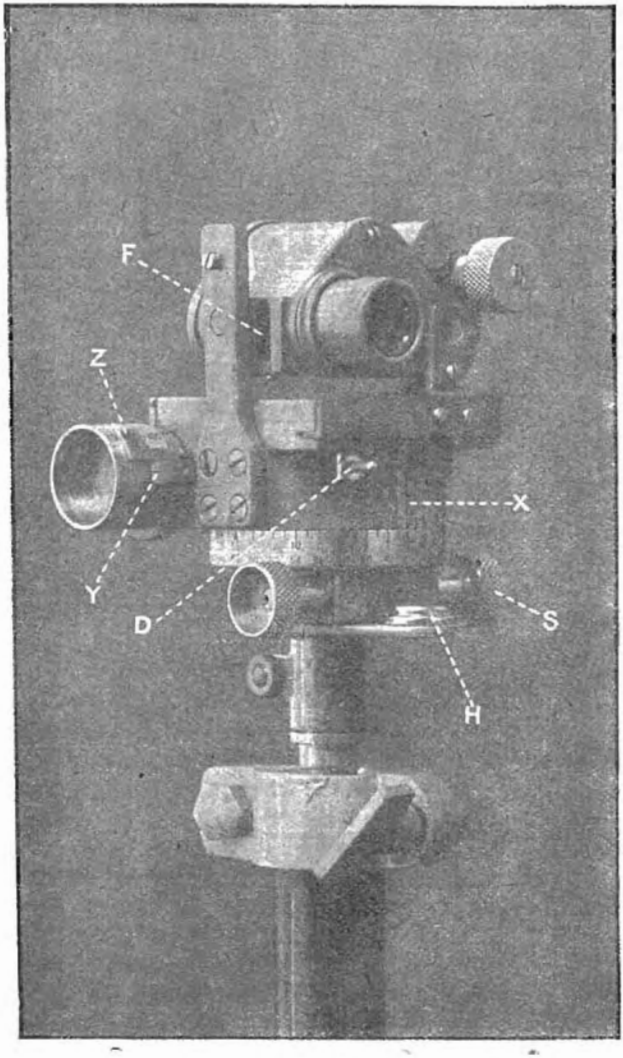


Fig. 118.

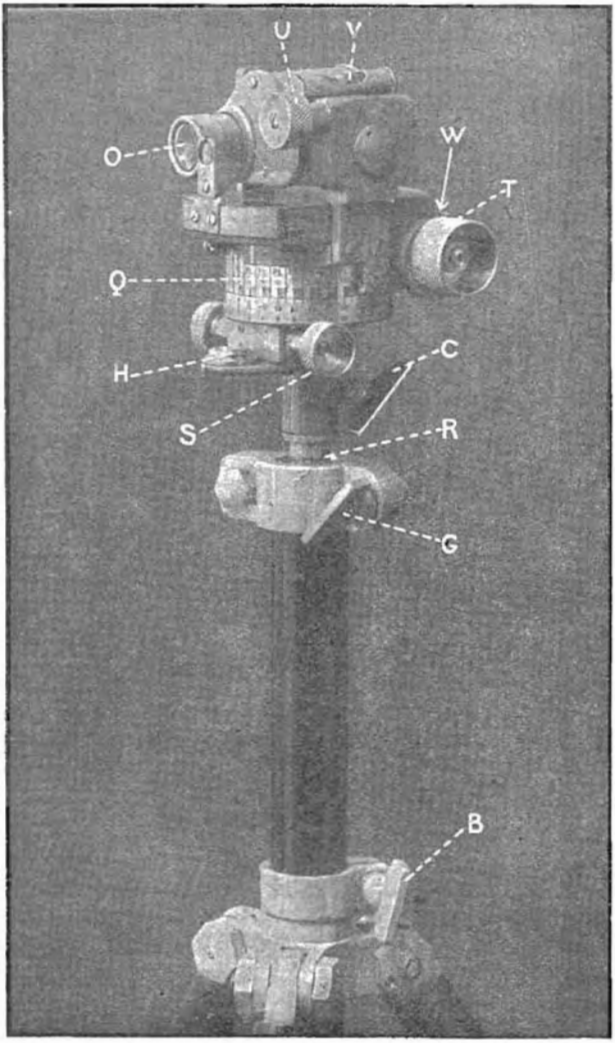


Fig. 119.

ments in altitude, and an inverted graticule scale (0 to 200 meters for measurement of ranges in connection with the 2 meter ranging rod). The optical axis, corresponds with the point at which the vertical scale is intersected by the zero graduation on the angle of site scale.

The needle of the compass can be clamped by a lever underneath the compass box. Care should be taken to always clamp the needle before moving the instrument from one position to another. By means of a small magnifying prism placed at the side of the eyepiece of the telescope the needle and its zero mark can be accurately observed. The zero mark on the far side of the compass is only used for rough setting, the final adjustment being always effected by getting the south end of the needle in line with the zero mark beneath the reading prism.

Movement in Azimuth. — The upper dial of the instrument carrying the telescope and compass can be moved over the lower dial by turning the milled head of the tangent screw. For quick setting this tangent screw can be thrown out of action by pressing downward on the pallet. Before using the slow motion, see that the tangent screw has properly engaged, but do not attempt to force it home. Turn the milled head and the screw will fall into gear.

Without upsetting the relative positions of the upper and lower dials the whole instrument can be rotated by means of the lower milled heads. For rough setting first slacken the clamp which holds the instrument to the vertical pivot.

Verticality of the Pivot. — The pivot of the instrument is fixed to the tripod stand by means of a ball and socket joint. A spherical level alongside of the lower milled head enables the pivot to be set vertical.

Tripod Stand. — The tripod consists of three telescopic legs and a sliding vertical tube. By loosening the tripod clamp the height of the instrument can be varied as desired between 0.80 meter and 1.80 meter. In using the instrument for accurate topographical surveys it is not advisable to raise the vertical tube more than necessary.

Graduations. — There are two graduations :

(*a*) On the lower dial is a continuous clockwise graduation from 0 to 6400 mils, used in conjunction with the black index on the upper dial. Each division is 100 mils and intermediate values are read on the left-hand side graduations of the tangent screw drum. Each division of the drum graduation is 1 mil, and it is read in conjunction with the black index mark engraved on the indicator at the side of the drum.

(*b*) A second graduation on the upper dial, in conjunction with the right-hand side graduation on the tangent screw drum, is intended for use especially with 75 mm. artillery batteries when the angles are measured in terms of "plateau" and "tambour" (dial and drum) of the gun sight.

INSTRUCTIONS FOR USE.

70. When employing the goniometer as a topographical instrument the continuous clockwise graduation on the lower dial in conjunction with the left-hand side graduation on the tangent screw is used exclusively.

TO SET UP THE INSTRUMENT OVER A GIVEN STATION.

Erect the stand so that the pivot of the instrument is vertically above the given point; press each leg well into the ground so that the sliding tube is approximately vertical. Loosen the clamp of the ball and socket joint and adjust the instrument until the bubble is at the center of the spherical level. Tighten the clamp.

TO ORIENT THE INSTRUMENT OCCUPYING A KNOWN STATION.

Let O be the known station occupied and A, B, C, other known points visible from O and as far away as possible. First, determine *a, b, c,* ... the grid bearings of A, B, C, ... This can be done from the map by means of a protractor, or by calculation. Erect the instrument over station O and set off the angle *a* on the continuous graduation of the lower dial corresponding to the grid bearing of A. Loosen the lower clamp of

general movement of the instrument and direct the telescope roughly on A; tighten the clamp and turn the milled screw of general movement until A coincides with the vertical cross hair. Then, without touching the general movement, lay successively and in a clockwise direction on A, B, and C, finishing up on A, thus completing one revolution. Let a', b', c', be the read-

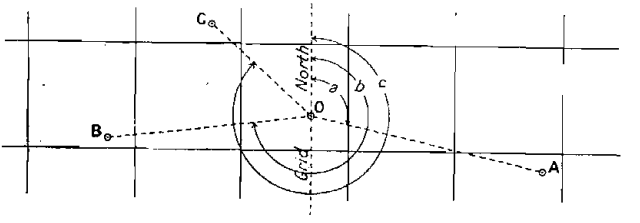


Fig. 120.

ing. If these values agree within one mil with the theoretical bearings, a, b, c, the instrument is correctly oriented.

If the differences are considerable, take the mean x of the differences $a - a'$, $b - b'$, $c - c'$, and by using the general slow motion screw, turn the instrument so as to increase all the readings by the angle x. When this is done, the instrument will be oriented as correctly as possible.

TO FIND THE DECLINATION CONSTANT OF THE INSTRUMENT OCCUPYING A KNOWN STATION.

The instrument is first oriented as described above. This done, free the magnetic needle by pushing the safety clamp to the left. Disengage the tangent screw and roughly set the compass by turning the upper dial; finally adjust by the tangent screw until the point of the needle is exactly in line with its zero mark. Read off the angle. Repeat this operation three or four times and take the mean of the readings which should be carefully noted on the celluloid plate provided for this purpose. It should be observed that the value thus found only holds good for that particular instrument and within a reasonable distance from the point at

which it has been determined. In changing locality the constant will have to be determined anew.

The declination given by the map can only be used as a rough approximation. In reality the axis of the telescope is only approximately parallel to the line joining the index marks of the compass. The difference between two instruments may be as much as 20 to 30 mils.

TO ORIENT AN INSTRUMENT WHOSE DECLINATION CONSTANT HAS BEEN DETERMINED.

Set up the instrument and set on the dial an angle equal to its known declination constant. Free the needle and bring it into coincidence with its index mark by using the general movement. The instrument is then correctly oriented.

TO FIND THE BEARING OF A DIRECTION AB.

The instrument having been set up over station A and oriented as described above, disengage the tangent screw and lay roughly on station B, using the tangent screw for final adjustment. The reading on continuous graduation will then indicate the true bearing of the direction A B.

TO MEASURE A HORIZONTAL ANGLE.

Lay successively on two points as described above and subtract the readings of their respective bearings. If it is desired to measure only one angle it will not be necessary to first orient the instrument, the operation being simplified as below :

Set the zero line of the continuous graduation in line with the index mark by using the relative movement. Lay on the left-hand point by using the general movement, then lay on the right-hand point, using the relative movement. The angle required will then be given on continuous graduation.

TO MEASURE THE ANGLE OF SITE OF A GIVEN STATION.

Set up the instrument, lay on the station, getting its image to fall on the angle of site scale of the micrometer.

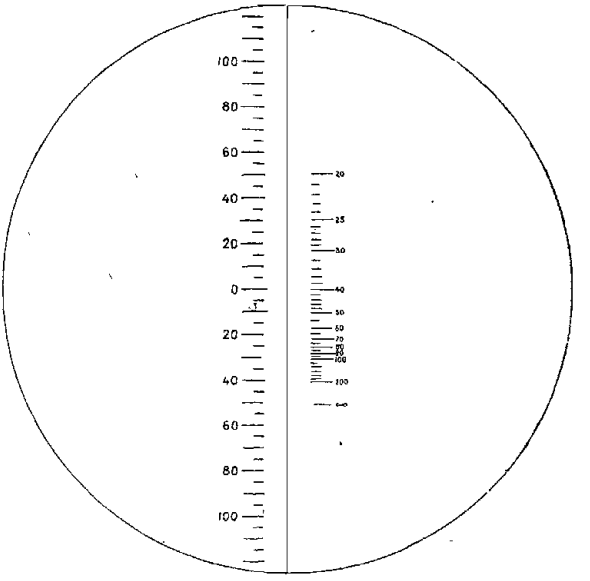


Fig. 121.

The optical axis of the telescope corresponds with the point at which the vertical graticule is intersected by the zero graticule of the left-hand side scale.
The right-hand scale is used when measuring distances; it is graduated in meters.

Bring the bubble of the upper level to the center of its run. Read the angle of site on the micrometer, taking note of the sign. (See Fig. 121.)

TO TAKE A RANGE BY MEANS OF A TWO-METER RANGING ROD.

Place the rod vertically at the station the range of which it is desired to measure. Lay the telescope on the rod so that its image falls on the telemetric scale of the micrometer. By turning the milled head of the

elevation movement bring the lower sighting mark on the infinity (∞) graticule; read the range as indicated by the image of the upper sighting mark.

For ranges under 25 meters use one of the fixed sighting marks and the bolt joining the two halves of the rod, this distance being one meter. In this case the reading observed must be halved.

To get accurate results it is essential that the rod should be held absolutely vertical. Working with care the possible error is about one meter in a hundred meters. This error increases very rapidly with the range and for this reason it should not be attempted to take ranges exceeding 150 meters.

INTERSECTION AND RESECTION WITH THE GONIOMETER.

These operations can be performed either by laying out the true bearings as measured by the instrument after its declination constant has been found, or by measuring the angles between objects when the declination constant is unknown.

CLEARING THE CREST.

From the top of the crest or the base of the cover measure the angle of site of the target. Add this angle to the angle of tangent elevation corresponding to the range of the target from the crest or cover. Place the instrument at the height of the trunnions of the gun, this being approximately realized when the vertical tube of the tripod is all the way down. Bring the bubble of the level to the center of its run and read off the division of the angle of site scale upon which the image of the crest falls. If the angle thus obtained does not exceed the sum of the angle of site of the target and the angle of tangent elevation, the emplacement can be occupied.

ACCESSORIES.

71. These include cases for the tripod and the instrument, made of reinforced waterproof cloth and leather and a battery box for illumination of the micro-

meter. The illuminating attachment comprises a battery box with a battery inside, a rheostat, a switch, insulated connecting wire and a small lamp in a mounting which can be fixed to the left telescope support. The light thus falls on the edge of the micrometer and illuminates the scale. By means of the rheostat the illumination can be varied. The lamp can also be used to facilitate the reading of angles and to illuminate the compass needle. A pocket lamp might also be used to illuminate the micrometer (by reflection), the needle and the graduations.

TO PUT THE INSTRUMENT AND TRIPOD BACK IN THEIR CASES.

72. After loosening the lowest clamp on the instrument, remove the instrument from the tripod and put it in its case, telescope first, the pallet of slow motion turned toward the hinge of the case. Shut the lid and fasten the strap. Loosen the clamps of the telescopic legs on the tripod and push them home. Tighten the clamps again, taking care to turn the legs so that the clamps will not project outwards. Place the tripod in its case, legs first. Shut the lid and do up the fastening strap.

CARE OF THE GONIOMETER.

73. Cleaning of the internal parts and dismounting of the dials or telescope are strictly forbidden. If necessary, the instrument should be returned for repairs to the "Service Géographique de l'Armée" in Paris. The external parts only are to be cleaned. In cleaning a lens never rub it with a cloth or anything which might grease or scratch the glass. Breathe on the surface and dry immediately by rubbing gently with a piece of fine, dry linen which is not fluffy. Repeat this until the vapor condenses regularly and evaporates concentrically. Frequently clean the sliding tubes of the tripod with an oily rag.

Compass.

74. The *compass* (Fig. 122) is the standard instrument for the determination of *azimuths* in topographical reconnaissances. It consists of case, needle, dial, pivot and stop.

The *dial* may be fixed to the case or it may be *movable*, that is, moving with the needle to which it is attached. The *stop* raises the needle from the *pivot* and clamps it against the glass cover. A good compass must have a



Fig. 122.

needle sufficiently magnetized to settle accurately and a *pivot* which is true. If the needle becomes too weak it may be remagnetized by rubbing gently *from pivot to point* on a permanent magnet or electromagnet, each end of the needle to be rubbed on the pole of the magnet

which attracts it. In returning the needle for another stroke, carry it a foot or more from the magnet. The *pivot* may be polished with Putz pomade or a similar substance on a soft stick. *If possible, turn in a defective compass* and get one in its place.

A needle loses part of its magnetism if kept for a long time out of the plane of the magnetic meridian. *In storing a compass,* therefore, care should be taken to see that the needle is in the magnetic meridian with the N. end of the needle pointing north.

A symmetrical needle tends to point downward toward the nearer magnetic pole of the earth. This displacement from the horizontal is called *dip,* and is measured in degrees of arc. Immediately over the magnetic poles the needle stands vertically or has a dip of 90°. Near the Equator, where North and South Poles of the earth exert an equal influence, the needle will be horizontal, or the *dip* 0.

For reading azimuths the needle must be kept in a horizontal plane, which is done by a small movable counterweight (to overcome the *dip*). For considerable changes in latitude, as in passing from the United States to the Philippines, the counterweight will require adjustment to keep the needle horizontal, and in passing from the Northern to the Southern Hemisphere, the counterweight must be changed to the other end of the needle.

There are two adopted forms of compass for topographical reconnaissance, one in which the *dial is fixed* to the case and one in which the *dial moves with the needle* to which it is fixed.

BOX COMPASS.

75. The *dial* or face on which the graduations are marked is rigidly attached to the case. The type of *box compass best adapted to running courses by azimuth* is constructed as follows : the graduations read counterclockwise continuously from 0 to 360; the instrument reads 0 when pointing south and 180° when pointing north; the E. and W. points, if marked, are reversed.

To determine the azimuth of a line, point the north and south line of the case along the line (the north point away from the observer) and read the N. end

of the needle. The dial is graduated to single degrees, but when the needle is stationary the reading can be estimated to half degrees.

Many box compasses are not graduated in the manner above described. To use such compasses for azimuth reading they should be altered to conform to the conditions cited. This is ordinarily done by pasting paper over the stamped numbers on the dial and renumbering in ink or pencil.

PRISMATIC COMPASS.

76. The dial containing the graduations is attached to the needle and *moves* with it. It is read by means of a small prism, adjustable for focus. This prism is mounted on a hinge joint and can be turned down for carrying. The line of sight of the instrument is determined by front and rear sights ,which fold down when not in use, at the same time stopping the needle. The needle may be compensated for dip by a bit of sealing wax on the under side of the dial card. The graduations on the dial should be numbered so as to read azimuths, as above described, beginning at the south point. If the graduations are not so numbered, they should be altered as follows : The zero should be at the north end of the needle (which is on the under side of the dial) and the graduations should run clockwise continuously to 360°. *It is to be noted that with such numbering the instrument will not read azimuths if used as a box compass.* The index is a point on the case, and as the dial is movable the graduations are numbered clockwise, instead of counter-clockwise, as in the box compass. *Readings should be made through the prism.*

To determine the *azimuth* of a line with this instrument, adjust the prism until the graduations on the dial are distinct, raise the front sight; look through the slit in the prism plate and bring the front sight in line with the forward station; then when the needle comes to rest, read the azimuth through the prism.

COMPASS ERRORS.

77. The magnetic and the true meridian generally

do not coincide. The angle between them at any point is called the *magnetic declination at that point.* If the needle points east of the true meridian, it is called an *east declination;* if west, a *west declination.* Magnetic declination varies in amount and direction at different points on the earth. At no point is the declination constant. It is subject to the following variations: the daily variation consists of a swing from the extreme easterly position at about 8 a. m. to the extreme westerly position about 1:30 p. m.; the mean position occurring about 10 a. m. and 5 p. m. The daily variation is from 5′ to 15′ of arc. The *secular variation* is a long slow swing, covering many years. In the United States all *east declinations* are now gradually decreasing and all *west declinations* gradually increasing at the rate of about 3′ per year). The *annual variation* is very small (less than 1′ per year) and need not be considered in surveying work. The Lunar declination is still smaller. All of the foregoing variations are periodic in character. Irregular variations due to so-called magnetic storms are uncertain in character and cannot be predicted. Such variations are sometimes large. Local attractions may greatly disturb the needle, and often come from unknown sources. The observer should have them constantly in mind and endeavor to keep all magnetic influences, such as magnetic bodies, electric wires, etc., at a distance from the instrument when the needle is being read.

The geometric axis of a needle may not coincide with its magnetic axis, hence the *readings of two compasses at the same station may differ slightly.*

A simple way to detect — not measure — such disturbances is to take frequent back azimuths. If the position of the needle is normal at both stations, the azimuth and back asimuth will differ by 180°. If there is local attraction on the course, it will usually be stronger or cause a greater deflection at one station than at the other, and the azimuth and back azimuth will *not* differ by 180°.

Another way is, when taking the bearing to a station, to select a well-defined point beyond and on the same course. On arriving at the new station, take a bearing from there to the selected point ahead. If it is the

same as the first bearing to that point, there probably is no local disturbance.

Corrections for abrupt deflections of the needle due to local attractions must not be distributed uniformly over the traverse. *A course in which local attraction is detected or suspected should be noted,* and if, on closing, an azimuth correction is necessary, it should be applied to the suspected courses.

METHOD OF READING COMPASSES.

78. A good needle requires time to settle, then when the case is firmly supported, and the user should cultivate the knack of catching it at the middle of its swing, which is the desired reading. If the compass can be supported, it is always better to do so. Then the sight can be carefully taken and the position of the eye changed to read the needle. Wait till the swing gets down to 4° or 5°, which it will usually do in a few seconds. Then catch the highest and the lowest readings on the same swing and take their mean for the true reading. If the first swings are very large, catch the needle with the stop near the middle of the swing and release it quickly. This will suddenly check the swings and shorten the time in which the reading can be taken.

In using the box compass without a support, hold it sufficiently below the eye so that the swing of the needle can be seen. Point the line of sight in the required direction, catch the needle with the stop in the middle of the swing, and hold it stopped until the reading is taken. Stop readings are less accurate than sight readings, due to the difficulty in stopping the needle at the middle of the swing and to the tendency to displace the needle slightly in lifting it off the pivot. When the stop is used, *press it firmly and quickly.*

With the prismatic compass the stop is not used except to check the swings. Utilize a support if practicable. The prism having been adjusted for focus, level the case so as to bring the scale into focus, and when the swing becomes small, read the extremes and take the mean.

Protractors.

79. Protractors are used in connection with maps to lay out and measure angles. They may be made of celluloid, wood, brass or German silver. In shape they are rectangular, a full circle, or semi-circular.

General Description.

The rectangular protractors for ordinary use are made about six inches long and two inches wide. The middle of one side, corresponding to the diameter of a circle, is marked as the center, and on the other side and two ends are the mil, degree or grade divisions corresponding to the semi-circle. The divisions are numbered both ways from each end of the diameter from (if

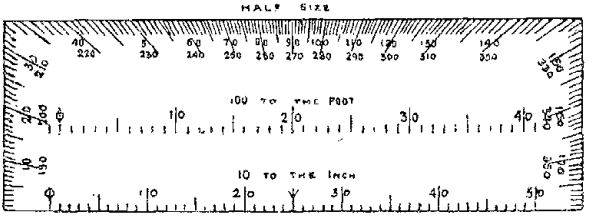


Fig. 123.

graduated in mils) 0 to 3200 or otherwise. It is nothing more than a semi-circular protractor cut down to a rectangular shape and is used in the same manner. On some are scales for measuring centimeters, or inches.

In the whole circle protractors the graduations are from 0 to 6400 (if graduated in mils) around the circumference; the center of the circle being marked with a cross or some other distinguishing mark.

The semi-circular protractor has its semi-circumference divided into mils graduated from 0 to 3200. The middle of the diameter line is marked to indicate the center. The straight edge is graduated in centimeters

from 0 to 24. On the diameter line is a scale graduated from 0 to 5000 for reading map distances on a map of

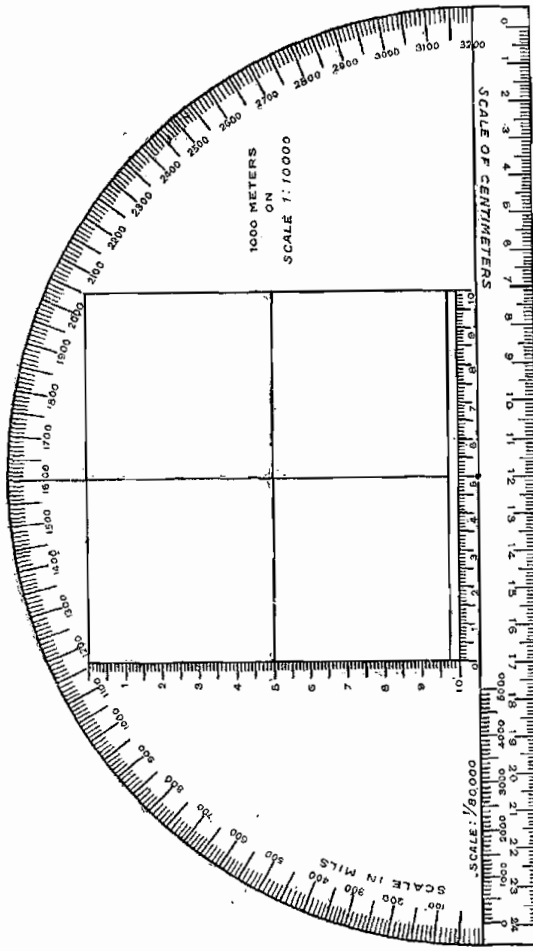


Fig. 124.

the scale of 1/80000. In the center of the protractor is a coordinate square (described later).

To Use the Protractor.

To lay off an angle from a point on a straight line, lay the diameter on the line with the center at the point. Make a dot with a sharp pointed pencil on the map or paper opposite the required reading on the circumference. Remove the protractor and through the two points draw a straight line, it will make the required angle with the given line.

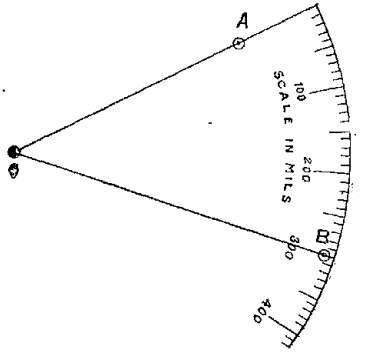


Fig. 125.

To find the number of mils (degrees, grades) between two points on a map (A and B) from a third point O.

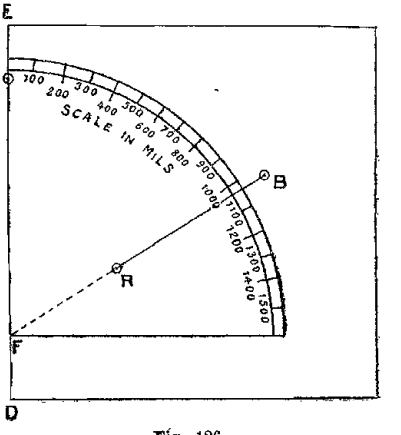


Fig. 126.

Draw the lines OA and OB on the map. Place the diameter of the protractor along OA the center at O. Note where the continuation of OB cuts the graduated circumference. This will give the value of the angle AOB or the number of mils (degrees, grades) between the points A and B.

To find the grid bearing between two points (A and B) on a map : Fig. 126. Draw a line from B to A and continue this line until it cuts the grid line DE. Place the diameter of the protractor on the grid line DE, the center at the point F. Note where the line FAB cuts the graduated circumference of the protractor. This will be the grid bearing of the point B from A.

Grid bearings are always taken from the grid line and the reading is always made in azimuth.

Alidade.

80. The alidade is an instrument used with a plane table to draw a ray in the direction of any visible object. It is also used to obtain per cent grades.

General Description.

The alidade used by Machine Gun Organizations is of French manufacture. The base is graduated on one side in centimeters and may be used as a ruler. In the center of the base is a spirit level used to level the instrument.

Two rectangular folding arms, one at each end constitute the sighting apparatus. The rear arm contains three small holes for sighting. The front arm has an opening through the center of which runs a vertical wire. The sides are graduated in per cent grade.

To Use the Alidade.

To draw a ray. — Place the alidade on the plane table and sight through one of the holes in the rear arm. When the object desired is cut by the wire on the front arm, draw a line along the graduated side of the base. This will be the ray from the point where you are to the object sighted on.

To determine per cent grades. — Place the alidade on the plane table and level it using the spirit level in the center of the base. Sight through the lower hole in the rear arm and note where the top of the hill cuts the scale on the right of the front arm. This will give the per cent grade of a hill from the base to the summit. Being at the summit to read the per cent grade to the base look through the upper hole in the rear arm and note where the base of the hill cuts the scale on the left of the front arm.

Plane Table.

81. The plane table issued to machine gun organizations is a portable instrument used in the field for sketching and map work. It consists of a drawing board about 40 cm. square mounted on a tripod with folding legs.

When set up for use the drawing board is fastened to the tripod in such a manner that it may be turned in azimuth or clamped in any position.

When not in use the board is carried by the handle of a waterproof canvas cover fitted with pockets for the alidade, compass and drawing materials. The legs of the tripod are folded and held together by a strap.

Uses of the Plane Table.

82. *The selection of a base.* — In using the plane table for determining points by intersection, a base-line must be accurately measured between two points over which the table may be set, and this base-line must be plotted to scale on the paper in practically the same relative position it occupies on the ground to be plotted. The selection of the site for plane table base-line should be governed by the following considerations. First, its position should be a central one. Second, it should be of a length proportioned to the area to be surveyed.

If the nature of the country is such that a base-line of a length proportioned to the extent of the survey cannot be found, the intersections may be extended as described under triangulation.

In triangulation work, several of the triangulation points are plotted to scale on the table sheet, the distances between them having been computed. These points and computed distances constitute stations and base lines for beginning work with the plane table. Any errors in measuring or plotting the base-line produce proportional errors in all other lines plotted.

83. *Orientation.* — The chief and controlling condition in work with the plane table, and without which no accurate work can be done, is that it shall be oriented: that is, that at every station all lines joining points on the paper shall be parallel to the corresponding lines on the ground, or, that the table shall have at every station a position parallel to those it had at all others.

84. *Locations by intersection.* — This consists in the location on the map or plot of points not occupied, by pointings from known and plotted points after the table has been oriented at each known point.

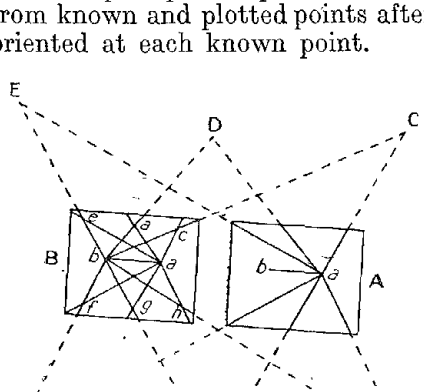


Fig. 127.

The base-line, or the stations A and B at its extremities (Fig. 127), having been plotted to scale on the paper in *a* and *b*, the table is set up over one of them, as A, approximately oriented with the plotted point *a* directly over the point A on the ground, and then leveled.

The beveled edge of the alidade is placed on the two plotted points *a* and *b* and the table revolved until B is bisected by the line of sight, with the point *b* towards it, then the table is clamped. The table is now said to be oriented, and it must be brought parallel to this position at every setting for this survey.

The ruler, with its beveled edge pivoted on *a*, is now revolved around towards the points C, D, E, F, G, H, and all other points the location of whose positions it is desired to fix by intersection, and a short line is drawn at the estimated distance of the point each time, and marked with a letter or number so as to distinguish it, keeping a note of the same for reference.

A pin or needle is sometimes stuck in the plotted station, against which the ruler is pivoted in taking sights, but this defaces the paper if many stations are occupied.

The table is then carried to B and set up approximately oriented with the point *b* over B, the end *a* of the plotted line *ab* pointing towards A, and then leveled. The beveled edge of the ruler is now placed on *ba*, and the table revolved until A is bisected by the line of sight then clamped. In this position the table is oriented. The alidade, with its beveled edge pivoted on *b*, is now revolved around towards each of the points sighted from A, and the intersection of the two pointings on the same object marked, thus locating the true position, on the plot, of the point with reference to the base-line. Other points, seen from B, on which it is desired to intersect from subsequent stations, are now sighted and lines drawn, as at A. If the table be now taken to any of the points intersected from A and B, as C, and there set up and oriented by sighting back on A or B, and then sights be taken on the other points D, E, etc., and lines drawn, these lines should pass through the points already determined. By this means the previous work is checked, and this check should not be omitted for important points.

Precautions to be observed. — When the alidade is directed upon an object, the extreme ends should be marked by check dots, so that it may be replaced with greater certainty by these than it could on the short

line between the objects, if it should be desired to use such lines subsequently to orient the table. Angles of intersection less than 30° or greater than 150° should be avoided, if possible, or checked from other points. Preferably they should be between 60° and 120°, 90° being the best. To obtain such angles, the points intersected should not be at a much greater distance from either of the viewing stations than the distance between the latter; nor should the angle between the line joining the two viewing stations and the line joining either viewing station with the point sighted upon, be much greater than 90°.

Points unsuitably situated for intersecting from the ends of the base-line may be sighted from one end, with a view to intersection from more favorably situated points later. As soon as a point is determined, the details surrounding it should be drawn in.

85. *Location by resection.* — This consists in finding the point on the map or plot which corresponds to the point on the ground over which the table is set, and is done by pointing to known and plotted points, after the table has been oriented. All problems under Resection consist of two parts—viz., the orientation and the resection.

In this determination the difficulty that arises is, how to orient the table.

1st method. — By use of the magnetic needle.

Orientation. — If the magnetic meridian has been marked on the plot, then by using the compass the table may be oriented at any place where it may be set up, as described under Traversing.

Resection. — The point occupied may be plotted by selecting two points (already plotted) about 90° apart, pivoting the ruler on the plotted position of one, sighting the object, and drawing a line back; then pivoting the ruler on the plotted position of the second object, sighting it, and drawing a line back, intersecting the previous line drawn; this intersection will be the plotted position of the point occupied.

Magnetic disturbances of the needle will, of course, affect the accuracy of this method, which may be tested

by sighting, as before, on any other visible plotted point and seeing if the line passes through the point found. If not, it proves that the table was not exactly oriented.

2nd method. — By use of three known and plotted points (the three-point problem).

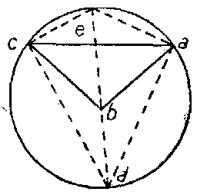


Fig. 128.

Orientation. — The table may be at once oriented at any unknown point from which three known plotted points are visible, except when itl ies on the circumference of a circle passing through the three known plotted points. In Fig. 128 let *a, b,* and *c* be the plotted positions of A, B, and C respectively, and D the unknown point. The table is set up over D and leveled. The ruler is set on the line *ca,* and *a* directed, by revolving the table, to its corresponding signal A and the table clamped. Then with the alidade pivoted on *c,* the middle signal B is sighted and the line *ce* drawn. The alidade is then set on the line *ac,* and *c* directed, by revolving the table, to its corresponding signal C and the table clamped. Then, with the alidade pivoted on *a,* the middle signal B is sighted and the line *ae* drawn. The point *e* (intersection of these two lines) will be in the line passing through the middle point and the point *d.* Set the alidade on the line *be,* direct *b* to the signal B by revolving the table and it will be oriented.

Resection. — Clamp the table, pivot the alidade on *a,* sight A and draw the line *ad;* this will intersect the line *be* at the point *d* sought. Pivoting on *c,* sighting C will verify it. The angles *ace* and *ade* are subtended by the same chord *ae,* and *cae* and *cde* by the chord *ce,* hence *e* must fall on *db;* also, *f* being the point of inter-

section of *ac* and *de*, the triangles *adf* and *cef* are similar and the triangles *cdf* and *aef* are similar, hence *d*, *f*, and *e* must be in a right line through *b*. (This is called Bessel's method by inscribed quadrilateral.)

Coordinates.

86. The coordinates of a point are the kilometric and hectometric values of a point expressed numerically.

The kilometric values are shown on the grid lines along the borders of the map. The hectometric values in any square are obtained by measuring the horizontal and vertical distances from the grid lines with the coordinate square.

Example : Designation of point A,

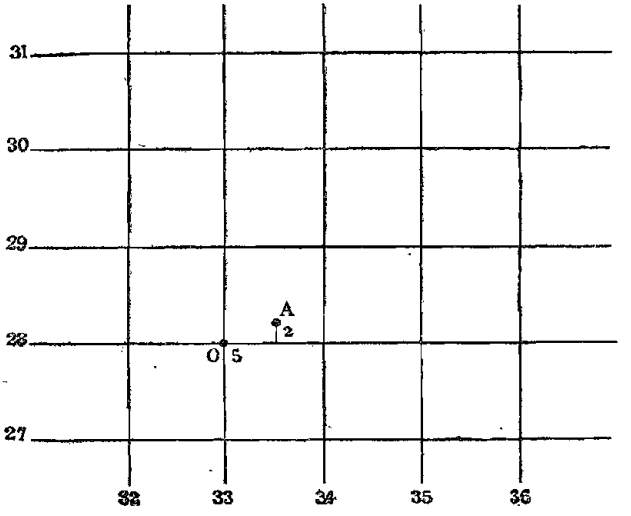


Fig. 129.

1. Determine the kilometric coordinates of the vertex of the angle 0 of the square in which point A is situated.

Coordinates of 0 are 33—28.

2. Determine the hectometric coordinates of point A as related to the lines passing through 0.

Hectometric coordinates of A are 5—2.

3. Inscribe the hectometric coordinates after the corresponding kilometric coordinates.

The coordinates of A are 33.5—28.2.

a) Always give the coordinates in the following order :

1 — Abscissae.
2 — Ordinates.

(*b*) When there cannot be any error of 10 kilometers, suppress the 1st figure of each group of coordinates of A, viz. 3.5—8.2.

Coordinate Squares.

87. The coordinate square is an instrument used for determining the location of a point whose coordinates are known. It is made to the same scale as the map on which it is to be used. It may also be used to find the coordinates of a known point on the map.

GENERAL DESCRIPTION OF COORDINATE SQUARES.

The coordinate square on the protractor is graduated in centimeters (0 to 10) on the left and bottom sides. A slit is placed along the bottom side to permit the marking of points when located on a map (see diagram on semi-circular protractor). This coordinate square is for use with maps drawn to the scale of 1/10000. Each side of the squares on these maps made by the abscissae and the ordinate is 1 kilometer.

Coordinate squares may be made with cross section paper in the following manner :

Cut out an "L" shaped piece of the paper with a vertical arm of 10 centimeters and a horizontal arm of 10 centimeters. Care should be taken that the measuring edge is straight. A slight irregularity in the measuring surface will account for an error of ten or twenty meters in the location of a point. The most convenient size to make the arms of the square is three centimeters wide and in order to make it easier to handle and less liable to be torn, it should be mounted on a

stiff piece of paper or cardboard. After the square has been cut out, it is numbered as shown in figure 130.

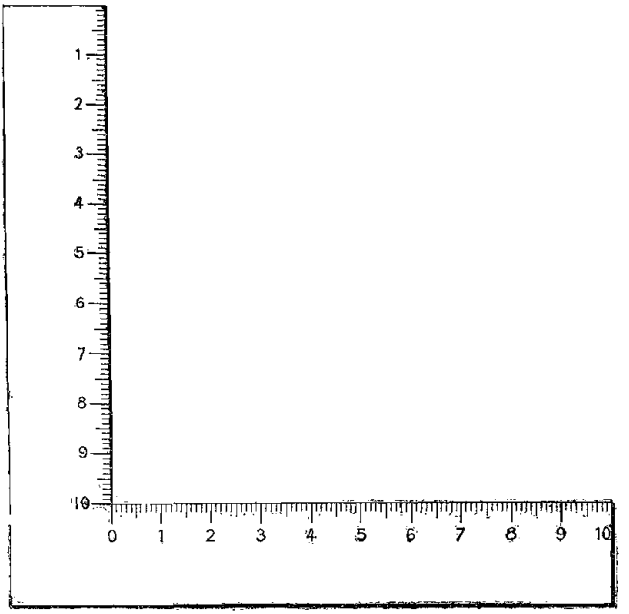


Fig. 130.

The numbers from 0 to 10 on the vertical arm, and 0 to 10 on the horizontal represent centimeters, while the smaller divisions in between read millimeters.

USE OF THE COORDINATE SQUARE.

Given the coordinates 35.40—15.35. To locate this point on the map proceed as follows : it has been stated that the horizontal coordinate is given first followed by the vertical ordinate. (This holds true in all cases and should be remembered). 35—15 refers to the lower left hand corner of the rectangle formed by the intersection of the vertical line 35 and the horizontal line 15. Place the coordinate square on the rectangle with the intersection of the horizontal and vertical arms

directly over the lower left hand corner of the rectangle in question. Next, keeping the vertical arm parallel to the sides of the rectangle, move the square from the bottom toward the top of the rectangle until the line bounding it on the top cuts the vertical arm of the square at 3.5. Then look along the horizontal arm of the square until the division 4.0 is reached. Make a small dot on the map at this point 35.40—15.35. Any point whose coordinates are known would be located in the same manner.

In order to find the coordinates of a known point on the map proceed as follows : note the numbers of the lines which intersect at the lower left hand corner of the rectangle in which the point is to be located. For example, assume the point in question lies directly in the center of the rectangle 35—15. Place the coordinate square on the lower left hand corner of this rectangle, as before, and move it from the bottom towards the top of the rectangle until the horizontal arm of the square crosses the point on the map. Note the reading on the horizontal arm, in this case it will be found to be 3.4, and then note the reading on the vertical scale where the line bounding the rectangle on the top cuts it at 5.0. In this manner it will be found that the coordinates of the point are 35.34—15.50.

Gun Level.

88. The gun level is an instrument used in conjunction with the rear sight leaf of the machine gun to lay the gun in elevation.

General Description.

It consists of a graduated glass tube mounted on a triangular base. The base fits on the rear sight leaf of the gun. The bubble which is free in the tube registers under the graduations, which run from 1 to 9.

Use of the Gun Level.

The gun level is used :

1. In connection with table No. 8 for the laying of the gun in elevation.

2. As each graduation of the gun level has a value of approximately three mils it may be used to elevate or depress the muzzle of the gun through small vertical angles until the lines of the tube are reached by the bubble.

In either case the level is placed on the rear sight leaf with the apex to the rear.

APPENDIX 1.

PART 1.

Orders for gun positions.

The squad commander is responsible for the following:

1. That the number of the emplacement is placed outside of the emplacement where it can be readily seen.

2. That concealment of machine gun emplacements being important, machine guns are not fired from their regular emplacements, except in case of emergency.

3. That unless emplacements are well concealed, guns are not mounted except between evening and morning "posts" and when visibility is poor.

4. That two men by night and one man by day per detachment are always on duty with the gun.

5. That written orders for the emplacement are posted where they can be read by all members of the squad.

6. That a range card is prepared and posted near the gun. That in addition to the range to each objective the range card shows the clinometer or gun level reading for indirect laying on each objective.

7. That there is a minimum of 4250 rounds of ammunition in belts or strips and sufficient other ammunition to bring the total up to 10000 rounds.

8. That each man has 35 rounds of pistol ammunition.

9. That there are 48 grenades.

10. That all machine guns, pistols, ammunition and grenades are inspected and cleaned at morning and evening posts.

11. That there is a bolo or hatchet convenient for opening boxes of ammunition or grenades.

12. That the emergency mount is at hand for use in case tripod is damaged.

13. That there is a sufficient quantity of water for cooling gun and not less than a pint of oil.

14. That there is a spare barrel and spare parts case in the emplacements.

15. That there are 1 pick, 1 shovel and 12 sand bags in the emplacement.

16. That elevating and traversing clamps are used when provided and that otherwise stakes and cross-pieces (fool proofs) be used to limit the movement of the gun.

17. That aiming stakes are placed to indicate to the gunner his normal direction of fire. Night firing boxes or luminous discs to be used at night.

18. That the gun is inspected for all points covered in pars. 146 and 148, Machine Gun Drill Regulations.

19. That the camouflage of the emplacement is kept in good condition and that there is no movement to disclose position to the enemy.

20. That in addition to the flash arrestor, wet sand bags are used to hide the flash of the gun when firing at night.

21. That during the day the gun is kept covered unless it is very close to the enemy. That at night it is always loaded. That all members of the squad know the location of and routes to any alternative emplacements assigned to the squad.

22. That sentries are relieved at prescribed intervals and that sentries know their orders thoroughly.

The sentry at the gun will know :

1. What to do if he sees the enemy.

2. The sector of fire assigned to the gun.

3. All objectives shown on the range card.

4. What the S. O. S. signal is.

5. What the S. O. S. barrage line is and how to lay the guns either by direct or indirect methods, when the S. O. S. signal is given.

6. Line of fire if enemy penetrates our front line.

7. When relieving another sentry, the following facts will always be ascertained.

(*a*) Whether the gun has been fired during the relief.

(*b*) If fired, what the target was.

(*c*) If fired, the emplacement from which it was fired.

(*d*) Whether any instruction have been received as to friendly patrols or wiring parties.

8. The sentry will always inspect the gun when taking over the position.

9. In case of alarm, or a gas attack, the sentry will wake the gun team.

PART 2.

Report of inspection of M. G. organizations.

Machine gun battalion commanders, infantry battalion commanders, and other officers inspecting machine gun organizations in the presence of the enemy should cover the following points in their inspection :

1. That all orders prescribed for commander of gun squad and for the sentry on duty at the gun are carried out.

2. That there is an officer on duty with each platoon.

3. That the 4 guns of the platoon are close enough together to be inspected readily and controlled by the platoon commander, if the tactical situation permits.

4. That the platoon and company command posts are centrally located with reference to the guns of the platoon and company.

5. That communication by telephone, visual signals and runner is provided for.

6. The following points should be noted with reference to emplacements :

Siting.
Field of fire.
Type.
Cover.
State of camouflage.
Are there tracks leading to emplacements which will give away position ?

7. Is there a deep trench, shrapnel proof or dugout for the members of the gun squad? If so,

Distance from gun,
Type,
Capacity,
Are there gas curtains and anti-gas apparatus ?

8. Disposition of reserve guns. Possible disposition, one at each platoon command post and one at company command post.

9. Are riflemen, auto-riflemen or bombers employed to cover dead ground that cannot be covered by the machine gun ?

APPENDIX II.

PART I.

Procedure in calculating data for a barrage position involving indirect fire from a map.

(A) *Data to lay in Direction.*

1. Plot positions of barrage platoon, targets, friendly troops, or mask and reference object on map. Note the angle made by the target, or the barrage position, with the line through a flank gun and the corresponding element of the target; if greater than 1870 mils or less than 1330 mils, a "working base" must be used.

2. Measure range : { Gun to target / Gun to reference object / Gun to friendly troops

platoon front.

target front.

NOTE. — If working base is not required, range of directing gun to its element of the target is sufficient.

3. Decide upon and draw the zero line of the directing gun on the map. Find grid bearing of reference object and zero line.

4. Find parallax for flank gun and then for each other gun of the platoon.

5. Find the angle of switch for directing gun and then that for each other gun of the barrage platoon by adding to the angle of switch of the directing gun the parallax of that particular gun.

NOTE. — The angle of switch plus the parallax for each gun lays it on its zero line.

6. Find the angle of distribution or concentration

for the flank gun and then for each other gun of the barrage platoon.

7. Make necessary corrections for lateral wind.

8. Compute the deviation in mils from its zero line for each gun.

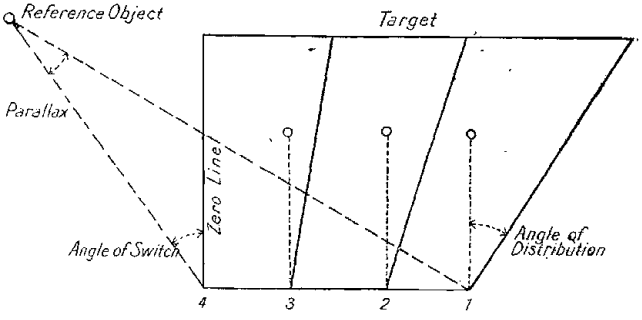


Fig. 1. — Barrage position.

(B) *Data to lay in Elevation.*

1. Determine contour of barrage position target, friendly troops and mask.

NOTE. — The average contour of the barrage position is sufficient unless there is a difference of more than 3 meters between the ends of the barrage position.

2. Compute vertical interval. { Gun position to target. / Gun position to friendly troops or mask.

3. Find angle site from gun to target.

4. Correct the measured range for *atmospheric conditions,* if practicable.

5. Obtain rear sight setting and bubble reading for corrected range.

6. Obtain the quadrant elevation in mils.

7. Determine the clearance of the lowest shot over friendly troops or mask.

8. Fill in "Platoon Chart" and "Gun Chart" and prepare Platoon Commander's Flighting Map.

For Successive Barrages from same Barrage Position.

(A) *Data to lay in Direction.*

NOTE. — All calculations or measurements for laying in direction for successive barrages must be made from the zero line of the barrage position.

1. Determine the deviation of the directing gun from its zero line when laid on its element of the new target.

2. To this add the angle of distribution or concentration for each gun, which gives the deviation of each gun from its zero line.

3. Compute the necessary corrections for latera wind.

4. Make the necessary correction in the deviation from its zero line for each gun.

(B) *Data to lay in Elevation.*

1. Proceed as in the case of the first target.

Should the angle formed by the target and the line joining a flank gun with its corresponding end of the target be greater than 1870 mils or less than 1330 mils, construct a working base.

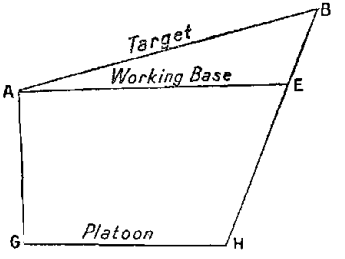


Fig. 2

2. Compute the data for laying in direction on the working base as given above.

3. Determine the data to lay in elevation on oblique target by determining the quadrant elevation and rear sight setting and bubble reading of the directing gun on each end of the oblique target. Divide the difference

between the two quadrant elevations by the number of gun intervals. Beginning with the directing gun, give each gun its angle of elevation in a manner similar to the method prescribed for giving it the angle to "open" or "close" for distribution or concentration (Up 30 mils, add 10; down 10 mils, less 5).

NOTE. — The following pages illustrate the methods employed in calculating fire data for successive barrages and making platoon charts, gun charts and fighting maps.

Example.

Given :

1/10000 Map of Langres, No. 4-b.

Coordinates of Targets . . . . { (A) 38.09—19.01. 38.15—19.25. (B) 39.295—18.815. 39.36—19.06.

Coordinates of Barrage Position. { 36.48—19.35. 36.48—19.32.

Coordinates of Friendly Troops. { 37.21—19.31, 1st position. 38.13—19.20, 2nd position.

Coordinates of Reference Object : 37.625—19.330.
Platoon of 4 guns. No. 4 directing gun.
Barometer : 73.7.
Thermometer + 7.2.
Wind : 8.94 m. p. s. at 4 o'clock (2160 mils from T).

Example.

Direction—Target "A"

1. Plot Barrage Position. Targets. Friendly Troops. Reference Object. Measure angle between line of target and lines from gun to target.

2. Range : G to T { (A) 1000 meters. (B) 1900 meters.
G to R.O. . . . . 815 meters.
G to F.T. . . . . { (1) 400 meters. (2) 1000 meters.

Platoon Front . . 10 meters.
Target Front . . . (A) 250 meters.
(B) 250 meters.

3. Draw Zero Line of directing gun through points 36.48—19.33 and 38.15—19.25.
Grid Bearing Reference Object = 1600 mils.
Grid Bearing Zero Line = 1683 mils.

4. Parallax of flank gun (No. 1) = 12.3 mils.
(*a*) By protractor on map = 12 mils.

(*b*) $$M = \frac{W}{R} \times 1000 = \frac{\text{Platoon Front} \times 1000}{\text{Range to Reference Object.}}$$

$$= \frac{10}{815} \times 1000 = 12.3 \text{ mils.}$$

$$\text{Parallax of No. 2 Gun} = \frac{12.3}{3} \times 2 = 8.2 \text{ mils.}$$

$$\text{Parallax of No. 3 Gun} = \frac{12.3}{3} = 4.1 \text{ mils.}$$

Parallax of No. 4 Gun = 0.

5. Switch for directing Gun (No. 4) :
(*a*) Measure angle between zero line of directing gun and line D. G. to R. O. by protractor. Angle = 83 mils Right.

(*b*) $$M = \frac{W}{R} \times 1000 = \frac{\text{Perpendicular Distance R. O. to Zero Line} \times 1000}{\text{Range D. G. to R. O.}}$$

$$= \frac{68}{815} \times 1000 = 83.5 \text{ mils Right.}$$

Switch for No. 3 Gun = 83.5 mils + 4.1 mils = 87.6 mils Right.
Switch for No. 2 Gun = 83.5 mils + 8.2 mils = 91.7 mils Right.
Switch for No. 1 Gun = 83.5 mils + 12.3 mils = 95.8 mils Right.

6. Distribution for Flank Gun (No. 1).

$$M = \frac{W}{R} \times 1000 = \frac{\text{Target Frontage} - \text{Platoon Frontage}}{\text{Range G to T}} \times 1000$$

$$= \frac{250 - 10}{1000} \times 1000 = 240 \text{ mils Right.}$$

Distribution for No. 2 Gun = 2/3 × 240 = 160 mils Right.
Distribution for No. 3 Gun = 1/3 × 240 = 80 mils Right.
Distribution for No. 4 Gun = 0.

7. Lateral Wind Correction :
Lateral Component of 8.94 m. p. s. at 4 o'clock requires approximately 4 1/2 mils at 1000 meters. Wind from 4 o'clock requires 4 1/2 mils Right.

8. Deviation from Zero Line :
No. 4 Gun : 0 Distribution + 4 1/2 mils Right (Wind) = 4 1/2 mils Right.
No. 3 Gun : 80 mils Right + 4 1/2 mils Right (Wind) = 84 1/2 mils Right.
No. 2 Gun : 160 mils Right + 4 1/2 mils Right (Wind) = 164 1/2 mils Right.
No. 1 Gun : 240 mils Right + 4 1/2 mils Right (Wind) = 244 1/2 mils Right.
NOTE. — Omnibus tripod, 1 division = 7.5 mils.
New Hotchkiss tripod, 1 division = 10 mils.

Elevation — Target "A"

9. Gun Contour : 396 meters.
Target Contour : 391 meters (nine o'clock end).
376 meters (three o'clock end.)
F. T. Contour : 370 meters.

10. V. I. from G to T :
No. 4 = — 5 meters.
No. 3 = — 10 meters.
No. 2 = — 15 meters.
No. 1 = — 20 meters.
V. I. from G to FT : = — 26 meters.

11. Angle of Site G to T : No. 4 = — 5 mils (Table 3)

$$\text{or } M = \frac{W}{R} \times 1000 = \frac{5}{1000} \times 1000.$$

No. 3 = — 10 mils (Table 3) or $M = \frac{10}{1000} \times 1000.$

No. 2 = — 15 mils (Table 3) or $M = \frac{15}{1000} \times 1000.$

No. 1 = — 20 mils (Table 3) or M = $\frac{20}{1000} \times 1000$.

12. Correct measured range for atmosphere :

(*a*) (By Table No. 4.)

Barometer correction = 11.7 meters (deduct).

(*b*) (By Table No. 4.)

Thermometer correction = 20.3 meters (add).

(*c*) (By Table No. 5.)

Wind Correction :

Tail component at 100 meters = approximately 11 meters.

Net correction = — 11. + 20.3 — 11 = — 2.4 meters (deduct).

13. Rear Sight Setting and Bubble Reading :

By Table 8 :

Range 1000 ∠ site — 5 mils = 1608.
Range 1000 ∠ site — 10 mils = 1606.5
Range 1000 ∠ site — 15 mils = 1605.
Range 1000 ∠ site — 20 mils = 1603.

By Abaque :

Range 1000, V. I. — 5 meters = 1608. : No. 4 Gun.
Range 1000, V. I. — 10 meters = 1606.5 : No. 3 Gun.
Range 1000, V. I. — 15 meters = 1605. : No. 2 Gun.
Range 1000, V. I. — 20 meters = 1603. : No. 1 Gun.

14. Quadrant Elevation.

Abaque :	Table No. 2 Q. E. = T. E. ± ∠ site.
No. 4 Gun = + 13 mils	No. 4 = 18 — 5 = 13 mils.
No. 3 Gun = + 8 mils	No. 3 = 18 — 10 = 8 mils.
No. 2 Gun = + 3 mils	No. 2 = 18 — 15 = 3 mils.
No. 1 Gun = — 2 mils	No. 1 = 18 — 20 = — 2 mils.

15. Clearance of lowest shot over Friendly Troops.

Height of center shot above horizontal at 400 meters.

By calculation :

No. 4 = + 3.4 meters.
No. 3 = + 1.4 meters.
No. 2 = — .56 meters.
No. 1 = — 2.7 meters.

} + .38 meters is average.

By abaque :

No. 4 = + 3.4 meters.
No. 3 = + 1.4 meters.
No. 2 = — .6 meters.
No. 1 = — 2.7 meters.
} + .37 meters is average.

Height of center shot above lowest shot = 1.2 from Table of Ordinates.

Height of lowest shot above horizontal = — 2.7 — 1.2 = — 3.9 meters.

Contour of F. T. = 370.

Height of F. T. below gun = 370 — 396 = — 26 meters.

Height of L. S. above F.T. = 26 — 3.9 = 22.1 meters.

Second Barrage — Direction — Target "B".

1. To obtain deviation of Directing Gun from its Zero Line, measure on map the angle between Zero Line and line through Directing Gun and left element of target "B", 66 mils; or measure the distance between these lines at target "A" and then use :

$$M = \frac{W}{R} \times 1000 = \frac{66}{1000} \times 1000 = 66 \text{ mils.}$$

All guns deviate 66 mils Right.

2. Distribution for Flank Gun No. 1 $= \frac{250 - 10}{1900}$ $\times$ 1000 = 126 mils Right.

No. 2 Gun = 2/3 of 126 = 84 mils Right.
No. 3 Gun = 1/3 of 126 = 42 mils Right.
No. 4 Gun = 0.

3. Wind Correction (By Table No. 5) :

8.94 m. p. s. at 1900 meters = 19.6 meters correction or 10 mils Right.

4. Deviation from Zero Line :

No. 4 Gun : 66 mils Right (Deviation) + 0 (Distribution) + 10 mils Right (Wind) = 76 mils Right.

No. 3 Gun : 66 mils Right (Deviation) + 42 mils Right (Distribution) + 10 mils Right (Wind) = 118 mils Right.

No. 2 Gun : 66 mils Right (Deviation) + 84 mils Right (Distribution) + 10 mils Right (Wind) = 160 mils Right.

No. 1. Gun : 66 mils Right (Deviation) + 126 mils Right (Distribution) + 10 mils Right (Wind) = 202 mils Right.

Elevation — Target "B".

5. Gun Contour : 396.
Target Contour : 352.
F. T. Contour : 390.
V. I. from G to T : — 44 meters.
V. I. from G to F. T. : — 6 meters.
∠ site G to T : — 23 mils.

6. Correct measured range for atmosphere (By Tables No. 4 and No. 5).
Barometer correction = 25.35 meters (deduct).
Thermometer correction = 44.46 meters (add).
Wind correction = 39.33 meters (deduct).
Net correction = — 25.35 + 44.46 — 39.33 = — 20.22 meters (deduct).
Corrected Range = 1900 — 20 = 1880 meters.

7. Rear Sight Setting and Bubble Reading for :

Range 1900 { ∠ site — 23 mils (Table 8) = 1656.25.
V. I. 44 meters (abaque) = 1656.5.

Range 1880 { ∠ site — 23 mils (Table 8) = 1656.25.
V. I. 44 meters (abaque) = 1656.5.

8. Quadrant Elevation :
(*a*) Normal :
By abaque = 32 mils.
By calculation = 32 mils.
(*b*) Corrected :
By abaque = 31 mils.
By calculation = 31 mils.

9. Equivalent Range = 1425 meters.

10. Clearance **of** lowest shot over Friendly Troops :
Height of C. S. above horizontal at 1000 meters :
By calculation = 14 meters.
By abaque = 14 meters.
Height of C. S. above L. S. = 3 meters.
Height of L. S. above horizontal = 14 — 3 = 11 meters.
Height of F. T. below Gun = 6 meters.
Height of L. S. above F. T. at 1000 meters = 11 + 6 = 17 meters.

CHARTS AND TABLES

APPENDIX II.

PART 1-A

Group organization chart.

Date .....

Reference ..... No..... Group Commanded by..... Group H. Q.

BARRAGE Platoon	COMPOSITION	NO. OF Guns	COMMANDER	LOCATION	TARGETS	TIMES From	TIMES To	RATE of fire R. P. M.	REMARKS
"A"	1st Platoon. . . 1st Co., 4th M. G. Bn. .	4 4	Lt. Smith.	36.48—19.33 36.48—19.32	1. Barrage . . . . . 38.09—19.01 to 38.15—19.25	0	0 + 15	150	300 on S. O. S.
					2. Barrage . . . . . 39.295—18.815 to 39.35—19.06.	0 + 16	0 + 30	100	Same.
"B"	2nd Platoon. . 1st Co, 4th M. G. Bn .	4 4	Lt. Jones	36.62—19.71 36.61—19.66	1. Engage Strong Point. . . . 38.22—19.49.	Same	as for	"A"	Same.
					2. Barrage . . . . . 39.35—19.06 to 39.40—19.30.	"	"	"	"
		4			3. Engage Strong Point. . . . 40.05—19.16.	0 + 35	0 + 45	150	"
"C"	Etc.	Etc.	Lt. White	Etc.	Etc.	Etc.	Etc.		Etc.

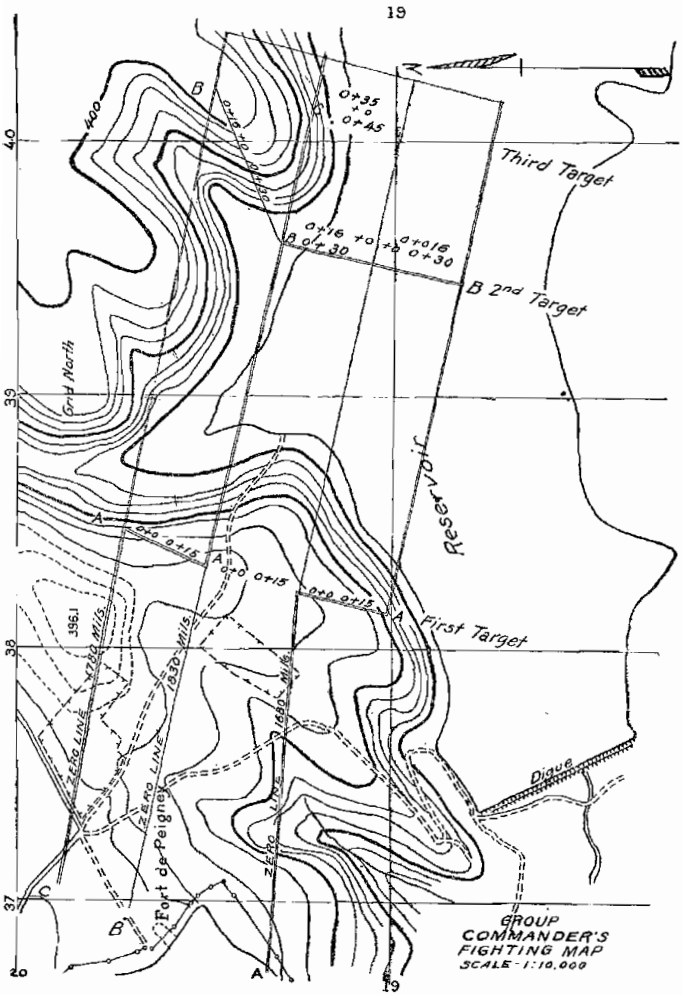
Map used
1/10000 Langres No. 4-b.

Date 5/3/18.

Signature *J. L. Moore,*
Capt. Infantry.
Group Commander

APPENDIX II.

PART 1-B.



APPENDIX II.

PART 2-A.

Platoon chart.

Barrage Platoon "A"	Place Target Range A.I.S. School		Date May 4. 1918
Composition 1st Plat. 2nd Co. 4th M. G. Bn.	Grid Bearing to R.O. 1600	Mils	Tasks
Commanded by Lt. Smith	Grid Bearing of Zero Line 1683	Mils	Standing Barrage on
Location of D.G. 3648.1933	Angle of Switch of D. G. 83	Mils	A and B S.O.S., on Signal.
No. of Dir. Gun No. 4.	Parallax of Barrage Position 12.3	Mils	
Platoon Front 10 Meters	Zero Line from 3648.1933	through 3809.1901	

No. of Barrage	Targets	Clock Time	Zero Time	Normal Deviation from Zero Mils	Distribution in Mils	Range in Meters	V.I. Meters (Plus or Minus)	Q.E. in Mils		R.S. Table No. 8		Range to F.T. Meters	Clearance of L.S. Meters	Rate of Fire R.P.H
								Normal	Corrected	Normal	Corrected			
A	3609.1901 3615.1925		0 to 0+15	0	240 R	1000	No. 1-20 No. 4-5	-2 +13	-2 +13	1603 1608	1603 1608	400	22.1	150
B	39295.18815 3935 1906		0+15 0+30	66 R	126 R	1900	-44	32	31	16565	16565	1000	17	100
C														
D														
E														

	Normal Deviation				Corrected Deviation			
	4	3	2	1	4	3	2	1
A	0	80 R	160 R	240 R	4.5 R	84.5 R	164.5 R	244.5 R
B	66 R	108 R	150 R	192 R	76 R	118 R	160 R	202 R
C								
D								
E								

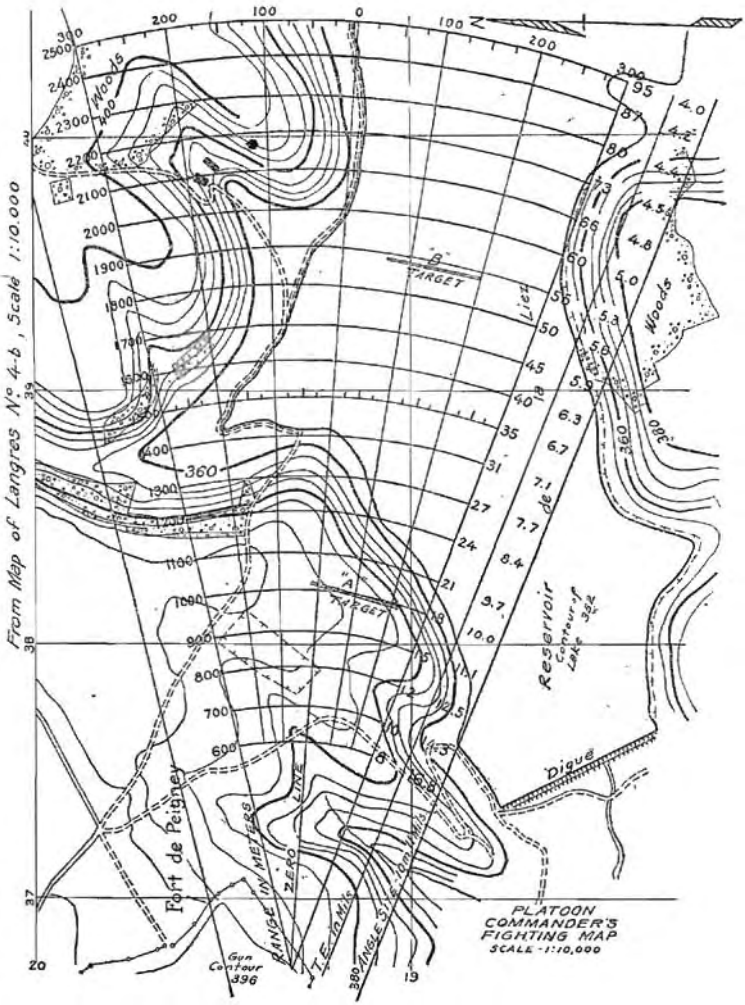
This shows the deviation in mils from Zero Line for each gun. From this the barrage chart for each gun is compiled and issued to the gun commanders. In addition, these angles may be shown in divisions of the scale.

Remarks.

Checked by: Captain Young

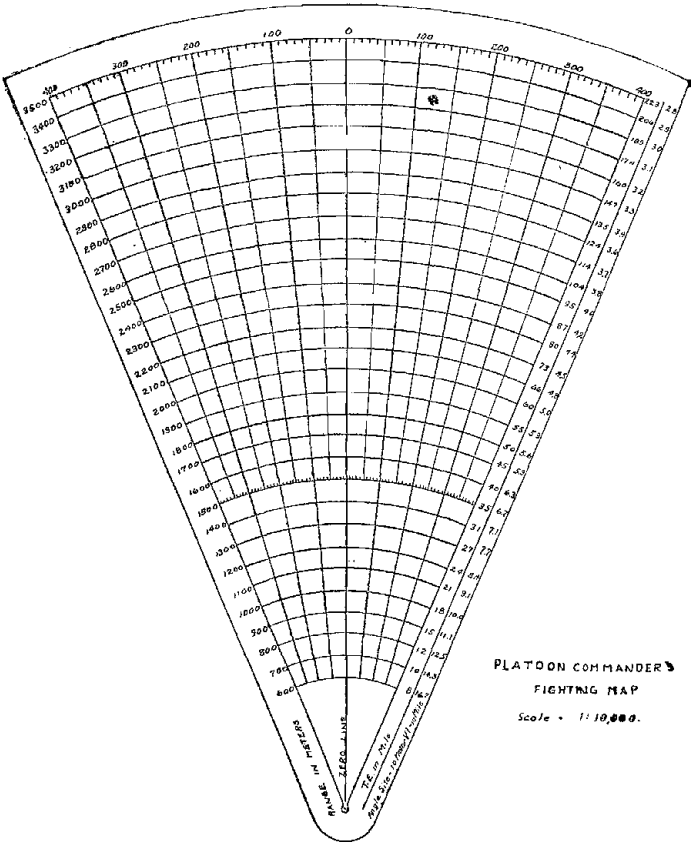
APPENDIX II.

PART 2-B.



APPENDIX II.

PART 2-B.



APPENDIX II.

PART 3-A.

Gun Chart.

Gun No. 1. Barrage Platoon "A"

Gun Commander Corporal Jones Barrage Platoon Commander Lt. Smith

Grid Bearing of Zero Line 1683 Mils | Date May 4, 1918.

Number of Barrage	Clock Time		Zero Time		Deviation from Zero Line		Q. E. in Mils		R.S. Table 8		Traverse in Mils	Search in Mils	Rate of fire R.P.H
	From	To	From	To	Mils	Div.	Normal	Corrected	Normal	Corrected			
A			0	0+15	240 R	24 R	-2	-2	1603	1603	20	6	150
B			0+15	0+30	192 R	19 R	32	31	1656.5	1656.25	20	6	100
C													
D													
E													
F													

Remarks

Add 4.5 Mils Right on "A" due to wind.

Add 10 Mils Right on "B" due to wind.

Special Orders.

1. Check elevation after every two strips for first 200 rounds. Check elevation and direction every 200 Rounds thereafter.
2. Run oiled cleaning rod brush through bore after every 200 rounds.
3. Watch Platoon Commander carefully for signals.

APPENDIX III.

TABLE 1.

Value of degrees and minutes in mils.

DEGREES	MINUTES					
	0′	10′	20′	30′	40′	50′
0°.	0 0	2.9	5.8	8.8	11.8	14.7
1°.	17.7	20.6	23 5	26.5	29 5	32.4
2°.	35.4	38 3	41.2	44.2	47.2	50.1
3°.	53.1	56.0	58.9	61.9	64 9	67.8
4°.	70.8	73.7	76.6	79 6	82.6	85.5
5°.	88.5	91.4	94.3	97.3	100.3	103.2
6°.	106.2	109 1	112 0	115.0	118 0	121.9
7°.	123.9	126.8	129.7	132.7	135.7	139.6
8°.	141.6	144 5	147.4	150.4	153.4	156.3
9°.	159.3	162.2	165.1	168.1	171.1	174.0
10°.	177.0	179.9	182.8	185.8	188 8	191.7
11°.	194.7	197.6	200.5	203.5	206.5	209.4
12°.	212.4	215.3	218.2	221.2	224.2	227.1
13°.	230.1	233.0	235.9	238.9	242 9	244.8
14°.	247.8	250.7	253.6	256.6	260.6	262.5
15°.	265.5	268.4	271.3	274.3	278.3	280.2
16°.	283.2	286.1	289.0	292.0	295.0	297.9
17°.	300.9	303.8	306.7	309.7	312.7	315.6
18°.	318.6	321.5	324.4	327.4	330.4	333.3
19°.	336.3	339.2	342.1	345.1	348.1	351.0
20°.	354.0	356.9	359.8	362.8	365.8	368.7
21°.	371.7	374.6	377.5	380.5	383.5	386.4
22°.	389.4	392.3	395.2	398.2	401.2	404.1
23°.	407.1	400.0	412.9	415.9	418.9	421.8
24°.	424.8	427.7	430.6	433.6	436.6	439.5
25°.	442.5	445.4	440.3	451.3	454.3	457.2
26°.	460.2	463.1	466.0	469.0	472.0	474.9
27°.	477.9	480.8	483.7	486.7	489.7	492.6
28°.	495.6	498.5	501.4	504.4	507.4	510.3
29°.	513.3	516.2	519.1	522.1	525.1	528.0
30°.	531.0	533.9	536.8	539 8	542.8	545.7
31°.	548.7	551.6	544.5	557.5	560.5	563.4

APPENDIX III.

TABLE 2.

Hotchkiss machine gun model 1914.
Table of tangent elevation.
Normal temperature 15°. — Normal pressure 750 mm.

RANGE IN METERS	ANGLES OF TANGENT ELEVATION	
	In degrees	In mils
0	0	0
100	0° 3′ .375	1.0
200	0° 7′ .425	2.2
300	0° 11′ .980	3.55
400	0° 16′ .875	5.0
500	0° 22′ .275	6.6
600	0° 27′ .675	8.2
700	0° 33′ .750	10.0
800	0° 40′ .838	12.1
900	0° 50′ .625	15.0
1000	1° 0′	18
1100	1° 10′	21
1200	1° 21′	24
1300	1° 32′	27
1400	1° 45′	31
1500	1° 59′	35
1600	2° 14′	40
1700	2° 30′	45
1800	2° 47′	50
1900	3° 5′	55
2000	3° 24′	60
2100	3° 44′	66
2200	4° 5′	73
2300	4° 28′	80
2400	4° 53′	87
2500	5° 21′	95
2600	5° 51′	104
2700	6° 23′	114
2800	6° 58′	124
2900	7° 36′	135
3000	8° 16′	147
3100	8° 59′	160
3200	9° 46′	174
3300	10° 38′	189
3400	11° 33′	206
3500	12° 33′	223

APPENDIX

—

TABLE

The quadrant elevation in mils,

8 mm. Hotchkiss Machine Gun,

V. I. in Meters	Target Above Range To Target													
	500	600	700	800	900	1000	1100	1200	1300	1400	1500	1600	1700	1800
1.	2.0	1.7	1.4	1.2	1.1	1.0	.9	.8	.8	.7	.7	.6	.6	.6
5	16.6	16.5	17.1	18.3	20.5	23	26	28	31	35	38	43	48	53
10	26.6	24.9	24.3	24.6	26.1	28	30	32	35	38	42	46	51	56
15	36.6	33.2	31.4	30.9	31.7	33	35	36	39	42	45	49	54	58
20	46.6	41.5	38.6	37.1	37.2	38	39	41	42	45	48	52	57	61
25	56.6	49.9	45.7	43.4	42.8	43	44	45	46	49	52	56	60	64
30	66.6	58.2	52.9	49.6	48.3	48	48	49	50	52	55	59	63	67
35	76.6	66.6	60.0	55.9	53.9	53	53	53	54	56	58	62	66	69
40	86.6	75.0	67.2	62.1	59.4	58	57	57	58	60	62	65	69	72
45	96.6	83.2	74.3	68.3	65.0	63	62	61	62	63	65	68	71	75
50	106.6	91.5	81.4	74.6	70.5	68	66	66	65	67	68	71	74	78
55	116.6	99.9	88.6	76.9	76.1	73	71	70	69	70	72	74	77	81
60	126.6	108.2	95.7	87.1	81.6	78	76	74	73	74	75	77	80	83
65	136.6	116.5	102.8	93.4	87.2	83	80	78	77	77	78	80	83	86
70	146.6	124.8	110.0	99.6	92.8	88	85	82	81	81	82	84	86	89
75	156.6	133.2	117.1	105.9	98.4	93	89	87	84	84	85	87	89	92
80	166.6	141.5	124.2	112.1	103.8	98	94	91	89	88	88	90	92	94
85	176.6	149.9	131.3	118.2	109.4	103	98	95	92	92	92	93	95	97
90	186.6	158.2	138.5	124.6	115.0	108	103	99	96	95	95	96	98	100
95	196.6	166.5	145.8	130.9	120.6	113	107	103	100	99	98	99	101	103
100	206.6	174.9	152.8	137.1	126.2	118	112	107	104	102	102	103	104	106

NO

1. — This table combines the angle of site with the angle of tangent elevation, thereby producing
2. — It is used as follows : — Range = 1900 meters. Target 55 meters above gun. Quadrant ele
3. — The top line where V. I. = 1 meter is used as follows : — *Example I* : Range = 1900, V. I. meter of V. I. the top line shows that 1/2 mil must be ADDED. Therefore necessary quadrant angle

III.

3 A.

knowing range and vertical interval.

Ball "D" Ammunition.

Gun.

In Meters.

1900	2000	2100	2200	2300	2400	2500	2600	2700	2800	2900	3000	3100	3200	3300	3400	3500
.5	.5	.5	.5	.4	.4	.4	.4	.4	.4	.3	.3	.3	.3	.3	.3	.3
58	63	68	75	82	89	97	106	116	126	137	149	162	176	191	207	224
60	65	71	78	84	91	99	108	118	128	138	150	163	177	192	209	226
63	67	73	80	87	93	101	110	120	129	140	152	165	179	194	210	227
66	70	76	82	89	95	103	112	121	131	142	154	166	180	195	212	229
68	72	78	84	91	97	105	114	123	133	144	155	168	182	197	213	230
71	75	80	87	93	99	107	116	125	135	145	157	170	183	198	215	232
73	77	83	89	95	102	109	117	127	136	147	159	171	185	200	216	233
76	80	85	91	97	104	111	119	129	138	149	160	173	186	201	218	234
79	82	87	93	100	106	113	121	131	140	151	162	174	188	203	219	236
81	85	90	96	102	108	115	123	133	142	152	164	176	190	204	221	237
84	87	92	98	104	110	117	125	134	144	154	165	178	191	206	222	239
87	90	95	100	106	112	119	127	136	145	156	167	179	193	207	224	240
89	92	97	103	108	114	121	129	138	147	157	169	181	194	209	225	242
92	95	99	105	110	116	123	131	140	149	159	170	183	196	210	227	243
94	97	102	107	113	118	125	133	142	151	161	172	184	197	212	228	244
97	100	104	109	115	120	127	135	144	153	163	174	186	199	213	229	246
100	102	106	112	117	122	129	137	145	155	164	175	187	201	215	231	247
102	105	109	114	119	124	131	139	147	156	166	177	189	202	216	232	249
105	107	111	116	121	127	133	141	149	158	168	179	191	204	218	234	250
108	110	114	118	123	129	135	142	151	160	169	180	192	205	219	235	252

TES.

the quadrant elevation directly. –

vation = 84 mils.

= 57 meters. The quadrant elevation for range = 1900 and V. I. = 55 is 84 mils. For each extra
is 84 plus (2 × .5) = 85 mils.

APPENDIX

TABLE

The quadrant elevation in mils,

8 mm. Hotchkiss Machine Gun,

V. I. in Meters	Target Below Range To Target													
	500	600	700	800	900	1000	1100	1200	1300	1400	1500	1600	1700	1800
1	2	1.7	1.4	1.2	1.1	1.0	.9	.8	.8	.7	.7	.6	.6	.6
5	—3	—0.1	3	6	9	13	16	20	23	27	32	37	42	47
10	—13	—9	—4	—0.4	4	8	12	16	19	24	28	34	39	44
15	—23	—17	—11	—7	—2	3	7	12	17	20	25	31	36	42
20	—33	—25	—19	—12	—7	—2	3	7	12	17	22	28	33	39
25	—43	—33	—26	—19	—13	—7	—2	3	8	13	18	24	30	36
30	—53	—42	—33	—25	—18	—12	—6	—1	4	10	15	21	27	33
35	—63	—50	—40	—32	—24	—17	—11	—5	0.	6	12	18	24	31
40	—73	—58	—47	—38	—29	—22	—15	—9	—4	2	8	15	21	28
45	—83	—67	—54	—44	—35	—27	—20	—14	—8	—1	5	12	19	25
50	—93	—75	—61	—50	—41	—32	—24	—18	—12	—5	2	9	16	22
55	—103	—84	—69	—57	—46	—37	—29	—22	—15	—8	—2	6	13	19
60	—113	—93	—76	—63	—52	—42	—34	—26	—19	—12	—5	3	10	17
65	—123	—100	—83	—69	—57	—47	—38	—30	—23	—15	—8	1	7	14
70	—133	—109	—90	—75	—63	—52	—43	—34	—27	—19	—12	—4	4	11
75	—143	—117	—97	—82	—68	—57	—47	—39	—31	—23	—15	—7	1	8
80	—153	—125	—104	—88	—74	—62	—52	—43	—35	—26	—18	—10	—2	6
85	—163	—134	—111	—94	—80	—67	—56	—47	—38	—30	—22	—13	—5	3
90	—173	—142	—119	—100	—85	—72	—61	—51	—42	—33	—25	—16	—8	0
95	—183	—150	—126	—107	—91	—77	—65	—55	—46	—37	—28	—19	—11	—3
100	—193	—158	—133	—113	—96	—82	—70	—59	—50	—40	—32	—22	—14	—5

NO

1. — This table combines the angle of site with the angle of tangent elevation, thereby producing
2. — It is used as follows : — Range = 1900 meters. Target 55 meters below gun. Quadrant eleva
3. — The top line where V. I. = 1 meter is used as follows : — *Example I :* Range = 1900 meters. For each extra meter of V. I. the top line shows that 1/2 mil must be *subtracted*. Therefore = 38 meters. Q. E. = 0 — (3 × .8) = — 2.4. *Example III :* Range = 1100 meters, V. I. = 47

III.

—

3 B.

knowing range and vertical interval.

Ball "D" Ammunition.

Gun.																
In Meters.																
1900	2000	2100	2200	2300	2400	2500	2600	2700	2800	2900	3000	3100	3200	3300	3400	3500
.5	.5	.5	.5	.4	.4	.4	.4	.4	.4	.3	.3	.3	.3	.3	.3	.3
52	58	64	71	78	85	93	102	112	122	133	145	158	172	188	205	222
50	55	61	68	76	83	91	100	110	120	132	144	157	171	186	203	220
47	53	59	66	74	81	89	98	108	119	130	142	155	169	184	202	219
45	50	57	64	71	79	87	96	107	117	128	140	154	168	183	200	217
42	48	54	62	69	77	85	94	105	115	126	139	152	166	181	199	216
39	45	52	59	67	75	83	92	103	113	125	137	150	165	180	197	214
37	43	49	57	65	72	81	91	101	112	123	135	149	163	178	196	213
34	40	47	55	63	70	79	89	99	110	121	134	147	162	177	194	212
32	38	45	53	61	68	77	87	97	108	119	132	145	160	175	193	210
29	35	42	50	58	66	75	85	96	106	118	130	144	158	174	191	209
26	33	40	48	56	64	73	83	94	104	116	129	142	157	172	190	207
23	30	37	46	54	62	71	81	92	103	114	127	141	155	171	188	206
21	28	35	43	52	60	69	79	90	101	113	125	139	154	169	187	204
18	25	33	41	50	58	67	77	88	99	111	124	137	152	168	185	203
16	23	30	39	47	56	65	75	86	97	109	122	136	151	166	184	202
13	20	28	37	45	54	63	73	84	95	107	120	134	149	165	182	200
10	17	26	34	43	52	61	71	83	94	106	119	133	147	163	181	199
8	15	23	32	41	50	59	69	81	92	104	117	131	146	162	180	197
5	13	21	30	39	47	57	67	79	90	102	115	129	144	160	178	196
2	10	18	28	37	45	55	66	77	88	101	114	128	143	159	177	194

TES.

the quadrant elevation directly.

tion = 26 mils.

Target 57 meters below gun. The quadrant angle for range = 1900 and V. I. = 55 is 26 mil necessary quadrant angle is 26 — (2 × .5) = 25 meters. *Example II:* Range = 1300 meters, V. meters, Q. E. = — 20 — (2 × .9) = — 21.8 mils.

APPENDIX III.

TABLE 4.

Hotchkiss machine gun model 1914.
Table of correction for temperature and barometric pressure.

RANGE IN METERS	Correction of temperature in meters for a variation of 5° centigrade. Normal 15°	Correction of barometric pressure, in meters for a variation of 10 mm. Normal 750 mm.
1000	13.0	9.0
1200	16.0	11.0
1400	19.0	13.0
1600	22.5	15.5
1800	26.5	18.0
2000	30.5	21.0
2200	34.5	24.0
2400	39.0	27.0
2600	43.5	30.5
2800	48.0	33.5
3000	53.0	37.0
3200	59.0	41.0

NOTE — Above 15° subtract.
Below 15° add.
Above 750 mm. add.
Below 750 mm. subtract.

APPENDIX III.

TABLE 4 A.

Hotchkiss machine gun model 1914. Table of correction for temperature and barometric pressure.

RANGE IN METERS	Correction of temperature in mils for a variation of 5° centigrade. Normal 15°	Correction of barometric pressure, in mils for a variation of 10 mm. Normal 750 mm.
1000	0.39	0.27
1100	0.44	0.30
1200	0.48	0.33
1300	0.61	0.42
1400	0.76	0.52
1500	0.93	0.64
1600	1.13	0.78
1700	1.23	0.84
1800	1.33	0.90
1900	1 43	0.98
2000	1.68	1.15
2100	1.95	1.40
2200	2.24	1.68
2300	2.57	1 78
2400	3.12	2.16
2500	3.71	2.56
2600	4.35	3.00
2700	4.58	3.18
2800	5.28	3.60
2900	6.06	4.23
3000	6.90	4.82
3100	7.84	5.46
3200	8.85	6.15
3300	9.95	6.88
3400	11.13	7.74
3500	12.41	8.60

NOTE
Above 15° subtract.
Below 15° add.
Above 750 mm. add.
Below 750 mm. subtract.

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APPENDIX III.

TABLE 5.

Hotchkiss machine gun model 1914.
Table of correction for wind.

(1 meter per second.)

RANGE IN METERS	IN DIRECTION	IN RANGE	IN DIRECTION	IN RANGE
	3 or 9 o'clock wind. Correction in meters	6 or 12 o'clock wind. Correction in meters	1 : 30, 4 : 30, 7 : 30 or 10 : 30 o'clock wind	
			Correction in meters	Correction in meters
1500.	2.0	4.0	1.4	2.8
1600.	2.2	4.5	1.5	3.1
1700.	2.4	5.0	1.6	3.5
1800.	2.8	5.6	1.9	3.9
1900.	3.2	6.4	2.2	4.4
2000.	3.7	7.2	2.5	5.0
2100.	4.2	8.1	2.8	5.6
2200.	4.7	9.2	3.2	6.3
2300.	5.2	10.3	3.6	7.1
2400.	5.8	11.6	4.1	8.0
2500.	6.5	12.9	4.5	9.0
2600.	7.2	14.3	5.0	10.0
2700.	7.9	15.8	5.5	11.1
2800.	8.7	17.4	6.1	12.2
2900.	9.7	19.4	6.7	13.5
3000.	10.8	21.6	7.4	15.1
3100.	11.9	23.8	8.3	16.7
3200.	13.3	26.6	9.3	18.6
3300.	14.9	29.8	10.4	20.8
3400.	17.0	34.0	11.8	23.8
3500.	19.2	38.6	13.4	27.0

APPENDIX III.

TABLE 5 A.

Hotchkiss machine gun model 1914.

Table of correction for wind.

(1 meter per second.)

RANGE IN METERS	IN DIRECTION	IN RANGE	IN DIRECTION	IN RANGE
	3 or 9 o'clock wind. Correction in mils	6 or 12 o'clock wind. Correction in mils	1 : 30, 4 : 30, 7 : 30 or 10 : 30 o'clock wind	
			Correction in mils	Correction in mils
1000.	1.00	0.06	0.70	0.04
1100.	1.09	0.07	0.74	0.05
1200.	1.17	0.08	0.79	0.06
1300.	1.24	0.11	0.84	0.07
1400.	1.29	0.14	0.88	0.09
1500.	1.33	0.18	0.93	0.13
1600.	1.37	0.22	0.94	0.16
1700.	1.47	0.25	0.97	0.18
1800.	1.56	0.28	1.05	0.20
1900.	1.68	0.32	1.16	0.22
2000.	1.85	0.40	1.25	0.29
2100.	2.00	0.52	1.33	0.36
2200.	2.14	0.64	1.45	0.44
2300.	2.26	0.72	1.57	0.50
2400.	2.42	0.93	1.71	0.64
2500.	2.60	1.16	1.80	0.81
2600.	2.77	1.43	1.92	1.00
2700.	2.93	1.66	2.04	1.17
2800.	3.10	1.91	2.18	1.34
2900.	3.34	2.33	2.31	1.62
3000.	3.60	2.81	2.46	1.96
3100.	3.84	3.33	2.68	2.35
3200.	4.15	4.00	2.90	2.79
3300.	4.51	4.77	3.15	3.33
3400.	5.00	5.78	3.47	4.05
3500.	5.49	6.95	3.83	4.86

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APPENDIX

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TABLE

Table of ordinates 1898

	500	600	700	800	900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900
RANGE	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m
700	+2.4	+1.2	0	-1.6	-3.6	-7.0									
800	3.6	2.4	+1.4	0	-1.8	-5.0	-8.8								
900	4.0	3.6	2.8	+1.6	0	-3.0	-6.6	-10.8							
1000	5.4	5.3	4.8	3.8	+2.5	0	-3.3	-7.4	-12.4						
1100	6.3	7.1	6.9	6.2	5.2	+3.0	0	-3.8	-8.5	-14.6					
1200	8.5	9.0	9.1	8.8	8.1	6.2	+3.5	0	-4.3	-10.1	-17.0				
1300	10.2	11.0	11.4	11.4	11.1	9.5	7.2	+4.0	0	-5.5	-12.0	-20.0			
1400	12.1	13.3	14.1	14.6	14.6	13.4	11.4	8.6	+5.1	0	-6.2	-13.8	-22.6		
1500	14.2	15.8	17.0	17.8	18.3	17.5	16.0	13.6	10.4	+5.7	0	-7.2	-15.6	-25.7	
1600	16.4	18.5	20.2	21.4	22.3	22.0	20.3	19.0	16.3	12.0	+6.8	0	-8.0	-17.6	-28.7
1700	18.8	21.3	23.5	25.2	26.6	26.7	26.1	24.6	22.4	18.6	13.8	+7.5	0	-9.2	-19.8
1800	21.3	24.4	27.0	29.3	31.1	31.8	31.7	30.7	29.0	25.8	21.5	15.7	+8.7	0	-10.1
1900	24.0	27.5	30.7	33.5	35.9	37.1	37.5	37.1	35.9	33.2	29.4	24.2	17.7	+9.5	0
2000	26.8	30.9	34.7	38.0	41.0	42.7	43.7	43.8	43.2	41.0	37.8	33.1	27.2	19.6	+10.6
2100	29.8	34.5	38.9	42.8	46.4	48.7	50.3	51.0	51.0	49.4	46.8	42.7	37.4	30.4	22.0
2200	32.9	38.2	43.2	47.8	51.9	54.9	57.1	58.4	59.0	58.1	56.1	52.6	47.9	41.6	33.8
2300	36.3	42.3	48.0	53.2	58.0	61.7	64.6	66.6	67.9	67.6	66.3	63.5	59.5	53.8	46.7
2400	40.0	46.7	53.1	59.1	64.7	69.1	72.7	75.5	77.5	78.0	77.4	75.4	72.1	67.1	60.8
2500	44.1	51.7	58.9	65.8	72.2	77.4	81.8	85.4	88.3	89.6	89.9	88.6	86.2	82.1	76.6
2600	48.6	57.1	65.2	72.9	80.2	86.3	91.6	96.1	99.8	102.1	103.2	102.9	101.3	98.1	93.5
2700	53.3	62.8	71.8	80.5	88.7	95.8	102.1	107.5	112.2	115.4	117.5	118.1	117.5	115.2	111.5
2800	58.5	69.0	79.1	88.8	98.1	106.2	113.5	120.0	125.7	129.9	133.1	134.7	135.2	133.9	131.3
2900	64.2	75.8	87.0	97.8	108.3	117.5	126.0	133.6	140.4	145.7	150.0	152.8	154.4	154.3	152.8
3000	70.0	82.9	95.3	107.3	118.9	129.3	138.9	147.7	155.7	162.3	167.7	171.7	174.4	175.5	175.2
3100	76.5	90.5	104.2	117.5	130.4	142.1	153.0	163.1	172.4	180.2	186.9	192.2	196.2	198.5	199.5
3200	83.5	98.9	114.0	128.7	143.0	156.1	168.4	179.9	190.6	199.8	207.9	214.6	220.0	223.7	226.1
3300	91.2	108.2	124.8	141.0	156.9	171.5	185.4	198.4	210.6	221.3	231.0	239.2	246.2	251.5	255.4
3400	99.3	118.0	136.2	154.1	171.5	187.8	203.3	217.9	231.8	244.2	255.5	265.3	273.9	280.8	286.3
3500	108.2	128.6	148.7	168.3	187.6	205.6	222.9	239.3	254.9	269.1	282.2	293.8	304.2	312.8	320.1
LOWEST SHOT	1.6	1.8	2.1	2.5	2.7	3.0	3.6	4.3	4.8	5.4	6.1	6.6	7.2	7.9	8.4

III.

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6.

ammunition for Hotchkiss M. C.

2000 m	2100 m	2200 m	2300 m	2400 m	2500 m	2600 m	2700 m	2800 m	2900 m	3000 m	3100 m	3200 m	3300 m	3400 m	3500 m	3600 m	3700 m
-32.0																	
-21.8	-33.5																
-11.2	-24.4	-39.2															
0	-12.6	-26.8	-43.7														
+12.0	0	-13.6	-29.9	-49.0													
24.4	+13.0	0	-15.6	-34.1	-56.3												
38.0	27.3	+15.0	0	-17.8	-39.3	-64.0											
52.8	42.8	31.2	+17.0	0	-20.8	-44.7	-72.1										
69.4	60.3	49.5	36.1	+19.9	0	-23.1	-49.7	-80.6									
87.2	79.0	69.1	56.6	41.3	+22.3	0	-25.7	-55.7	-20.5								
106.2	98.9	90.0	78.4	64.1	46.0	+24.7	0	-29.1	-62.9	-100.5							
127.0	120.8	112.9	102.4	89.0	72.0	51.7	+28.1	0	-32.8	-69.3	-111.3						
149.6	144.3	137.7	128.3	116.2	100.3	81.1	58.6	+31.6	0	-35.4	-76.3	-123.5					
173.2	169.3	163.7	155.5	144.5	129.8	111.8	90.5	64.7	+34.2	0	-39.7	-85.8	-139.3				
198.8	196.1	191.8	184.9	175.2	161.8	145.1	125.0	100.5	71.3	+38.4	0	-44.8	-97.0	-155.4			
226.8	225.5	222.7	217.1	208.8	196.8	181.5	162.8	139.7	111.3	80.4	+43.4	0	-50.8	-107.8	-173.3		
257.6	257.3	256.5	252.5	245.6	235.3	221.5	204.4	182.8	156.6	126.6	91.1	+49.3	0	-55.4	-119.4	-33.9	
290.2	292.1	292.4	290.0	284.9	276.0	263.9	248.4	228.5	203.9	175.5	141.7	101.4	+53.8	0	-62.3	-24.2	-29.2
325.8	329.5	331.6	330.9	327.6	320.5	310.2	296.5	278.3	255.5	228.9	196.9	158.4	112.5	+60.5	0		
9.0	12.0	15.0	18.0	22.5	27.0	32.0	37.0	42.0	47.0	52.0	58.0	64.0	70.0	76.0	82.0	89.0	96.0

APPENDIX III.

TABLE 7.

Tangent elevation, angles of fall, dimensions of cones and zones for 8 mm. Hotchkiss machine gun, ball "D" ammunition.

Range Meters	Angle of Tangent Elevation in Mils	Slope of Descent in Mils	Height in meters of lowest shot below crest of cone	Dimensions in meters of battle beaten zones				Dimensions of cones in meters	
				Width		Length		Width	Height
				75 p.c.	90 p.c.	75 p.c.	90 p.c.	75 p.c.	75 p.c.
100	1.0	.							
200	2.2	2		3				3	
300	3.6	3		5				5	
400	5.0	4		6				6	
500	6.6	6	1.6	8	23	132	597	8	1.6
600	8.2	9	1.8	9	28	176	503	9	2.0
700	10.0	12	2.1	12	3.4	161	430	12	2.5
800	12.1	14	2.5	14	3.9	146	357	14	2.8
900	15.0	17	2.7	16	4.6	130	279	16	3.3
1000	18.0	21	3.0	18	5.5	118	247	18	3.7
1100	21.0	26	3.6	21	6.4	100	219	21	4.0
1200	24.0	32	4.3	25	7.4	89	188	25	4.5
1300	27.0	39	4.8	28	8.4	76	160	28	4.8
1400	31.0	47	5.4	33	9.6	67	142	33	5.2
1500	35.0	56	6.1	39	11.0	64	135	39	5.9
1600	40.0	66	6.6	46	12.3	64	130	46	7.3
1700	45.0	76	7.2	53	13.7	64	124	53	8.5
1800	50.0	87	7.9	61	14.9	64	119	61	9.7
1900	55.0	99	8.4	71	16.3	67	125	71	12.1
2000	60.0	112	9.0	83	17.6	71	135	83	14.6
2100	66.0	126	12.0	96	18.9	75	145	96	17.8
2200	73.0	141	15.1	112	20.3	80	155	112	21.5
2300	80.0	157	18.0	128	21.6	84	165	128	26.1
2400	87.0	174	22.5	159	23.2	93	175	159	32.9
2500	95.0	194	27.0	194	24.9	104	186	194	41.6
2600	104.0	217	32.0	229	26.6	114	196	229	53.0
2700	114.0	244	37.0						
2800	124.0	273	42.0						
2900	135.0	305	47.0						
3000	147.0	340	52.0						
3100	160.0	378	58.0						
3200	174.0	419	64.0						
3300	189.0	463	70.0						
3400	206.0	510	76.0						
3500	223.0	560	82.0						

TABLE 8.

Table of Assimilation, Hotchkiss.

APPENDIX III. —

Table of Assimilation

Angle of Site in Mils	-60	-50	-40	-30	-20	-10	0	+10
RANGE M								
1000	1504	1507.5	1553.5	1557.	1603	1606.5	1652.5	1656
1050	1504.5	1508	1554	1557.5	1603.5	1607	1653	1656.5
1100	1505	1508.5	1554.5	1558	1604	1607.5	1653.5	1657
1150	1505.5	1551.5	1555	1601.5	1604.5	1608	1654	1657.5
1200	1506	1552	1555.5	1602	1605.5	1608.5	1654.5	1658
1250	1507	1552.5	1556	1602.5	1606	1651.5	1655	1701
1300	1507.5	1553	1556.5	1603	1606.5	1652.5	1655.5	1701.5
1350	1508	1554	1557	1603.5	1607	1653	1656.5	1702.
1400	1508.5	1554.5	1558	1604.5	1607.5	1653.5	1657	1703
1450	1552	1555	1601.5	1605	1608.5	1654.5	1657.5	1703.5
1500	1552.5	1556	1602.5	1605.5	1651.5	1655	1701	1704.5
1550	1553	1556.5	1603	1606.5	1652.5	1655.5	1701.5	1705
1600	1554	1557.5	1604	1607	1653	1656.5	1702.5	1706
1650	1555	1558	1604.5	1608	1654	1657.5	1703	1706.5
1700	1555.5	1602	1605.5	1651.5	1654.5	1658	1704	1707.5
1750	1556.5	1603	1606	1652	1655.5	1701.5	1705	1708
1800	1557.5	1603.5	1607	1653	1656.5	1702.5	1705.5	1751.5
1850	1601	1604.5	1608	1654	1657.5	1703	1706.5	1752.5
1900	1602	1605.5	1651.5	1655	1658	1704	1707.5	1753.5
1950	1603	1606.5	1652.5	1655.5	1701.5	1705	1708.5	1754
2000	1604	1607.5	1653.5	1656.5	1702.5	1706	1752	1755.5
2050	1605	1608.5	1654.5	1657.5	1703.5	1707	1753	1756.5
2100	1606	1652	1655.5	1701	1704.5	1708	1754	1757.5
2150	1607	1653	1656.5	1702	1705.5	1751.5	1755	1758.5
2200	1608	1654	1657.5	1703.5	1706.5	1752.5	1756	1801.5
2250	1651.5	1655	1701	1704.5	1708	1753.5	1757	1802.5
2300	1653	1656.5	1702	1705.5	1751.5	1755	1758.5	1803.5
2350	1654	1657.5	1703.5	1706.5	1752.5	1756	1801.5	1805.
2400	1655.5	1701.5	1704	1708	1754	1757.5	1803	1806
2450	1657	1702.5	1706	1752	1755.5	1759	1804	1807.5
2500	1701	1704	1707.5	1753.5	1757	1802	18055	1809
2550	1702	1705.5	1751.5	1755	1758.5	1803.5	1807	1852
2600	1703.5	1707	1753	1756.5	1802	1805	1808.5	1853.5
2650	1705.5	1708.5	1754.5	1758	1803.5	1807	1851.5	1855
2700	1707	1753	1756	1801.5	1805	1808.5	1853.5	1856.5
2750	1708.5	1754.5	1758	1803.5	1806.5	1851.5	1855	1858.5
2800	1753	1756.5	1801.5	1805	1808.5	1853.5	1857	1901.5
2850	1755	1758	1803.5	1807	1852	1855.5	1858.5	1903.5
2900	1756.5	1802	1805.5	1809	1854	1857	1902	1905.5
2950	1758.5	1804	1807.5	1852.5	1856	1900.5	1904	1907.5
3000	1802.5	1806	1851	1854.5	1858	1902.5	1906	1909.5
3050	1805	1808	1853	1856.5	1901.5	1905	1908	1952
3100	1807	1852	1855.5	1858.5	1903.5	1907	1951	1954.5
3150	1851	1854	1857.5	1902.5	1906	1909.5	1953	1956.5
3200	1853	1856.5	1901.5	1905	1908.5	1952	1955.5	1959
3250	1856	1900.5	1904	1907.5	1951.5	1955	1958	2001.5
3300	1858.5	1903.5	1906.5	1951	1954	1957.5	2001	2004
3350	1902.5	1906	1909.5	1953.5	1956.5	2000.5	2003.5	2007
3400	1905.5	1909	1952.5	1956	1959.5	2003	2006.5	
3450	1908.5	1952.5	1955.5	1959	2002.5	2006		
3500	1952	1955.5	1958.5	2002	2005.5	2009		

A.W. BRANCH
OF
A.I.S. SCHOOLS

TABLE 8.

Hotchkiss.

·20	·30	·40	·50	·60	·70	·80	·90	·100
1702	1705	1751	1754.5	1758	1803.5	1806.5	1851.5	1855
1702.5	1705.5	1751.5	1755	1758.5	1804	1807	1852	1855.5
1703	1706	1752	1755.5	1759	1804.5	1807.5	1852.5	1856
1703.5	1706.5	1752.5	1756	1801.5	1805	1808	1853	1856.5
1704	1707.5	1753	1756.5	1802	1805.5	1809	1853.5	1857
1704.5	1708	1753.5	1757	1802.5	1806	1851	1854	1857.5
1705	1751	1754.5	1757.5	1803	1806.5	1851.5	1855	1858
1705.5	1751.5	1755	1758.5	1803.5	1807	1852	1855.5	1859
1706.5	1752	1755.5	1759	1804.5	1808	1852.5	1856	1901
1707	1753	1756.5	1801.5	1805	1808.5	1853.5	1857	1901.5
1707.5	1753.5	1757	1802.5	1806	1809	1854	1857.5	1902.5
1708.5	1754.5	1757.5	1803	1806.5	1851.5	1855	1858	1903
1751.5	1755	1758.5	1804	1807.5	1852	1855.5	1900.5	1904
1752.5	1755.5	1801.5	1804.5	1808	1853	1856.5	1901.5	1904.5
1753.5	1756.5	1802	1805.5	1809	1854	1857	1902	1905.5
1754	1757.5	1803.5	1806.5	1851	1854.5	1858	1903	19065
1755	1758.5	1804	1807	1852	1855.5	1900.5	1904	1907
1756	1801.5	1804.5	1808	1853	1856.5	1901.5	1904.5	1908
1757	1802	1805.5	1809	1854	1857.5	1902	1905.5	1909
1757.5	1803	1806.5	1851.5	1855	1858	1903	1906.5	1909.5
1758.5	1804	1807.5	1852.5	1856	1900.5	1904	1907.5	19515
1801.5	1805	1808.5	1853.5	1857	1901.5	1905	1908.5	1952.5
1802.5	1806	1851	1854.5	1858	1902.5	1906	1909.5	1953.5
1803.5	1807	1852	1855.5	1900.5	1903.5	1907	1951	1954.5
1805	1808	1853	1856.5	1901.5	1905	1908	1952	1955
1806	1851	1854	1857.5	1902.5	1906	1909.5	1953	1956.5
1807	1852	1855.5	1900.5	1903.5	1907	1951	1954.5	1958
1808.5	1853	1856.5	1901.5	1905	1908.5	1952	1955.5	1959
1851	1854.5	1858	1903	1906	1909.5	1953.5	1957	2001
1852.5	1856	1901	1904.5	1907.5	1951.5	1955	1958.5	2001.5
1854	1857.5	1902	19055	1909	1953	1956.5	1959.5	2003
1855.5	1900.5	1903.5	1907	1951	1954.5	1958	2001	2004.5
1857	1902	1905	1908.5	1952.5	1956	1959.5	2002.5	2006
1858.5	1903.5	1907	1950.5	1954	1957.5	2001	2004.5	2007.5
1901.5	1905	1908.5	1952.5	1955.5	1959	2002.5	2006	
1903.5	1906.5	1950.5	1954	1957.5	2001	2004	2007.5	
1905	1908.5	1952.5	1956	1959	2002.5	2006		
1907	1951	1954.5	1957.5	2001	2004.5	2008		
1909	1953	1956	1959.5	2003	2006.5			
1951.5	1955	1958	2001.5	2005	2008.5			
1953.5	1957	2000.5	2003.5	2007				
1955.5	1959	2002.5	2005.5	2009				
1957.5	2001	2004.5	2008					
2000.5	2003.5	2007						
2002.5	2006							
2005	2008.5							
2007.5								

APPENDIX IV.

The data for the tables in Appendix IV and the graphs for the Vickers and Browning guns in Appendix V were obtained by tests conducted at the Ordnance Armament School at St-Jean-des-Monts, Vendée. The trajectory figures and the beaten zone dimensions were obtained by actual firing. The table of positive and negative ordinates was compiled from the angles of departure.

The graph of wind correction was verified by experimental firing. Up to a range of 2000 meters, the graph fully corrects. Beyond 2000 meters, the graph does not give the full correction, but sufficient experimental data is not available to make alterations in the graph. The graph showing decrease of muzzle velocity due to erosion, or life of the barrel, was determined by experimental firings. The graph giving the drift was verified by experimental firing. Up to 2000 meters, the drift is fully corrected. Beyond 2000 meters, the graph does not give the full correction.

APPENDIX IV.

TABLE 1.

Browning Machine Gun.

Angles of departure (T. E.) for range in *meters*.

RANGE Meters	A. D. Mils	RANGE Meters	A. D. Mils
100	1	1650	57
150	1	1700	61.5
200	1.5	1750	66
250	2	1800	71
300	2.5	1850	76.5
350	3	1900	82
400	4	1950	87.5
450	4.5	2000	93.5
500	5	2050	100.5
550	6	2100	107
600	7.5	2150	114.5
650	9	2200	122
700	10.5	2250	130
750	12.5	2300	139
800	14	2350	148
850	16	2400	158
900	18	2450	169
950	20	2500	181
1000	22	2550	193
1050	24.5	2600	207
1100	27	2650	223
1150	29	2700	242
1200	31	2750	264
1250	33	2800	291
1300	35.5	2850	324
1350	38	2900	362
1400	40.5	2950	406
1450	43	3000	467
1500	46.5	3050	550
1550	49.5	3100	665
1600	53		

APPENDIX

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TABLE

Ordinates for

Ordi

	100	200	300	400	500	600	700
500.	0.4	0.7	0.75	0.4		1.55	3.85
600.	0.65	1.2	1.5	1.0	1.25		2.1
700.	0.95	1.8	2.4	2.6	2.75	1.8	
800.	1.3	2.5	3.45	4.0	4.5	3.9	2.45
900.	1.7	3.3	4.65	5.6	6.5	6.3	5.25
1000.	2.1	4.1	5.85	7.2	8.5	8.7	7.05
1100.	2.6	5.1	7.35	9.2	11.0	11 7	11.55
1200.	3.0	5.9	8.55	10.8	13.0	14.1	14.35
1300.	3.45	6.8	9.9	12.6	15.25	16.8	17.5
1400.	3.95	7.8	11.4	14.6	17.75	19.8	21.0
1500.	4.55	9.0	13.2	17.0	20.75	23.4	25.2
1600.	5.2	10.3	15.15	19.6	24.0	27.3	29.75
1700.	6.05	12.0	17.7	23.0	28.25	32.4	35.7
1800.	7.0	13.9	20.55	26.8	33.0	38.1	42.35
1900.	8.1	16.1	23.85	31.2	38.5	44.7	50.05
2000.	9.25	18.4	27.3	35.8	44.25	51.6	58.1
2100.	10.6	21.2	31.35	41.2	51.0	59.7	67.75
2200.	12.1	24.1	35.85	47.2	58.5	68.7	78.05
2300.	13.8	27.5	40.95	54.0	67.0	78.9	89.95
2400.	15.7	31.3	46.65	61.6	76.5	90.3	103.25
2500.	18.0	35.9	53.55	70.8	88.0	104.1	119.35
2600.	20.6	41.1	61.25	81.2	101.0	119.7	137.55
2700.	24.1	48.1	71.85	95.2	118.5	140.7	162.05
2800.	29.0	57.9	86.55	114.8	143.0	170.1	196.35
2900.	36.1	72.1	107.85	143.2	178.5	212.7	246.05
3000.	46.6	93.1	139.35	185.2	231.0	275.7	319.55
3100.	66.4	132.7	198.75	264.4	330.0	394.5	458.15
3200.	,,	,,	,,	,,	,,	,,	,,
3300.	,,	,,	,,	,,	,,	,,	,,

IV.

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2.

Browning Trajectory.

ates.

800	900	1000	1100	1200	1300	1400	1500	1600
9.2	11.7	17.00	24.20	31.20	39.65	49.70	62.25	76.80
5.2	9.45	14.50	21.45	28.20	36.40	46.20	58.50	72.80
2.4	6.75	11.50	18.15	24.60	32.50	42.00	54.00	68.00
	3.60	8.00	14.30	20.40	27.95	37.10	48.75	62.40
3.2		4.00	9.90	15.60	22.95	31.50	42.95	56.00
6.4	3.60		5.50	10.80	17.55	25.90	36.75	49.60
10.4	8.10	5.00		4.80	11.05	18.90	29.25	41.60
13.6	11.70	9.00	4.40		5.85	13.30	22.25	35.20
17.2	15.75	13.50	9.35	5.40		7.00	16.50	28.00
21.2	20.25	18.50	14.85	11.40	6.50		9.0	20.00
26.0	25.65	24.50	21.45	18.60	14.30	8.40		10.40
31.2	31.50	31.00	28.60	26.40	22.75	17.50	9.75	
38.0	39.15	39.50	37.95	36.60	33.80	29.40	23.50	13.60
45.6	47.70	49.00	48.40	48.00	46.15	42.70	36.75	28.80
54.4	57.60	60.00	60.50	61.20	60.45	58.10	53.25	46.40
63.6	67.95	71.50	73.15	75.00	75.40	74.20	70.50	64.80
74.4	80.10	85.00	88.00	91.20	92.95	93.10	90.75	86.40
86.4	93.60	100.00	104.50	109.20	112.45	114.10	113.25	110.45
100.0	108.90	117.00	123.20	129.60	134.55	137.90	138.75	137.60
115.2	126.00	136.00	144.10	152.40	159.25	164.50	167.25	168.00
133.6	146.7	159.0	169.4	180.0	189.15	196.7	201.75	204.8
154.4	170.1	185.0	198.0	211.2	222.95	233.1	240.75	246.4
182.4	201.6	220.0	236.5	253.2	268.45	282.1	293.25	302.4
221.6	245.7	269.0	290.4	312.0	332.15	350.7	366.75	380.8
278.4	309.6	340.0	368.5	397.2	424.45	450.1	473.25	494.4
362.4	404.1	445.0	484.0	523.2	560.95	597.1	630.75	662.4
520.8	582.3	643.0	701.8	760.8	818.35	874.3	927.75	979.2
,,	,,	,,	,,	,,	,,	,,	,,	,,
,,	,,	,,	,,	,,	,,	,,	,,	,,

APPENDIX

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TABLE

Ordinates for

Ordi

	1700	1800	1900	2000	2100	2200	2300
500.	96.05	118.8	146.3	177.0	214.1	257.4	308.2
600.	91.3	114.3	141.55	172.0	208.95	251.9	302.45
700.	86.7	108.9	135.85	166.0	202.65	245.3	295.55
800.	80.75	102.6	129.2	159.0	195.3	237.6	287.5
900.	73.95	95.4	121.6	151.0	186.9	228.8	278.3
1000.	67.15	88.2	114.0	143.0	178.5	220.0	269.1
1100.	58.65	79.2	104.5	133.0	168.0	209.0	257.6
1200.	51.85	72.0	96.9	125.0	159.6	200.2	248.4
1300.	44.2	63.9	88.35	116.0	150.15	190.3	238.05
1400.	35.7	54.9	78.85	106.0	139.65	179.3	226.55
1500.	25.5	44.1	67.45	94.0	127.05	166.1	212.75
1600.	14.45	32.4	55.1	81.0	113.05	151.8	197.8
1700.		17.1	38.95	64.0	95.55	133.1	178.25
1800.	16.15		20.9	45.0	75.6	112.2	156.4
1900.	30.85	19.8		23.0	52.5	88.0	131.1
2000.	54.4	40.5	21.85		28.35	62.7	104.65
2100.	77.35	64.8	47.3	29.0		33.0	73.6
2200.	102.85	91.8	76.0	57.0	31.5		39.1
2300.	131.75	122.4	108.3	91.0	67.2	37.4	
2400.	164.05	156.6	144.4	129.0	107.1	79.2	43.7
2500.	203.15	198.0	188.1	175.0	155.4	129.8	96.6
2600.	247.35	244.8	237.5	227.0	210.0	187.0	156.4
2700.	306.85	307.8	304.0	297.0	283.5	264.0	236.9
2800.	390.15	396.0	397.1	395.0	386.4	371.8	349.6
2900.	510.85	523.8	532.0	537.0	535.5	528.0	512.9
3000.	689.35	712.8	731.5	747.0	756.0	759.0	754.4
3100.	1025.95	1069.2	1107.7	1143.0	1171.8	1194.6	1209.8
3200.	,,	,,	,,	,,	,,	,,	,,
3300.	,,	,,	,,	,,	,,	,,	,,

IV.

3.

Browning Trajectory.

nates.

2400	2500	2600	2700	2800	2900	3000	3100	3200
367.2	440.0	525.2	639.9	800.8	1035.3	1386.0	2046.0	
361.2	433.75	518.7	633.15	793.8	1028.05	1378.5	2038.25	
354.0	426.25	510.9	625.05	785.4	1017.35	1369.5	2028.95	
345.6	417.50	501.8	615.60	775.6	1009.2	1359.0	2018.10	
336.0	407.5	491.4	604.80	764.4	997.6	1347.0	2005.7	
326.4	397.5	481.0	594.0	753.2	986.0	1335.0	1993.3	
314.4	385.0	468.0	580.5	739.2	971.5	1320.0	1977.8	
304.8	375.0	457.6	569.7	728.0	959.9	1308.0	1965.4	
294.0	363.75	445.9	557.55	715.4	946.85	1294.5	1951.45	
282.0	351.25	432.9	544.05	701.4	932.35	1279.5	1935.95	
267.6	336.85	417.3	527.85	684.6	914.95	1261.5	1917.35	
252.0	320.0	400.4	510.30	666.4	896.10	1242.0	1897.2	
231.6	298.75	378.3	487.35	642.6	871.45	1216.5	1870.35	
208.8	275.0	353.6	461.7	616.0	843.90	1188.0	1841.4	
182.4	247.50	325.0	432.0	585.2	812.0	1155.0	1807.3	
154.8	218.75	295.1	400.95	553.0	778.65	1120.5	1771.65	
122.4	185.0	260.0	364.5	515.2	739.5	1080.0	1729.8	
86.4	147.50	221.0	324.0	473.2	696.0	1035.0	1683.8	
45.6	105.0	176.8	278.1	425.6	646.7	984.0	1630.6	
	57.5	127.4	226.8	372.4	591.6	927.0	1571.7	
55.2		67.6	164.7	308.0	524.9	858.0	1500.4	
117.6	65.0		94.5	235.2	449.5	780.0	1419.8	
201.6	152.5	91.0		137.2	348.0	675.0	1311.3	
319.2	275.0	218.4	132.3		205.9	528.0	1169.4	
498.6	452.5	403.0	324.0	193.8		315.0	939.3	
741.6	715.0	676.0	607.5	492.8	304.5		613.3	
1216.8	1210.0	1190.8	1142.1	1047.2	878.7	594.0		
,,	,,	,,	,,	,,	,,	,,	,,	
,,	,,	,,	,,	,,	,,	,,		

APPENDIX IV.

TABLE 4.

Browning Machine Gun Beaten Zone. Length

Range and length in *meters*.

RANGE	100 °/₀	90 °/₀	75 °/₀
900	285	135	102
1000	263	127	94
1100	242	119	87
1200	222	112	80
1300	204	104	74
1400	188	97	68
1500	174	90	62
1600	162	82	57
1700	153	76	53
1800	146	71	49
1900	142	70	48
2000	146	73	50
2100	152	77	53
2200	160	84	59
2300	172	93	66
2400	186	106	76
2500	204	122	86
2600	224	140	97
2700	246	160	110
2800	271	184	123
2900	297	210	136
3000	325	236	152
3100			
3200			

APPENDIX IV.

TABLE 5.

Browning Beaten Zones.

Range and width in *meters*.

RANGE	100 o/o	90 o/o	75 o/o
800	9.6	5.4	4.8
900	8.0	4.8	4.0
1000	6.7	4.4	3.6
1100	6.2	4.1	3.2
1200	6.1	4.1	3.1
1300	6.4	4.2	3.1
1400	7.0	4.4	3.2
1500	7.8	4.8	3.4
1600	8.7	5.2	3.6
1700	9.6	5.5	3.9
1800	10.6	6.2	4.3
1900	11.6	6.8	4.7
2000	12.7	7.5	5.1
2100	13.8	8.2	5.6
2200	14.9	8.8	6.1
2300	16.0	9.6	6.6
2400	17.2	10.4	7.2
2500	18.4	11.2	7.8
2600	19.7	12.0	8.4
2700	21.0	12.9	9.0
2800	22.4	13.8	10.1
2900	23.8	14.8	10.7
3000	25.2	15.8	

Vickers Machine Gun.

TABLE 6. — Angles of Departure.
TABLE 7. — TABLE 8. — Ordinates for Vickers Trajectory.
TABLE 9. — Beaten Zone (Length).
TABLE 10. — Beaten Zone (Width).

APPENDIX IV.

TABLE 6.

Vickers Machine Gun.

Angles of Departure (T. E.) for range in *meters*.

RANGE Meters	A. D. Mils	RANGE Meters	A. D. Mils
100	1.0	1750	63.5
150	1.0	1800	67.5
200	1.5	1850	72
250	2.0	1900	76.5
300	2.5	1950	81
350	3.0	2000	86
400	4.0	2050	91
450	4.5	2100	96.5
500	5.0	2150	102
550	6.0	2200	108
600	7.0	2250	114
650	8.0	2300	121
700	9.0	2350	128.5
750	10	2400	136.5
800	11	2450	145.5
850	12.5	2500	155
900	14.5	2550	165.5
950	16.5	2600	177
1000	18	2650	190.5
1050	20.5	2700	204.5
1100	23	2750	221
1150	25	2800	237.5
1200	27.5	2850	254
1250	30.5	2900	274
1300	33	2950	294
1350	36	3000	317.5
1400	39	3050	342
1450	42	3100	373
1500	45	3150	413
1550	48	3200	464
1600	51.5	3250	537
1650	55	3300	652.5
1700	59		

APPENDIX

TABLE

Ordinates for

Intermediate ranges. Ordi

	100	200	300	400	500	600	700
500.	0.4	0.7	0.75	0.4		1.2	2.8
600.	0.6	1.1	1.35	1.2	1.0		1.4
700.	0.8	1.5	1.95	2.0	2.0	1.2	
800.	1.0	1.9	2.55	2.8	3.0	2.4	1.4
900.	1.35	2.6	3.6	4.2	4.75	4.5	3.85
1000.	1.7	3.3	4.65	5.6	6.5	6.6	6.3
1100.	2.2	4.3	6.15	7.6	9.0	9.6	9.8
1200.	2.65	5.2	7.5	9.4	11.25	12.3	12.95
1300.	3.2	6.3	9.15	11.6	14.0	15.6	16.8
1400.	3.8	7.5	10.95	14.0	17.0	19.2	21.0
1500.	4.4	8.7	12.75	16.4	20.0	23.8	25.2
1600.	5.05	10.0	14.7	19.0	23.25	26.7	29.75
1700.	5.8	11.5	16.95	22.0	27.0	31.2	35.0
1800.	6.65	13.2	19.5	25.4	31.25	36.3	40.95
1900.	7.55	15.0	22.2	29.0	35.75	41.7	47.25
2000.	8.5	16.9	25.05	32.8	40.5	47.4	53.9
2100.	9.55	19.0	28.2	37.0	45.75	53.7	61.25
2200.	10.7	21.3	31.65	41.6	51.5	60.6	69.3
2300.	12.0	23.9	35 55	46.8	58.0	68.4	78.4
2400.	13.55	27.0	40.2	53.0	65.75	77.7	89.25
2500.	15.4	30.7	46.75	60.4	75.0	88.8	102.2
2600.	17.6	35 1	52.35	69.2	86.0	102.0	117.6
2700.	20.35	40.6	60.6	80.2	99.75	118.5	136.85
2800.	23.65	47.2	70.5	93.4	116.25	138.3	159.95
2900.	27.3	54.5	81.45	108.0	134.5	160.2	185.5
3000.	31.65	63 2	94.5	125.4	156.25	186.3	215.95
3100.	37.2	74.3	111.15	147.6	184.0	219.6	254.8
3200.	46.3	92.5	138.45	184.0	229.5	274.2	318.5

IV.

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7.

Vickers Trajectory.

nates.

800	900	1000	1100	1200	1300	1400	1500	1600
4.8	8.55	13.0	19.8	27.0	36.4	47.6	60.0	74.4
3.2	6.75	11.0	17.6	24.6	33.8	44.8	57.0	71.2
1.6	4.95	9.0	15.4	22.2	31.2	42 0	54.0	68.0
	3.15	7.0	13.2	19.8	28.6	39.2	51.0	64.8
2.8		3.5	9.35	15.6	24.05	34.3	45.75	59.2
5.6	3.15		5.5	11.4	19.5	29.4	40.5	53.6
9.6	7.65	5.0		5.4	13.0	22.4	33.0	45.6
13.2	11.7	9.5	4.95		7.15	16.1	26.25	38.4
17.6	16.65	15.0	11.0	6.6		8.4	18.0	29.6
22.4	22.05	21.0	17.6	13.8	7.8		9.0	20.0
27.2	27.45	27.0	24.2	20.0	15.6	8.4		10.4
32.4	33.3	33.5	31.35	28.8	24.05	17.5	9.75	
38.4	40.05	41.0	39.6	37.8	33.8	28.0	21.0	12.0
45.2	47.7	49.5	48.95	49.0	44.85	39.9	33.75	25.6
52.4	55.8	58.5	58.85	58.8	56.55	52.5	47.25	40.0
60.0	64.35	68.0	69.3	70.2	68.8	65.8	61.5	55.2
68.4	73.8	78.5	80.85	82.8	82.55	80.5	77.25	72.0
77.6	84.15	90.0	93.5	96.5	97.5	96.6	94.5	90.4
88.0	95.85	103.0	107.8	112.2	114.4	114.8	114.0	111.2
100.4	109.8	118.5	124.85	130.8	134.55	136.5	137.25	136.0
115.2	126.45	137.0	145.2	153.0	158.6	162.4	165.0	165.6
132.8	146.25	159.0	169.4	179.4	187.2	193.2	198.0	200.8
154.8	171.0	186.5	199.65	212.4	222.95	231.7	239.25	244.8
181.2	200.7	219.5	235.95	252.0	265.85	277.9	288.75	297.6
210.4	233.85	256.0	276.1	295.8	313.3	329.0	343.5	356.0
245.2	272.7	299.5	323.95	348.0	369.85	389.9	408.75	425.6
289.6	322.65	355.0	385.0	414.6	442.0	467.6	492.0	514.4
362.4	404.55	446.0	485.1	523.8	560.3	595.0	628.5	660.0

APPENDIX

TABLE

Ordinates for

Ordi

	1700	1800	1900	2000	2100	2200	2300
500.	91.8	112.5	135.85	162.0	192.15	226.6	266.8
600.	88.4	108.9	132.05	158.0	187.95	222.2	262.2
700.	85.0	105.3	128.5	154.0	183.75	217.8	257.6
800.	81.6	101.7	124.45	150.0	179.55	213.4	253.0
900.	75.65	95.4	117.8	143.0	172.2	205.7	244.95
1000.	69.7	89.1	111.15	136.0	164.85	198.0	236.9
1100.	61.2	80.1	101.65	126.0	154.35	187.0	225.4
1200.	53.55	72.0	93.1	117.0	144.9	177.1	215.05
1300.	44.2	62.1	82.65	106.0	133.35	165.0	202.4
1400.	34.0	51.3	71.25	94.0	120.75	151.8	188.6
1500.	23.8	40.5	59.85	82.0	108.15	139.6	174.8
1600.	12.75	28.8	47.5	69.0	94.5	124.3	159.85
1700.		15.3	33.25	54.0	78.75	107.8	142.6
1800.	14.45		17.1	37.0	60.9	89.1	123.05
1900.	29.75	16.2		19.0	42.0	69.3	102.35
2000.	45.9	33.3	18.05		22.05	48.4	80.5
2100.	63.75	52.2	38.0	21.0		25.3	56.35
2200.	83.3	72.9	59.85	44.0	24.15		29.9
2300.	105.4	96.3	84.55	70.0	51.55	28.6	
2400.	131.75	124.2	114.0	101.0	84.0	62.7	35.65
2500.	163.2	157.5	149.15	138.0	122.85	103.4	78.2
2600.	200.6	197.1	190.95	182.0	169.05	151.8	128.8
2700.	247.35	246.6	243.2	237.0	226.8	212.3	192.05
2800.	303.45	306.0	305.9	303.0	296.1	284.9	267.95
2900.	365.5	371.7	375.25	376.0	372.75	365.2	351.9
3000.	439.45	450.0	457.9	463.0	464.1	460.9	451.95
3100.	533.8	549.9	563.35	574.0	580.65	583.0	579.6
3200.	688.5	713.7	726.25	756.0	771.75	783.2	788.9

IV.

3.

Vickers Trajectory.

aates.

2400	2500	2600	2700	2800	2900	3000	3100
315.6	375.0	447.2	538.95	651.0	780.1	937.5	1140.8
310.8	370.0	442.0	533.25	645.4	774.3	931.5	1134.6
306.0	365.0	436.8	527.85	639.8	768.5	925.5	1128.4
301.2	360.0	431.6	522.45	634.2	762.7	919.5	1122.2
296.8	351.5	422.25	513.0	624.4	752.55	909.0	1111.35
284.4	342.5	413.4	503.55	614.6	742.4	898.5	1100.5
272.4	330.0	400.4	490.05	600.6	727.9	883.5	1085.0
261.6	318.75	388.7	477.9	588.0	714.85	870.0	1071.05
248.4	305.0	374.4	463.05	572.6	698.9	853.5	1054 0
234.0	290.0	358.8	446.85	555.8	681.5	835.5	1035.4
219.6	275.0	343.2	430.65	539.0	664.1	817.5	1016.8
204.0	258.75	326.3	413.1	520.8	645.25	798.0	996.65
186.0	240.0	306.8	392.85	499.8	623.5	775.5	973.4
165.6	218.75	284.7	369.9	476.0	598.85	750.0	947.05
144.0	196.25	261.3	345.6	450.8	572.75	723.0	919.15
121.2	172.5	236.6	319.95	424.2	545.2	694.5	889.7
96.0	146.25	209.3	291.6	394.8	514.75	663.0	857.15
68.4	117.5	179.4	260.55	362.6	481.4	628.5	821.5
37.2	85.0	145.6	225.45	326.2	443.7	589.5	781.2
	46.25	105.3	183.6	282.8	398.75	543.0	733.15
44.4		57.2	133.65	231.0	345.1	487.5	675.8
97.2	55.0		74.25	169.4	281.3	421.5	607.6
163.2	123.75	71.5		92.4	201.55	339.0	522.35
242.4	206.25	157.3	89.1		105.85	240.0	420.05
330.0	297.5	252.2	187.65	102.2		130.5	306.9
434.4	406.25	365.3	305.1	224.0	126.15		172.05
567.6	545.0	509 6	454.95	379.4	287 1	166.5	
786.0	772.5	746.2	700.65	634.2	551.0	439.5	282.1

APPENDIX IV.

TABLE 9.

Vickers Machine Gun Beaten Zone. Length.

Range and length in *meters*.

RANGE	LENGTH 100 °/₀	LENGTH 90 °/₀	LENGTH 75 °/₀
900	220	131	100
950	210	126	95
1000	200	120	90
1050	191	114	84
1100	182	108	80
1150	174	102	75
1200	165	97	70
1250	158	92	66
1300	152	88	62
1350	146	84	58
1400	140	80	56
1450	134	76	52
1500	129	72	49
1550	124	69	47
1600	120	67	45
1650	117	65	43
1700	116	63	42
1750	114	62	41
1800	114	61	40
1850	114	60	40
1900	115	60	41
1950	116	61	42
2000	118	61	43
2050	122	62	45
2100	125	64	47
2150	129	67	49
2200	134	70	52
2250	139	74	55
2300	144	78	58
2350	151	83	62
2400	158	88	66
2450	165	94	70
2500	172	100	75
2550	180	107	80
2600	188	115	86
2650	196	120	92
2700	204	126	89
2750	212	134	104
2800	220	140	109
2850	229	149	116
2900	238	158	122
2950	247	167	128
3000	257	178	135
3050	266	188	142
3100	276	202	150
3150	286	218	156
3200	296	238	164
3250	306	254	170
3300	315	276	180

APPENDIX IV.

TABLE 10.

Vickers Machine Gun 100 °/₀ Beaten Zone Width.

RANGE Meters	WIDTH Meters
900	5.2
950	5.4
1000	5.6
1050	5.7
1100	5.9
1150	6.1
1200	6.3
1250	6.5
1300	6.7
1350	6.9
1400	7.2
1450	7.5
1500	7.7
1550	7.9
1600	8.2
1650	8.4
1700	8.7
1750	9.0
1800	9.3
1850	9.6
1900	9.9
1950	10.2
2000	10.5
2050	10.9
2100	11.3
2150	11.8
2200	12.3
2250	12.8
2300	13.3
2350	13.9
2400	14.6
2450	15.3
2500	16.0
2550	16.8
2600	17.8
2650	18.7
2700	19.6
2750	20.6
2800	21.6
2850	22.6
2900	23.8
2950	25.0
3000	26.3
3050	27.4
3100	28.6
3150	29.8
3200	31.0
3250	32.4
3300	33.7

PLATES FOR APPENDIX IV.

PLATE 1. — Wind Corrections.

PLATE 2. — Factor *f*.
Changes in barometer and temperature (C).

PLATE 3. — Factor *f*.
Changes in barometer and temperature (F).

PLATE 4. — Corrections to Elevation.
Variation of C from 1.000.

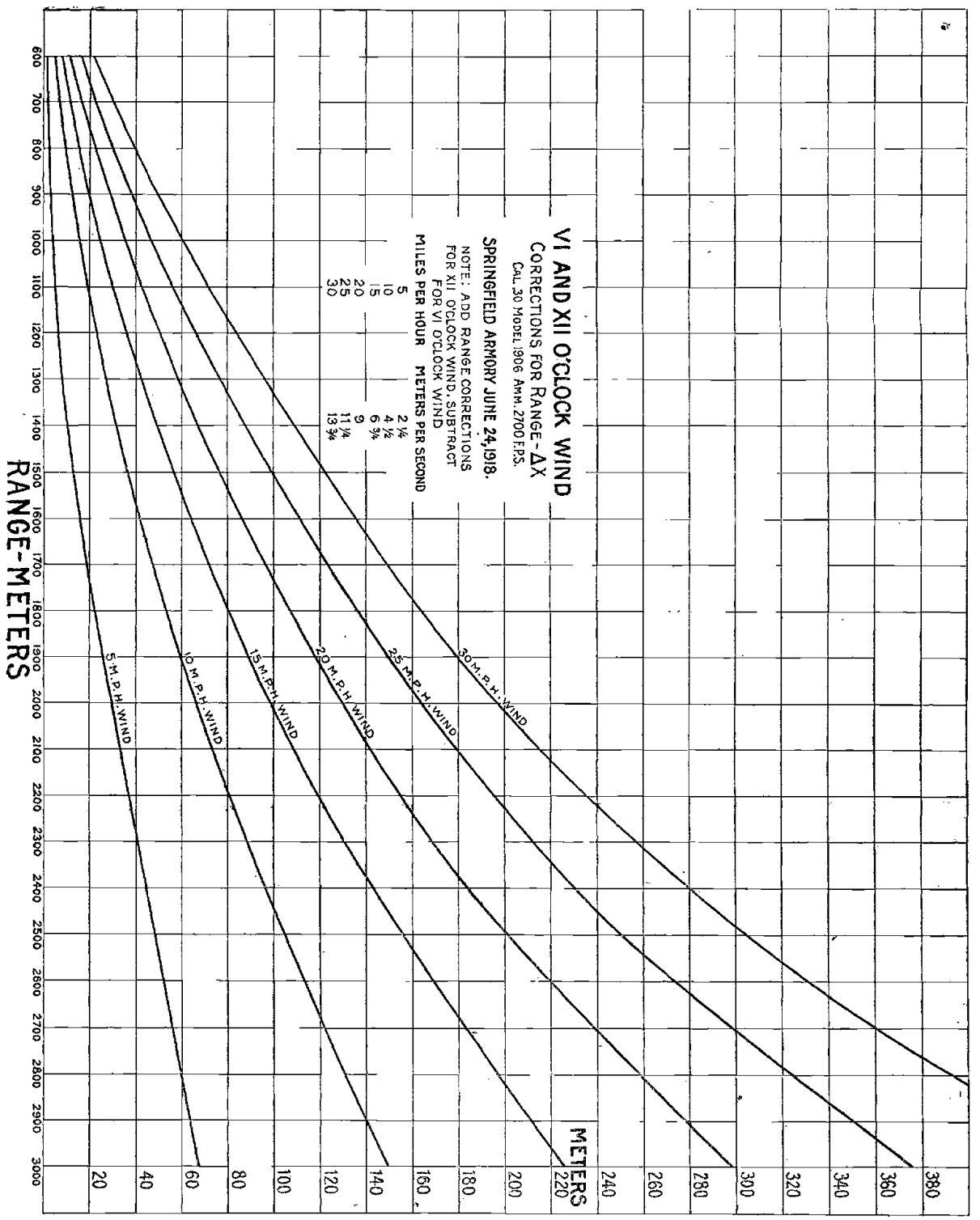
PLATE 5. — Decrease of Velocity.
Erosion of barrel.

PLATE 6. — Corrections to Elevation.
Changes of muzzle velocity.

PLATE 7. — Total Drift Curve.

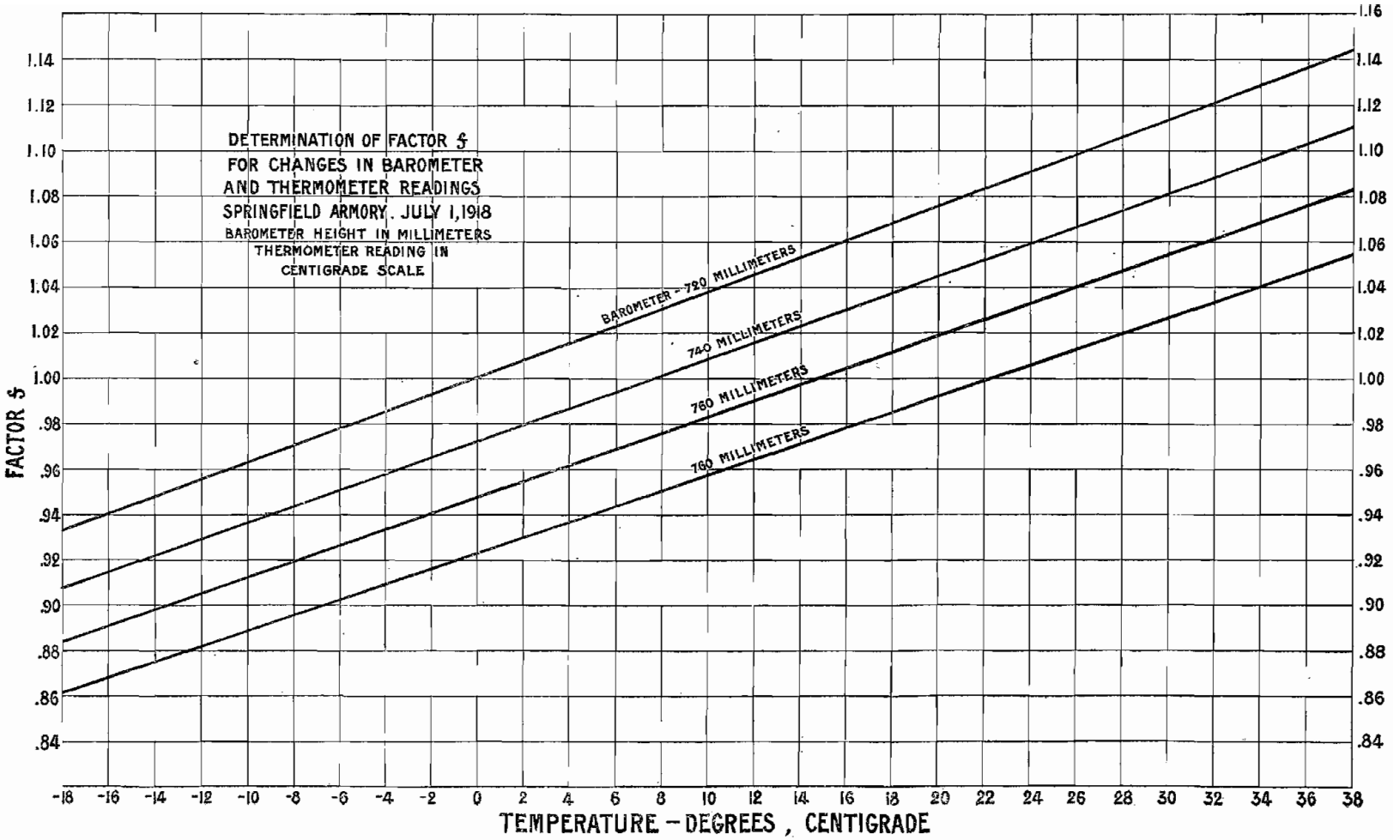
APPENDIX IV.

PLATE 1.



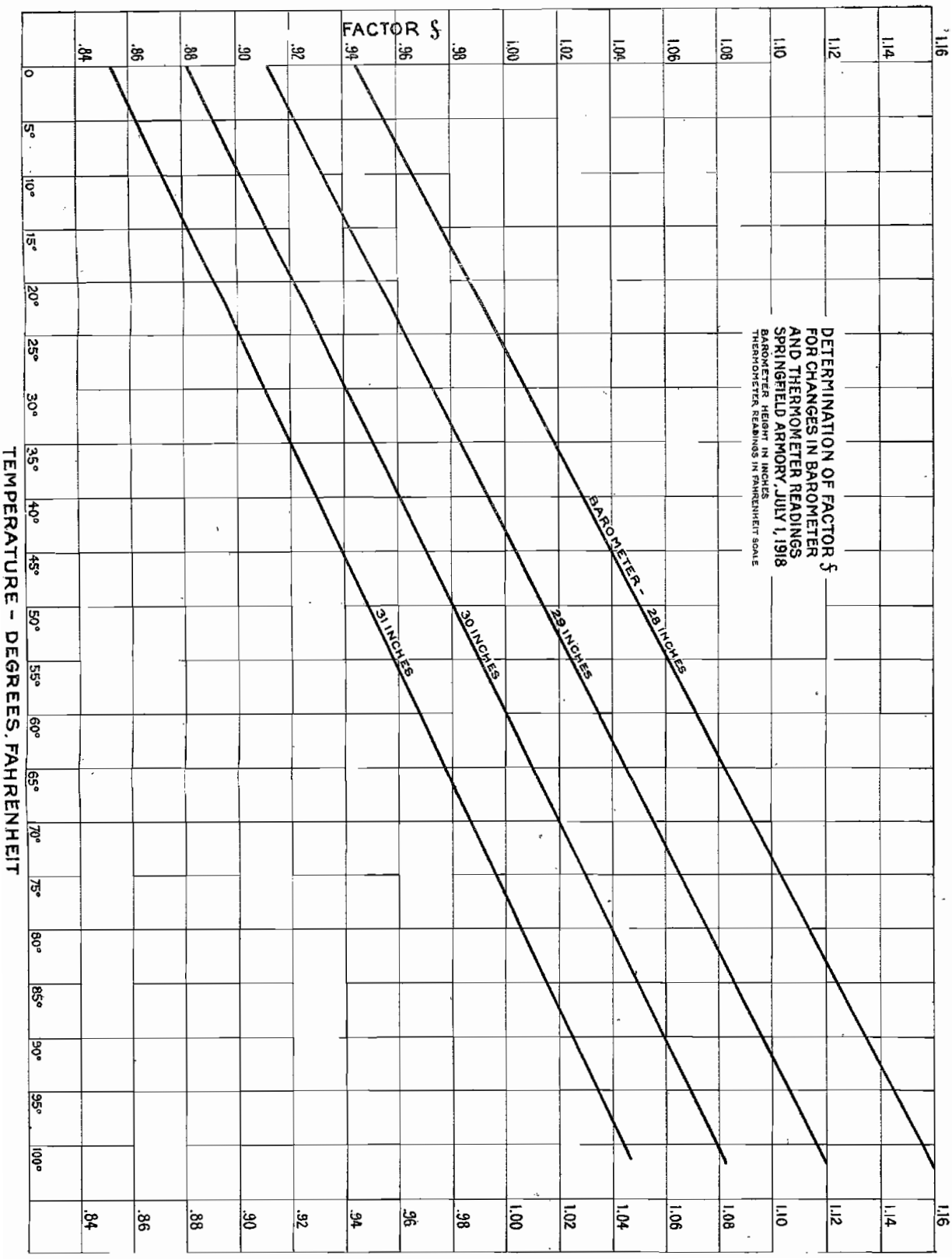
APPENDIX IV.

PLATE 2.



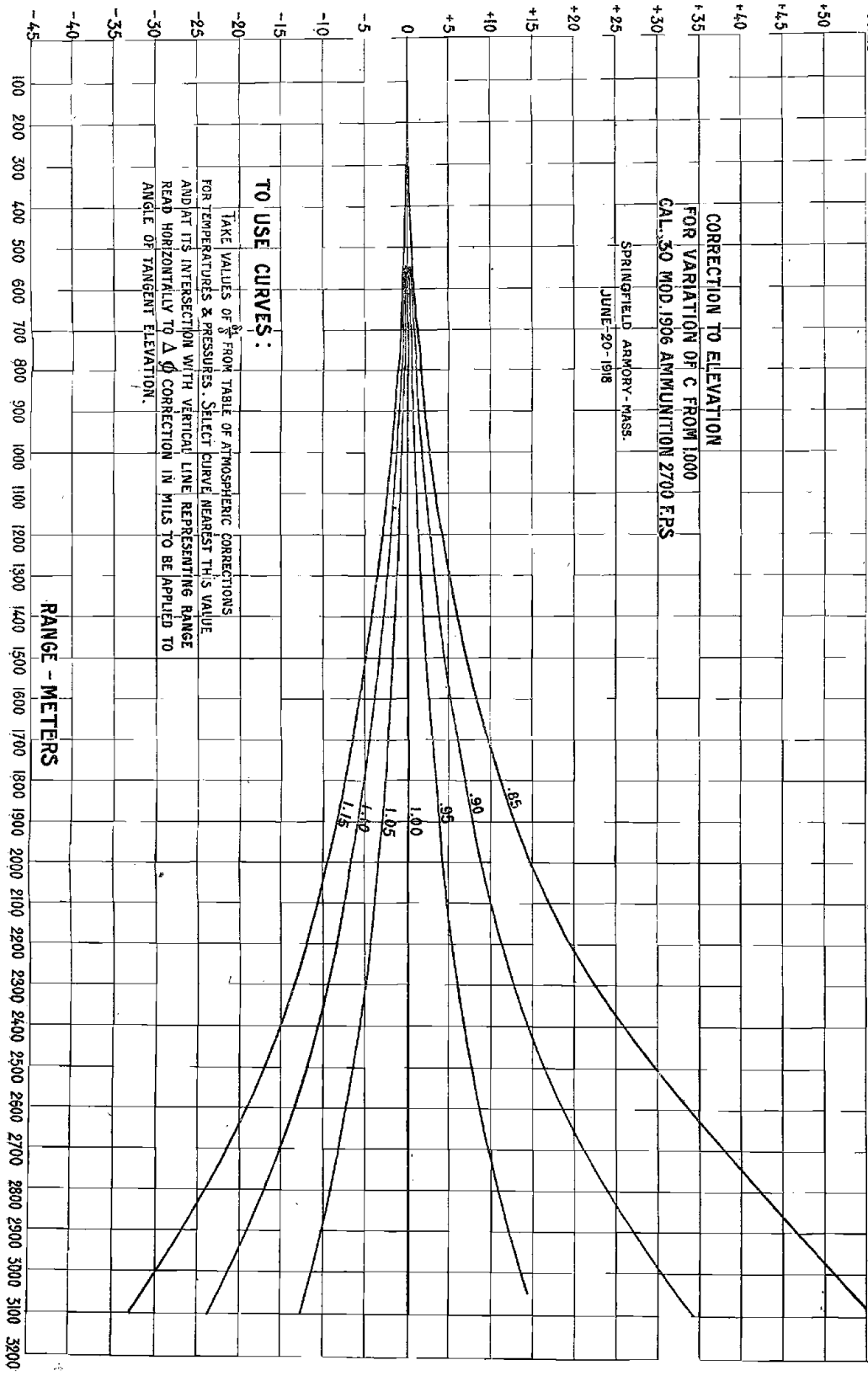
APPENDIX IV.

PLATE 3.



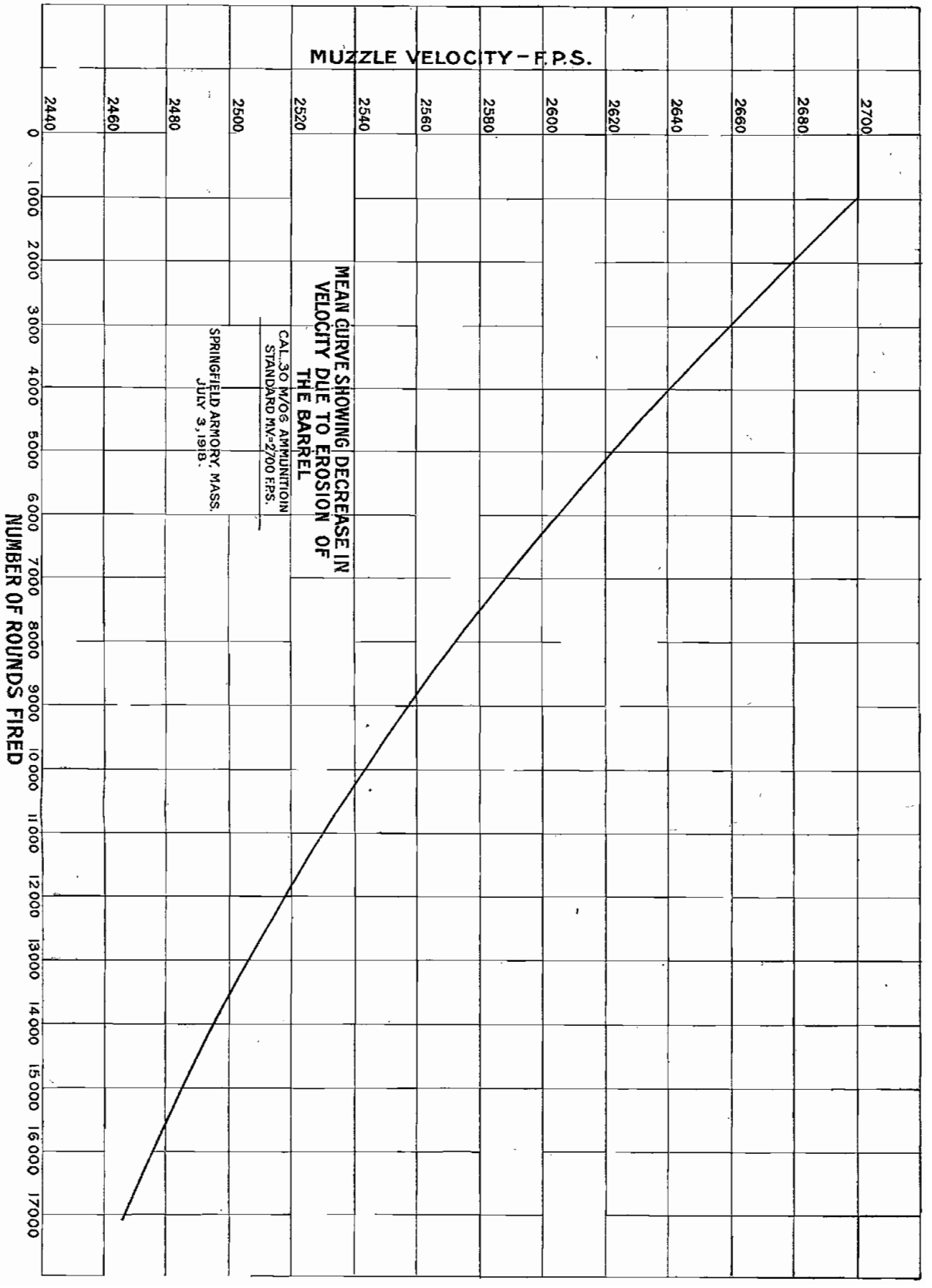
APPENDIX IV.

PLATE 4.



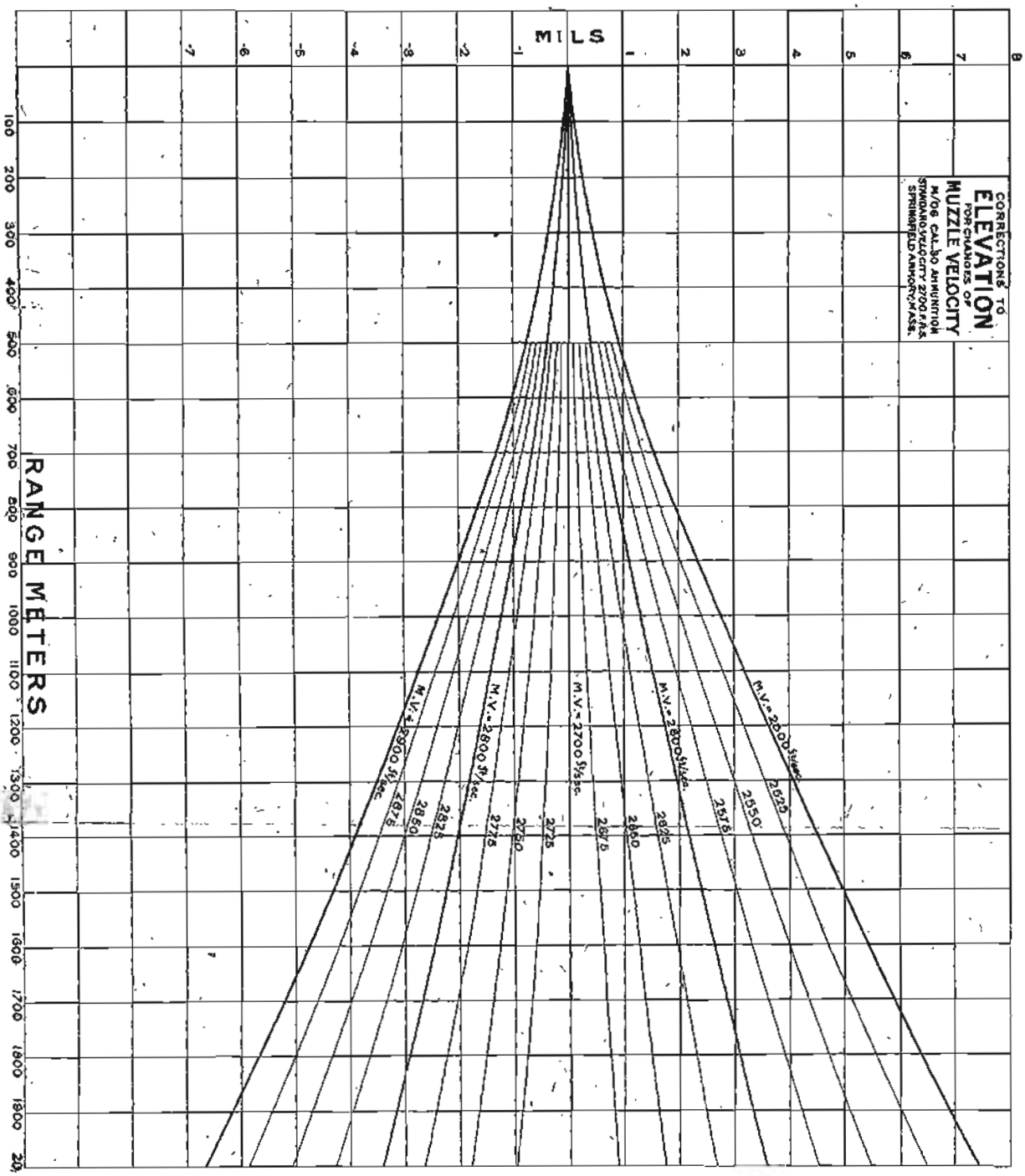
APPENDIX IV.

PLATE 5.



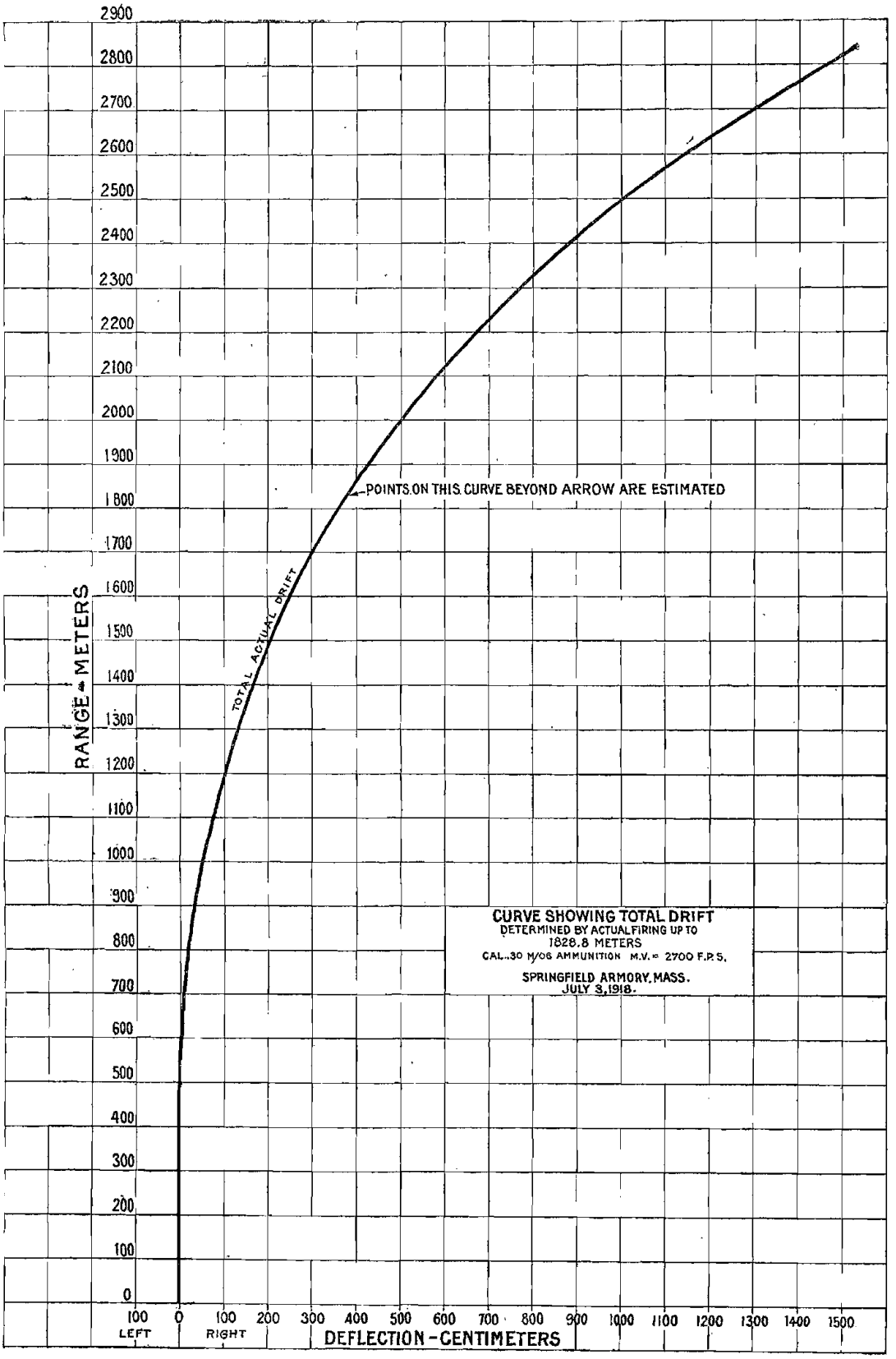
APPENDIX IV.

PLATE 6.



APPENDIX IV.

PLATE 7.



APPENDIX V.

PART 1.

Use of Trajectory Graphs.

To find quadrant elevation :

U. S. Ammunition Cal. .30. **Browning Machine Gun.**

(1) Take range to the gun in meters and move up or down this vertical range line until the horizontal line is crossed which represents the height of the target above or below the gun.

(2) Take the trajectory through this point and follow it down or up until it crosses the line of 0 elevation. The intersection with this line will show the equivalent range required. If the intersection falls between two vertical range lines, estimate the fractional part of the hundred meters.

(3) Look in table and obtain the tangent elevation in mils corresponding to the equivalent range.

Example :

Range to gun : 1800 meters.

Height of target above gun : 80 meters.

Follow up the 1800 meter vertical line until it cuts the horizontal line marked 80 meters. Take the trajectory through this point and follow it down until it crosses the horizontal line for 0 elevation at 2160 meters. Look in the table and find the tangent elevation for 2160, which is 116 mils.

Hotchkiss Machine Gun.

(1) Proceed as in par. (1) for U. S. ammunition cal. .30.

(2) Take the trajectory through the intersection and follow it down to the scale marked sight setting. This will give the reading at which the gun level is to be set.

Example :

Range : 3100 meters.

Target : 40 meters below the gun.

Follow down the 3100 meter vertical range line until it intersects the horizontal line marked 40. Take the trajectory through this point and follow it to the sight setting scale which gives a reading of 1905.

To find clearance.

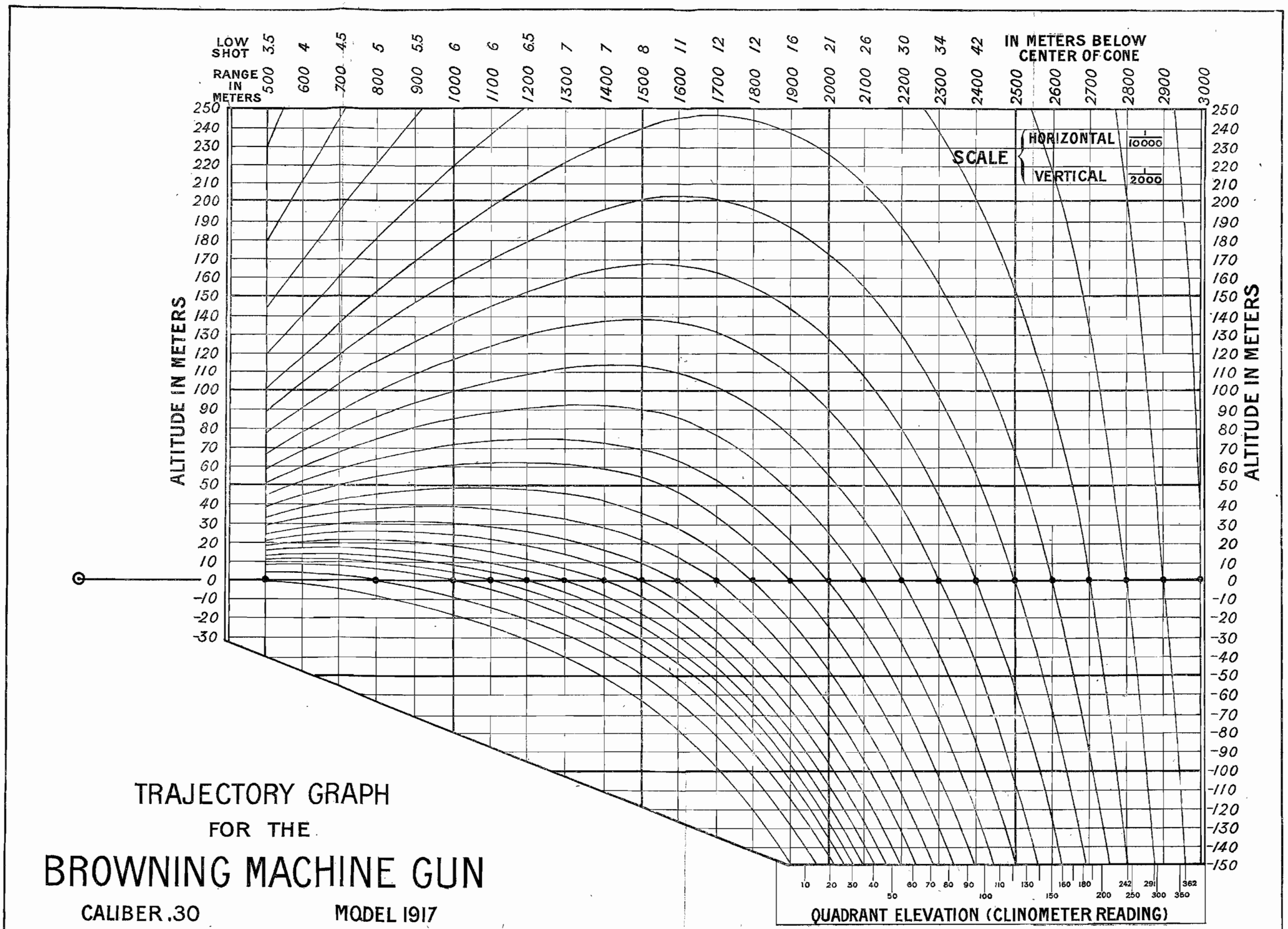
Follow the trajectory along and ascertain at what height it passes vertically above a point plotted to show distance and height (above or below gun) of own troops (or obstruction).

Example :

In the first example shown above assume that our troops are at a range of 1200 meters and 40 meters above the gun. Follow the 2160 trajectory back until it cuts the 1200 meter range line, which it intersects almost at the 100 meter horizontal line giving a height of 100 meters. The clearance then is 100 — 40 = 60 meters.

APPENDIX V.

PART 2.



TRAJECTORY GRAPH

FOR THE

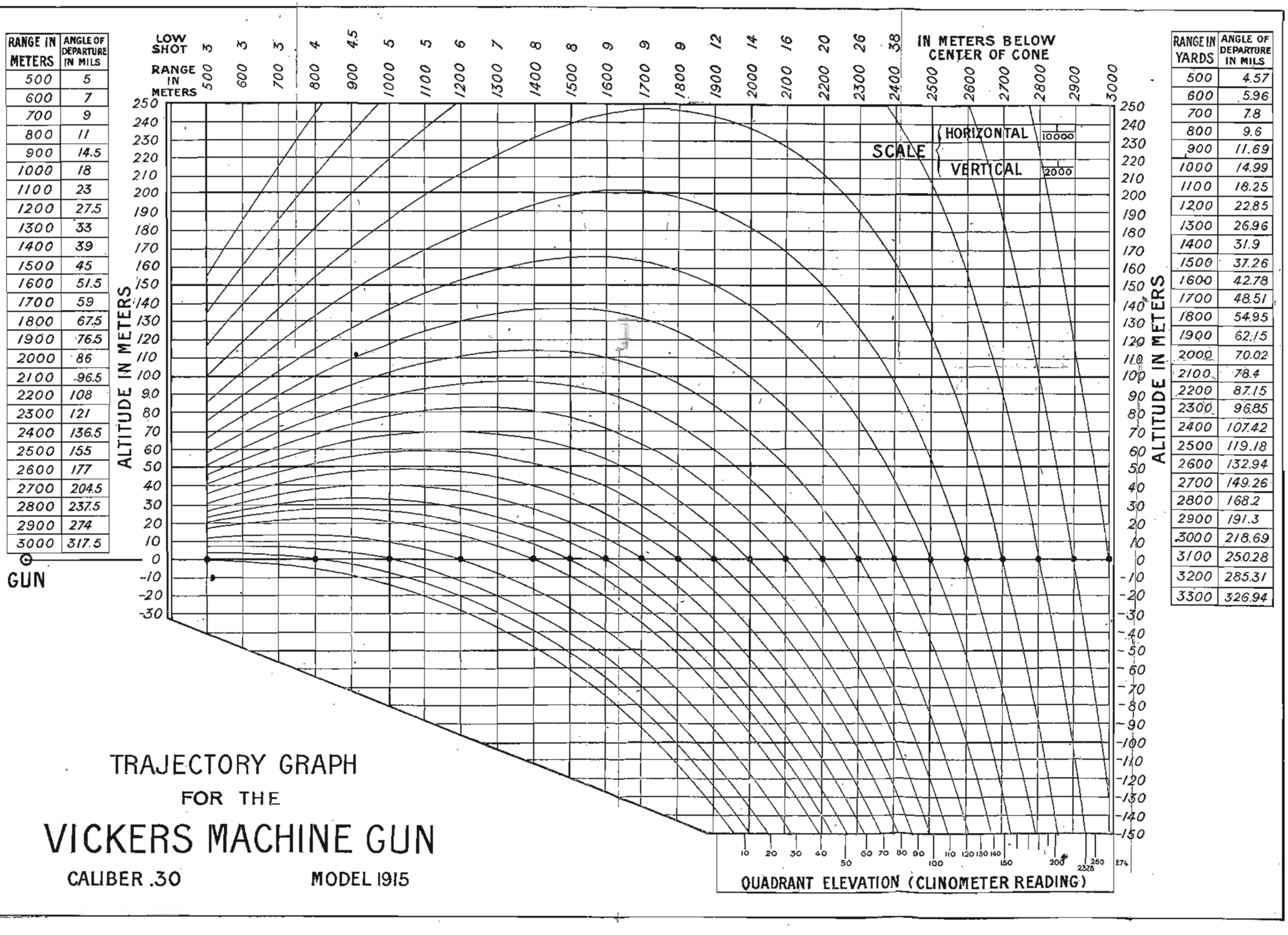
BROWNING MACHINE GUN

CALIBER .30 MODEL 1917

APPENDIX V.

PART 2 A.

RANGE IN METERS	ANGLE OF DEPARTURE IN MILS
500	5
600	7
700	9
800	11
900	14.5
1000	18
1100	23
1200	27.5
1300	33
1400	39
1500	45
1600	51.5
1700	59
1800	67.5
1900	76.5
2000	86
2100	96.5
2200	108
2300	121
2400	136.5
2500	155
2600	177
2700	204.5
2800	237.5
2900	274
3000	317.5



RANGE IN YARDS	ANGLE OF DEPARTURE IN MILS
500	4.57
600	5.96
700	7.8
800	9.6
900	11.69
1000	14.99
1100	18.25
1200	22.85
1300	26.96
1400	31.9
1500	37.26
1600	42.78
1700	48.51
1800	54.95
1900	62.15
2000	70.02
2100	78.4
2200	87.15
2300	96.85
2400	107.42
2500	119.18
2600	132.94
2700	149.26
2800	168.2
2900	191.3
3000	218.69
3100	250.28
3200	285.31
3300	326.94

TRAJECTORY GRAPH

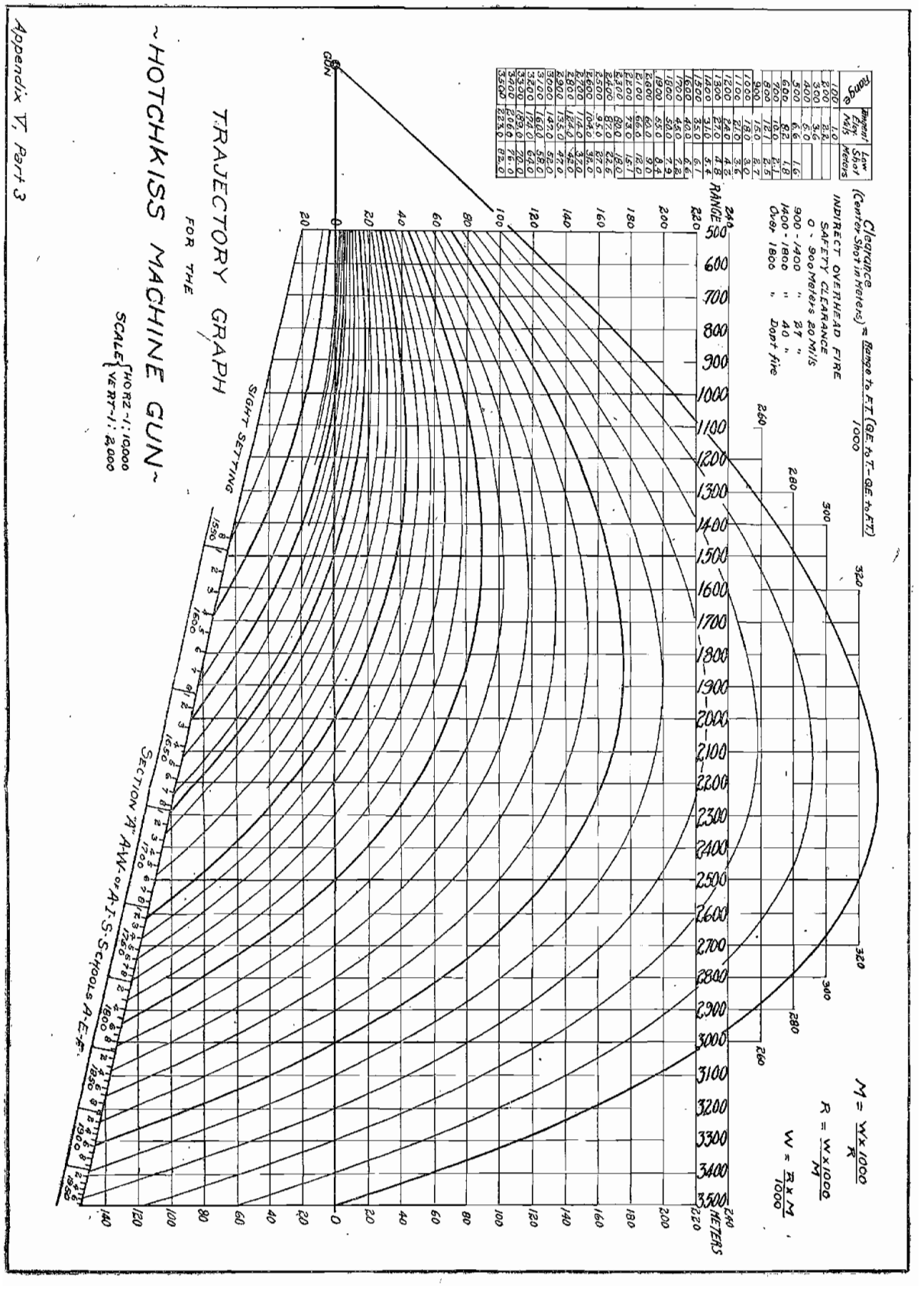
FOR THE

VICKERS MACHINE GUN

CALIBER .30 MODEL 1915

APPENDIX V.

PART 3.



Appendix V, Part 3

GRAPH of TRAVERSES. etc.

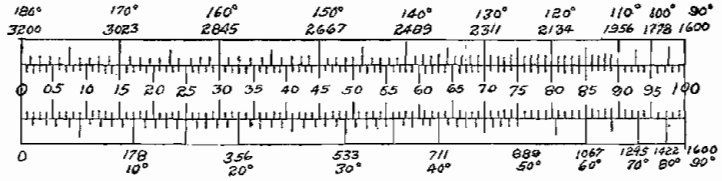
(IN YARDS OR METERS AND DEGREES)

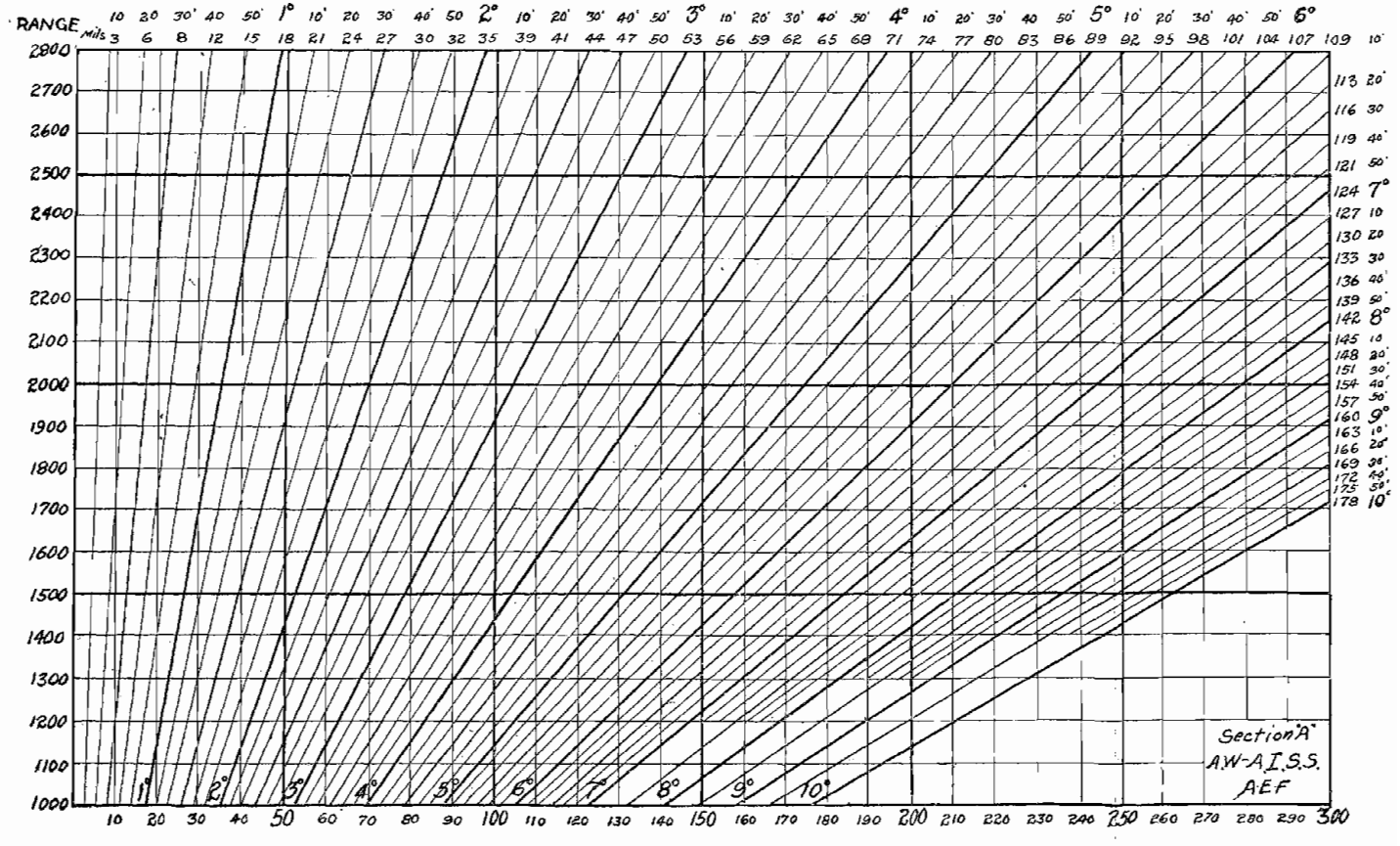
The angle is shown by the diagonal line nearest to the point of intersection of the required (vertical) Target-Frontage line and the (horizontal) Range line.

NOTE:- Both Target-Frontage and Range must be taken in the same unit of measure E.g: both in yards or both in meters.

SCALE FOR THE CONVERSION OF OBLIQUE TO EQUIVALENT FRONTAL TARGETS

Example:- Target 280ˣ long at angle of 150° to the line of fire
The scale gives .45 so equivalent frontal target = .45 of 280ˣ = 126ˣ

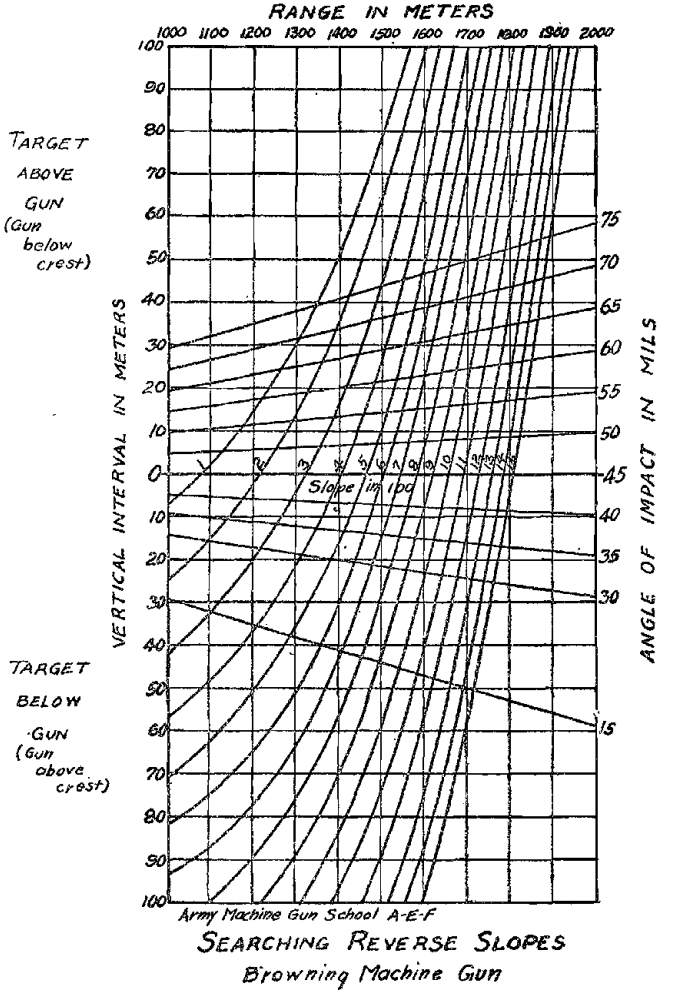




TARGET · FRONTAGE

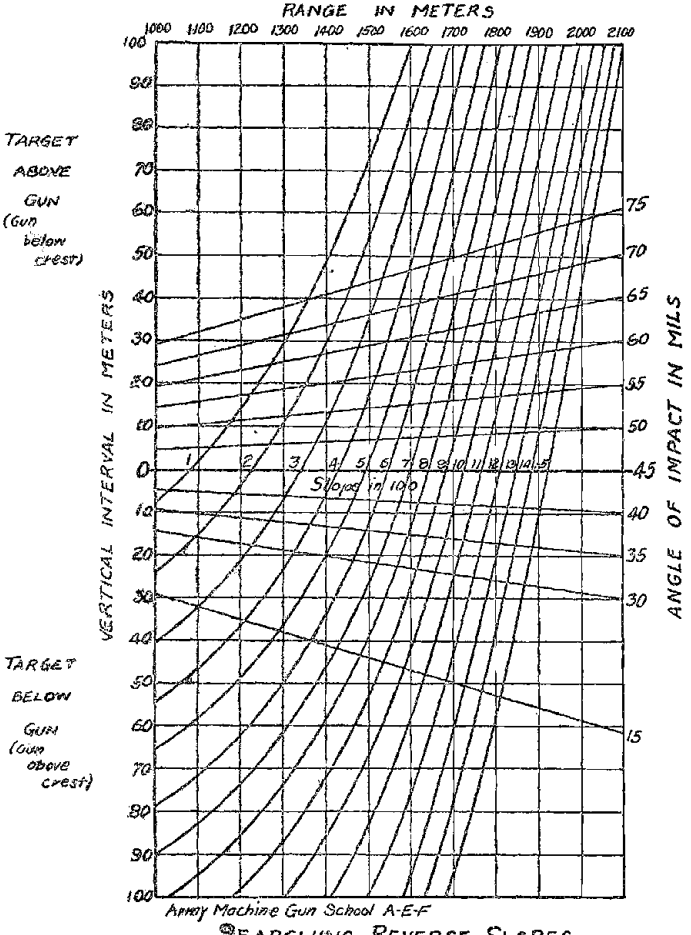
APPENDIX VII.

PART 1.



APPENDIX VII.

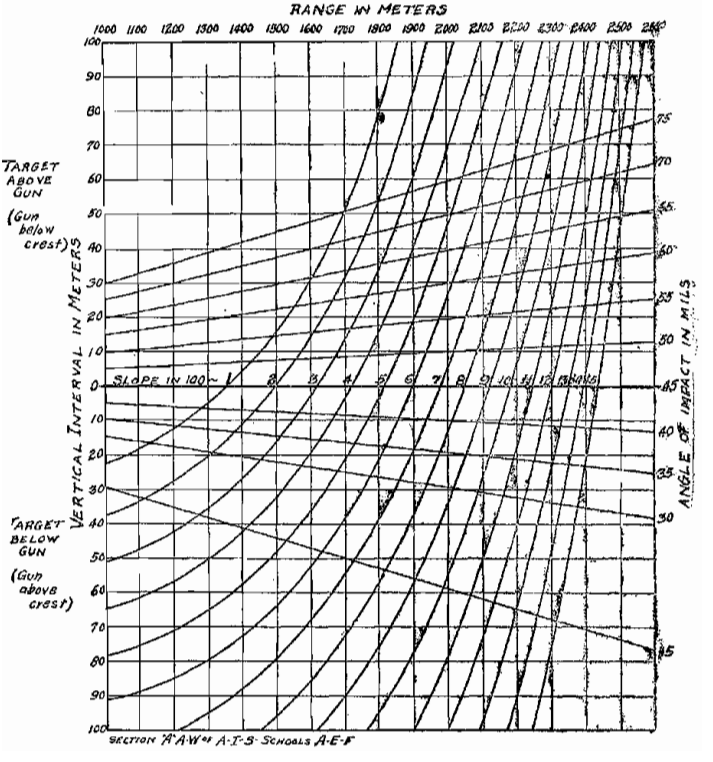
PART 1 A.



APPENDIX VII.

PART 2.

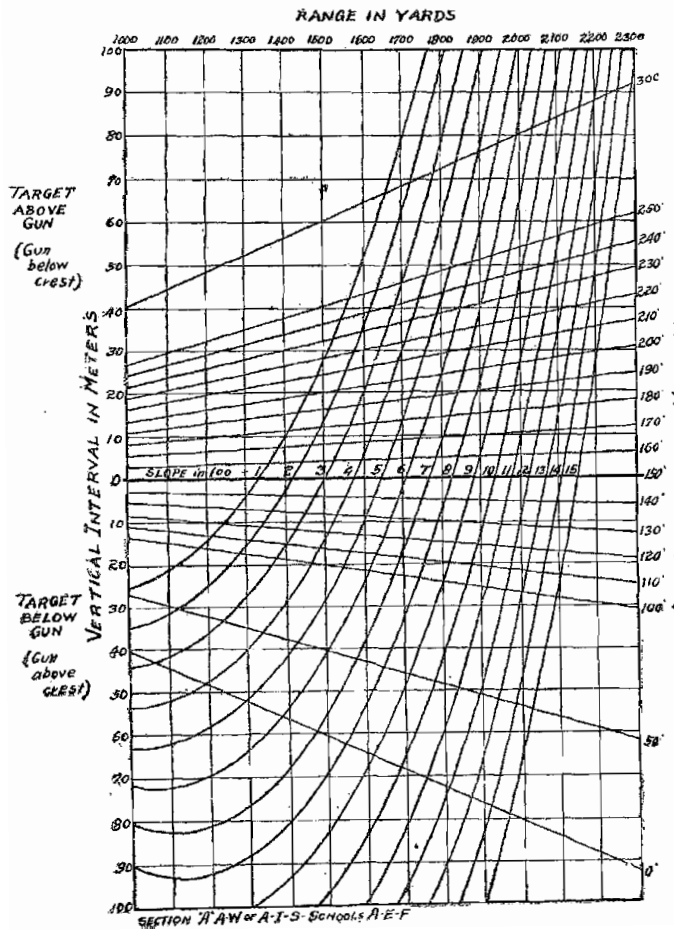
Searching Reverse Slopes.
Hotchkiss Machine Gun. Ball "D" Ammunition.



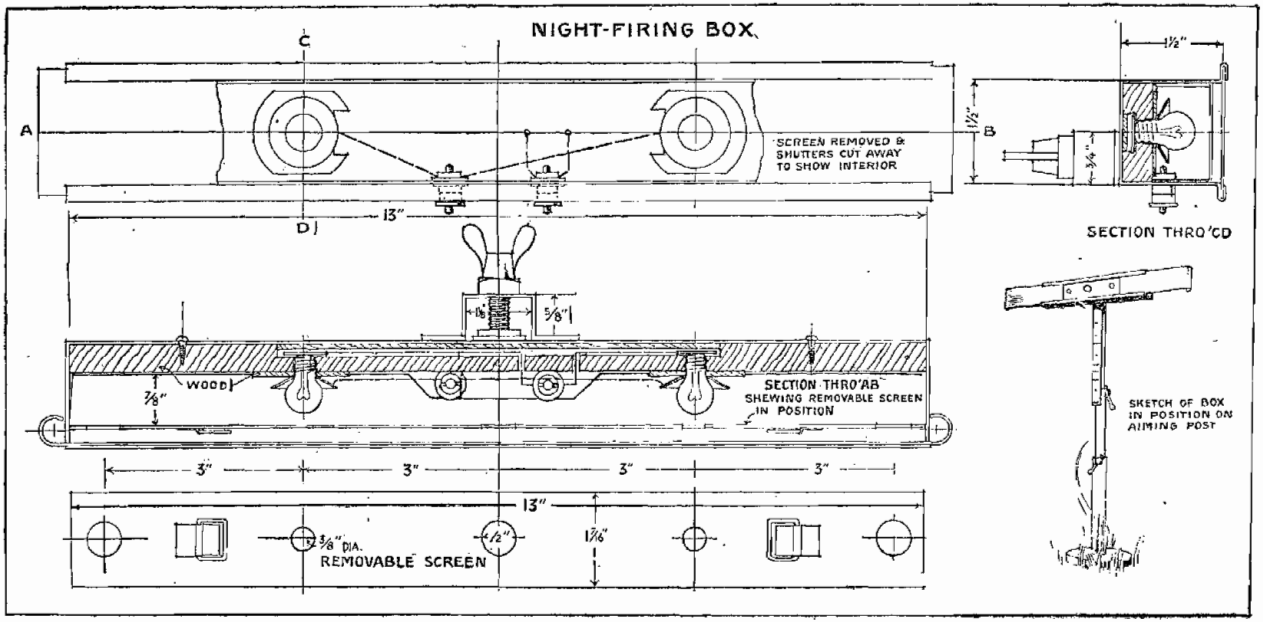
APPENDIX VII.

PART 3.

Searching Reverse Slopes.
Vicker's Machine Gun. 303 Ammunition.



APPENDIX VIII.



MACHINE GUN EMPLACEMENTS

Bill of Material and Work Data.

A — SHELL HOLE TYPE MACHINE GUN EMPLACEMENT

112 sand bags.
2 standard ammunition boxes.
1 standard "T" base.
8 revetting stakes : 3'6" × 2".
2 sheets corrugated iron (light).
1 roll camouflage screen (6' × 30').

Excavation : 80 cu. ft. : 3 men — 2 hours.
Total work : 3 men — 4 hours.

B — DOUBLE MACHINE GUN EMPLACEMENT

WITH SPLINTER-PROOF COVER

ITEM	1 GUN 1/2 emplacement	2 GUNS Whole emplacement
Logs : 8′ × 6″	12	24
" : 8′ × 4″	60	120
" : 10′ × 5″	46	92
Corrugated iron or roofing paper.	375 sq. ft.	750 sq. ft.
Timbers : 6″ × 8″ × 3′	2	4
Standard "T" Bases.	1	2
Camouflage Screening	950 sq. ft.	1900 sq. ft.
Sand Bags.	120	240
Poles : 5′ × 2″	20	40
Plank : 12″ × 1″ × 2′	5	5
Brush for revetting steps.	1 bundle.	1 bundle.
Stakes : 12″	100	200
Wire; thin; smooth	1 coil.	2 coils.
Excavation	75 cu. ft.	150 cu. ft.
Man hours for excavation	60 "	120 "
Work of completion	6 men; 10 hours.	12 men; 10 hours.
Total work	6 men; 14 hours. (3-8 hr. shifts.)	12 men; 14 hours. (3-8 hour shifts.)

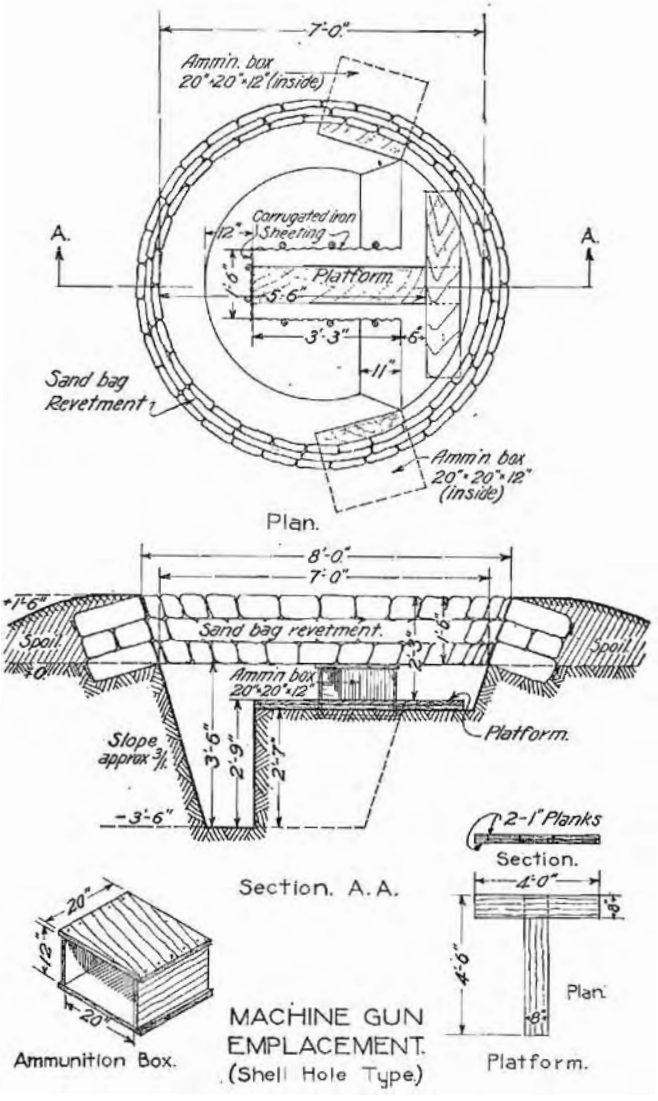
NOTE. — This is exclusive of work of getting material to site.

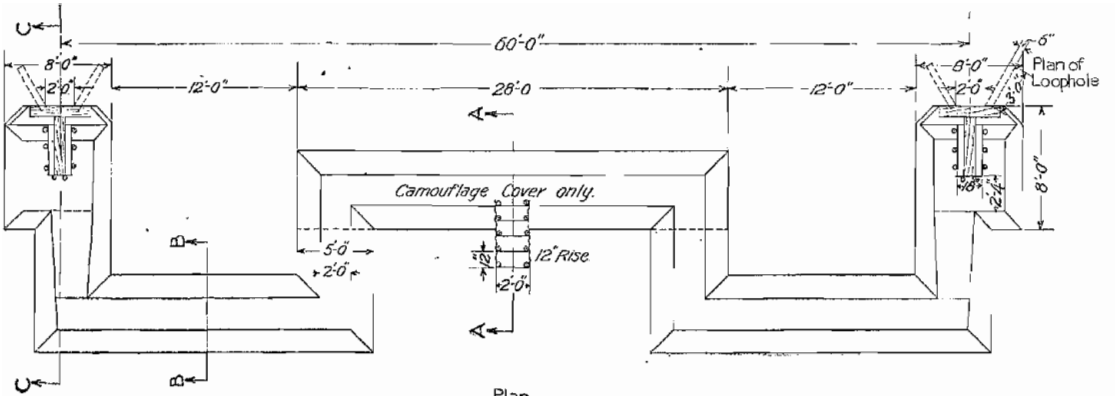
Bill of Material.

C — REINFORCED CONCRETE MACHINE GUN EMPLACEMENT

Excavation . . . . . 27.18 cu. yds.
Volume of concrete. . . . . 165.42 cu. yds.

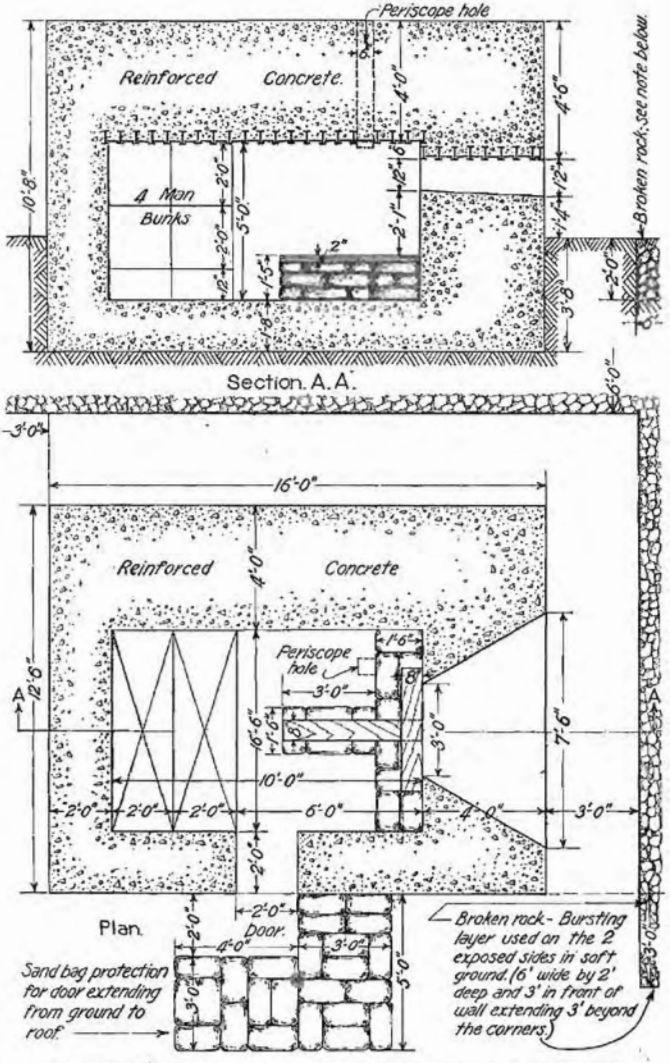
MATERIAL	CUBIC FEET	WEIGHT IN LBS	AMOUNT
	Concrete Material.		
Cement	359.81	35981.00 — 17.99 tons.	94.7 bbls. (28 cu. ft. per bbl.).
Sand.	719.62	71962.00 — 35.98 tons.	26.65 cu. yds.
Broken Rock.	1439.24	170092.00 — 85.05 tons.	53.30 cu. yds.
Water.	261.68	16355.00 — 8.18 tons.	1962.60 gallons.
	Reinforcing Material.		
5″ I beams	258 lin. ft.	2515.50 — 1.26 tons.	24 — 9′ beams. 2 — 8′ — 2 — 7′ — 2 — 6′ —
5/16″ iron wire for stirrups.	1452 lin. ft.	136.15	1500 linear ft.
5/8″ round iron bars for reinforcing grids	5804 lin. ft.	5995.53 — 3.00 tons.	5804 linear ft.
	TOTAL WEIGHT	151.52 tons.	
Sand bags.			375
"T" Base.			1
4 man double-deck bunk			1
	Material for burster course to be used in soft ground.		
Excavation.			13.26 cu. yds.
Broken Rock			13.26 cu. yds.


7'-0"
Ammn. box
20"×20"×12"(inside)
Corrugated iron
Sheeting
12"
A.
A.
1'-6"
Platform.
5'-6"
3'-3"
6"
11"
Sand bag
Revetment
Ammn box
20"×20"×12"
(inside)
Plan.
8'-0"
7'-0"
+1'-6"
Spoil
Sand bag revetment.
1'-6"
2'-3"
Spoil
±0
Ammn box
20"×20"×12"
Platform.
Slope
approx 3/1
3'-6"
2'-9"
2'-7"
-3'-6"
2-1" Planks
Section.
Section. A.A.
4'-0"
9"
4'-6"
Plan.
8"
20"
12"
20"
Ammunition Box.
MACHINE GUN
EMPLACEMENT.
(Shell Hole Type)
Platform.

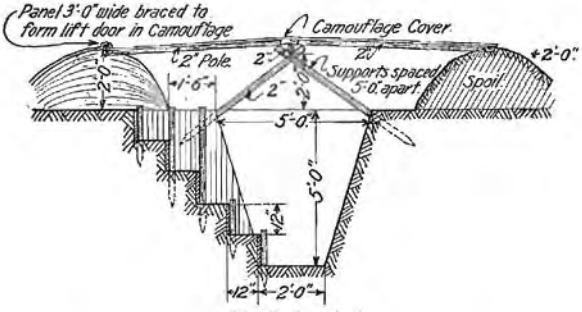


Plan.
at Ground Level.

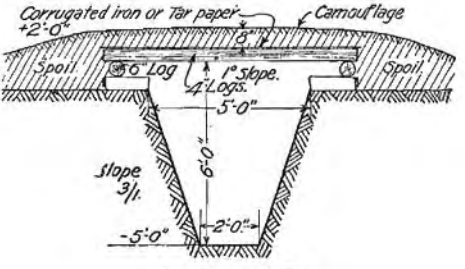
TWO GUN MACHINE GUN EMPLACEMENT.
(With Splinter Proof Shelter.)



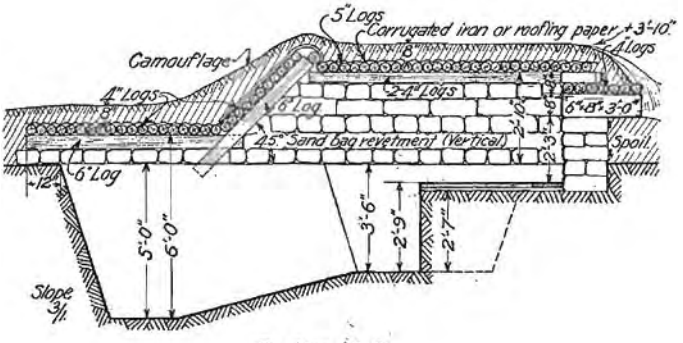
MACHINE GUN EMPLACEMENT OF REINFORCED CONCRETE.
(Safe against 210. m.m. H.E. Shell.)



Section. A.A.



Section B.B.



Section C.C.