TM 4-320

WAR DEPARTMENT

TECHNICAL MANUAL

COAST ARTILLERY GUNNERS' INSTRUCTION, MOBILE SEACOAST ARTILLERY, EXPERT GUNNERS

May 4, 1942

Doc. unit
gift
Non circ

TECHNICAL MANUAL No. 4-320 } WAR DEPARTMENT, WASHINGTON, May 4, 1942.

COAST ARTILLERY GUNNERS' INSTRUCTION, MOBILE SEACOAST ARTILLERY, EXPERT GUNNERS

CHAPTER 1

GENERAL

1. Purpose and scope.—*a. Purpose.*—This manual is designed primarily for use by organization commanders in the instruction of enlisted men of mobile seacoast artillery units of the Coast Artillery Corps. It may be used by officers conducting examinations of enlisted men for qualification as gunners, as contemplated by FM 4–150. The questions and answers in the manual are intended merely as a guide and should be supplemented by the extensive use of other questions and answers and by practical demonstrations.

b. Scope.—The topics included in this manual are those prescribed in FM 4–150 for qualification of enlisted men as expert gunners in mobile seacoast artillery units.

2. Assignment of topics.—The following is the general assignment of topics. Each organization should omit those portions of the assigned chapters, sections, and paragraphs that do not pertain to the particular equipment in use by the organization.

Subject	Chief of section (railway battery only), gun commander, and gun pointer	Chief of section, searchlight battery, 155-mm gun regiment
Definitions and elementary principles for seacoast artillery.	Sec. I, ch. 19	Sec. I, ch. 19.
Gun and carriage	Ch. 2 (155-mm gun battery) and ch. 3 (railway battery).	
Ability to instruct in the duties of each member of the gun section (practical).	Ch. 5	
Organization of a position	Sec. II, ch. 19	Sec. II, ch. 19.
Ammunition, seacoast artillery	Sec. I, ch. 6	
Preparations for subcaliber and service practice, to include safety precautions before and during firing.	Sec. I, ch. 14	
Pointing	Ch. 4	
Map reading	Sec. III, ch. 19 (see note 1).	
March rules and discipline	Sec. VII, ch. 16 (155-mm gun battery only).	
Railway cars	Par. 138 (railway battery only).	
Searchlight apparatus (mobile seacoast searchlights).		Secs. I and III, ch. 15.
Detailed knowledge of the indication and identification of naval targets.		Secs. I and II, ch. 13.
Troubles and remedies (mobile seacoast searchlights).		Sec. II, ch. 15.

NOTE 1.—For railway batteries, paragraphs 148 and 149 only.

Subject	Chief of section, ammunition train, 155-mm gun battalion	Transportation sergeant
Detailed knowledge of the care, service, repair, and maintenance of motor vehicles in the field.	Sec. IX, ch. 16	
Detailed knowledge of procuring, handling, and storage of ammunition.	Par. 15	
Loads and their proper distribution.	Sec. IV, ch. 16	Sec. IV, ch. 16.
Training of drivers	Sec. V, ch. 16	Sec. V, ch. 16.
Organization of bivouac	Sec. II, ch. 19	
Detailed knowledge of the rules of the road, convoy regulations and discipline, speed laws and regulations, parking, and road inspections.	Sec. VI, ch. 16	Sec. VI, ch. 16.
Ammunition records, reports, and forms; preparation, distribution, routing, and filing.	Par. 16	
Elementary principles of electricity, magnetism, and induction.		Sec. IV, ch. 19.
Principles of internal combustion engines.		Sec. I, ch. 16.
Inspection, maintenance, and adjustment of motor vehicles.		Sec. II, ch. 16.
Shop practices and supervision and instruction of mechanics.		Sec. III, ch. 16.
Records and reports, motor transportation.		Sec. VIII, ch. 16.

Subject	Plotters	Instrument sergeant or observer
Definitions and elementary principles for seacoast artillery.	Sec. I, ch. 19	Sec. I, ch. 19.
Position-finding system	Ch. 8	Ch. 8.
Position-finding apparatus (plotting room).	Sec. I, ch. 9 and sec. II, ch. 12. (See note 2.)	
Position-finding apparatus (observation stations).		Sec. II, ch. 9.
Ability to instruct in the duties of each member of the range section (practical).	Ch. 11. (See note 3.)	
Elementary gunnery	Sec. I, ch. 7	
Map reading	Pars. 148 and 149. (See note 3.)	Pars. 148 and 149.
Methods of observation of fire and how to apply corrections.	Sec. I, ch. 12	
Preparation of records and reports, to include a knowledge of the details of analysis of drill and target practice.	Sec. II, ch. 14. (See note 3.)	
Use of firing tables, charts, and scales.	Sec. II, ch. 7. (For headquarters battery only.)	
Detailed knowledge of spotting system.		Pars. 51, 53, and 54.
Observation of fire		Sec. I, ch. 12.
Duties of an assistant in the use of transit in establishing a battery position.		Ch. 10.
Organization of a position		Sec. II, ch. 19.
General duties of observers in observation posts.		Sec. III, ch. 12.
Detailed knowledge of the indication and identification of targets (naval and air).		Ch. 13.

NOTE 2.—For 155-mm gun units, section I, chapter 9 only.
NOTE 3.—For battalion headquarters batteries, omit.

Subject	Communication sergeant	Railway sergeant
Systems of communication	Sec. I, ch. 17	
Elementary principles of electricity, magnetism, and induction.	Sec. IV, ch. 19	
Visual signaling—panels	Sec. II, ch. 17	
Installation of a complete field telephone system required by the unit.	Sec. III, ch. 17	
Time-interval system	Sec. VII, ch. 17 (Searchlight battery, omit.)	
Location of faults, tests for grounds, and tests for short circuits.	Sec. IV, ch. 17	
Installation and operation of message centers; encoding and decoding.	Sec. V, ch. 17	
Ability to instruct in the duties of linemen and telephone and switchboard operators.	Sec. VI, ch. 17	
Railway cars, advanced		Pars. 138 and 139.
Railway movements		Par. 142.
Track construction		Par. 137.
Practical knowledge of loading and unloading cars.		Par. 140.
Make-up of trains for approaching combat battery positions.		Par. 141.

CHAPTER 2

GUN AND CARRIAGE, 155–MM GUNS

3. Functioning of parts.—*Q*. Explain the construction of the 155-mm gun. *A*. The gun consists of a forged steel tube surrounded and strengthened by a jacket, and two hoops of forged steel. The supporting parts are heated until they can be slipped on over the tube

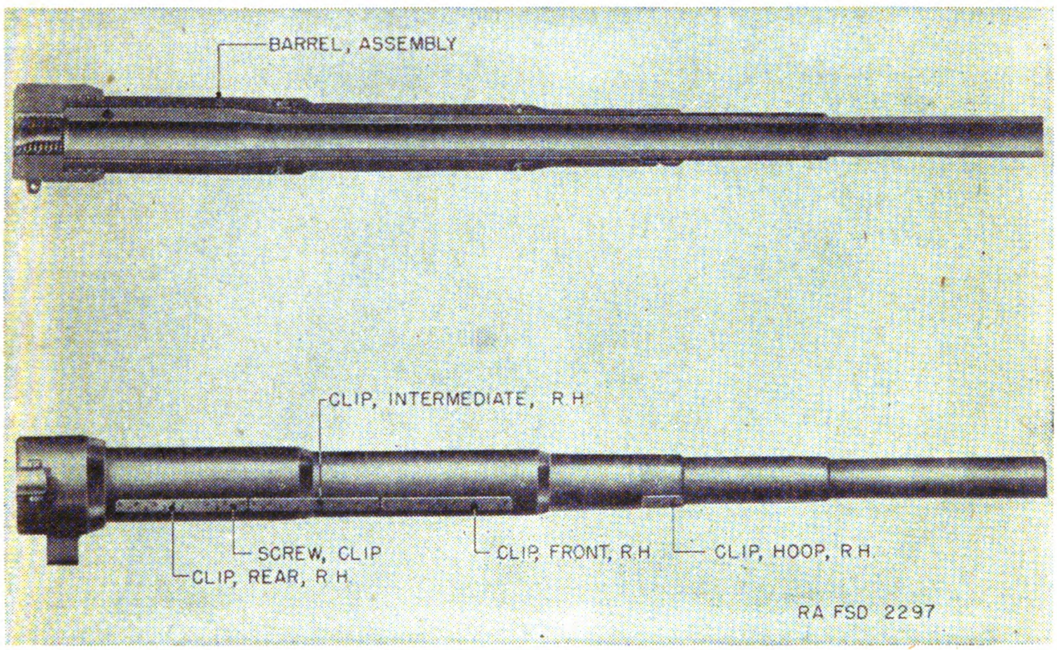


FIGURE 1.—155-mm gun M1918—assembled views.

and are then allowed to cool and shrink into place. They are keyed to each other and to the tube to prevent slipping off when the gun is fired. This method of making a gun is called the "built-up" method. A clip hook is added to the assembly to provide a place for attaching clips to help guide the gun in the cradle. The breech ring is screwed, cold, to the jacket. It forms the breech recess into which the breechblock fits.

Q. Name the principal parts of the breech mechanism. *A*. Breechblock, block carrier, operating lever, hinge pin, rack, obturating mechanism, firing mechanism, and counterbalance.

Q. Describe the breechblock. *A*. The breechblock is of the interrupted screw type; instead of being threaded around its entire circumference, its surface is divided alternately into four threaded sectors and four plain or slotted sectors, the latter of less diameter than the former. The same arrangement is made in the breech recess so that when the threaded sectors of the block are opposite the slotted sectors of the recess the block may be swung forward into place. The threaded sectors may then be engaged by rotating the block one-eighth of a

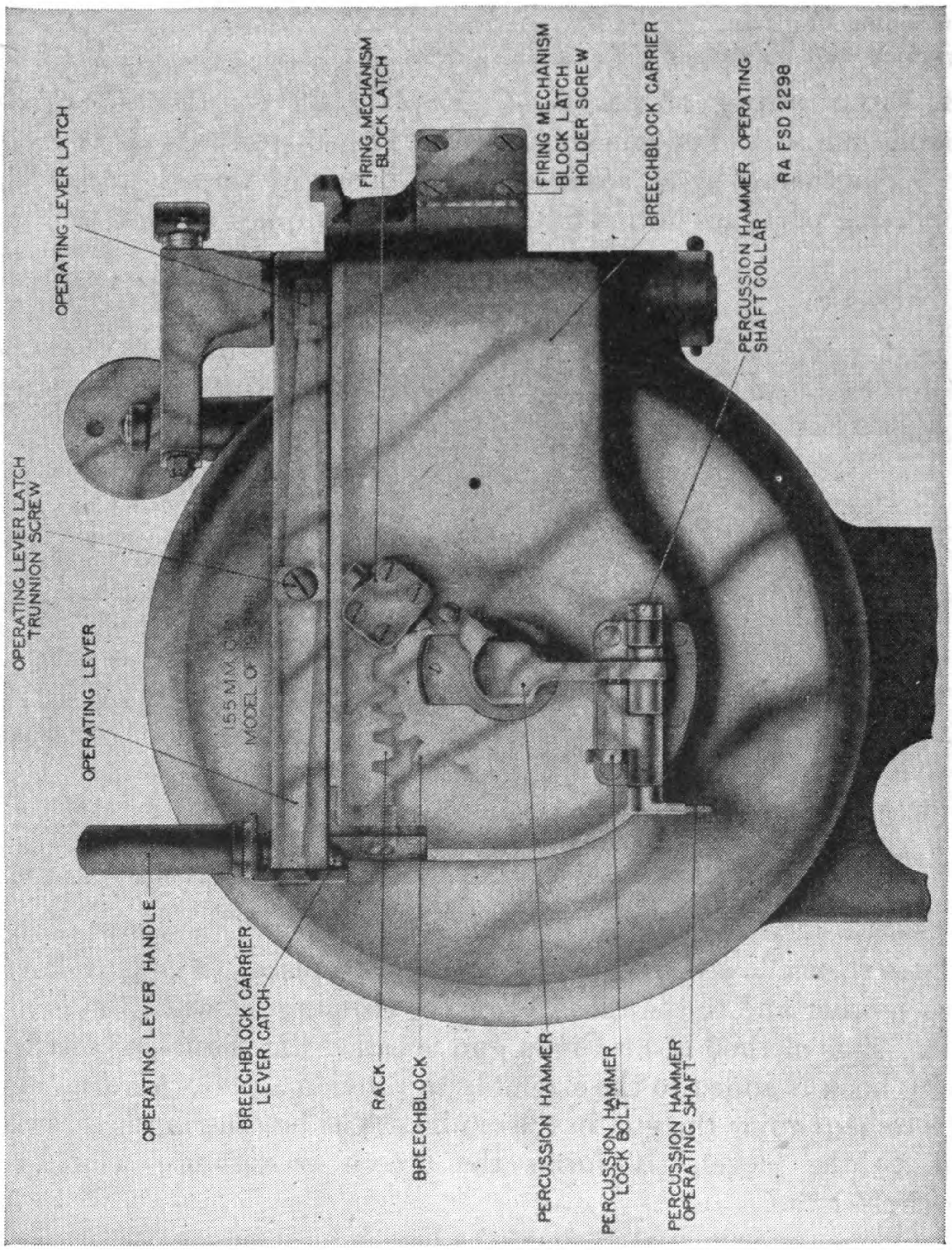


FIGURE 2.—Breech mechanism, 155-mm gun M1918—assembled view.

turn. If the whole surface were threaded, the block would have to be rotated several times to screw it into place. On the rear face of the breechblock are gear teeth which mesh with the teeth on the rack, by which the block is rotated. The outer surface of the block is threaded at its rear end and is screwed into the front face of the block carrier.

There is a hole running through the middle of the block, from front to rear, in which the obturator is mounted.

Q. Explain the action of the breech mechanism. *A*. The block carrier, viewed from the top, is L-shaped, with the long leg extending to the left across the face of the breech and the short leg forward

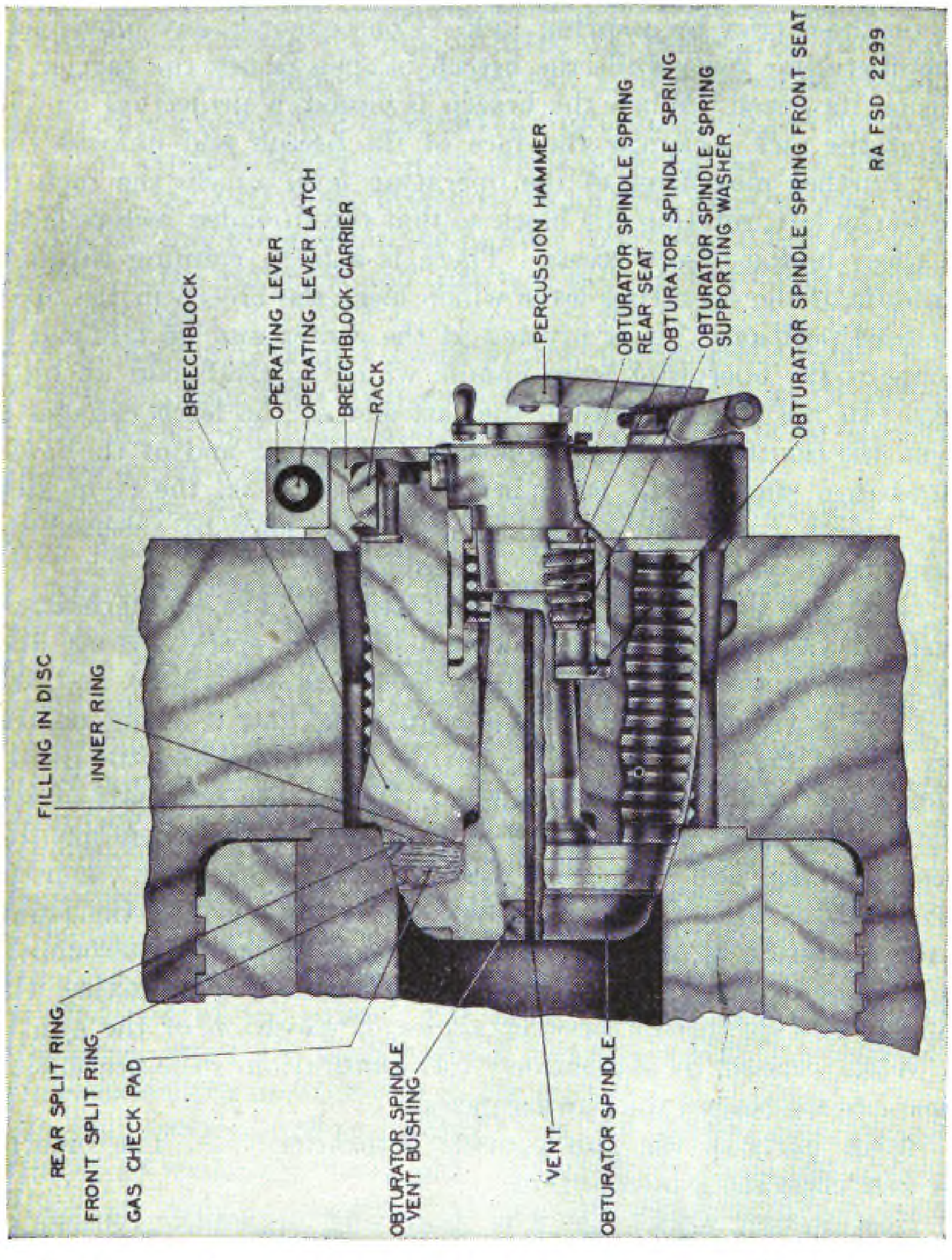


FIGURE 3.—Breech mechanism, 155-mm gun M1918—sectioned view.

to the hinge pin on the right of the breech ring. The hinge pin is mounted in lugs on the breech ring and serves as a turning support for the block carrier. The operating lever is shaped like the block carrier and rides on top of it. It is pivoted to the upper end of the hinge pin and has a lug at its elbow which sticks down into the carrier and engages in the right end of the rack. The rack is carried in the top of the block carrier and extends over the rear end of the breechblock. A set of gear teeth in the left end of the rack meshes with a similar set on the rear face of the breechblock. Any movement of the operating lever is transmitted through the lug in its elbow to the rack. While the breech is open the rack is held in place on the carrier by a spring lock. Consequently, any movement of the operating lever while the breech is open causes the carrier to swing on its pivot. When the breech is closed, a projection on the front of the rack lock hits the face of the breech and unlocks the rack. Further movement of the operating lever causes the rack to move to the left, rotating the block so that the threaded sectors mesh with those in the breech recess. There is a latch running through the middle of the operating lever which locks the breech in the open and closed positions. It is pivoted at the center and its left end is held up by the operating lever handle which is itself held up by a spring. In the closed position, the left end of the latch engages a stud on the carrier; in the open position, the right end of the latch engages in a stud on the latch bracket, which is on the right side of the breech ring. Either end of the latch may be released by pressing down on the operating lever handle.

Q. How does the counterbalance operate? *A.* The counterbalance consists of a cylinder, a piston rod and piston, a spiral spring, and a regulating nut. The cylinder is attached to the cradle and the piston rod is attached, through the regulating nut, to a lug on the upper end of the hinge pin. The spring is held between the piston head and the rear end of the cylinder. During the first half of the operation of either opening or closing the breech, the hinge pin lug moves to the rear and compresses the counterbalance spring. During the last half of the motion, the movement of the lug is to the front, and the operation is helped by the expansion of the counterbalance spring. The regulating nut provides a means for adjusting the tension of the spring for varying angles of elevation of the gun.

Q. What is meant by obturation? *A.* Obturation is the prevention of escape to the rear of the powder gases.

Q. What parts of the gun provide obturation? *A.* The breechblock and obturating mechanism.

Q. How do they work? *A.* The obturating mechanism consists of an obturator or "mushroom head" on a spindle that extends back through the middle of the breechblock, a gas check pad, three steel split rings, and a filling-in disk. The gas check pad is a mixture of nonfluid oil and asbestos in a canvas cover or copper wire screen. It is held between the mushroom head and the filling-in disk, which is next to the front face of the breechblock. Two of the split rings are carried around the outer edge of the pad and the other is around the inner edge next to the spindle. The firing mechanism housing screws on the rear end of the spindle where it extends into the hollow hub in the block carrier. The mushroom head is held tight by a spring placed between the firing mechanism housing and a shoulder in the block. When the gun is fired, the gases press back on the mushroom head. Since the breechblock cannot move backward, the gas check pad is squeezed between the mushroom head and the filling-in disk. It expands outward and inward, pushing the two outer rings up against the wall of the breech recess and the inner ring against the spindle, sealing the gases in the powder chamber. After the pressure goes down, the gas check pad contracts and relieves the pressure from the split rings.

Q. Name the principal parts of the firing mechanism. *A*. The firing mechanism block, primer seat plug, firing pin guide, firing pin spring, firing pin housing, firing pin, and the firing mechanism housing on the spindle.

Q. Explain the construction of the firing mechanism. *A*. The firing mechanism block is a plug-shaped piece of steel bored out to receive the other parts. The firing pin guide slides into the front end and is held in place by the primer seat plug, which is screwed into the front end of the firing mechanism block. The firing pin spring and firing pin are then inserted from the rear. The firing pin housing forms a sleeve around the rear end of the firing pin and screws into the firing mechanism block, pushing the firing pin against the spring and compressing it. This causes the firing pin to stick out slightly to the rear of the housing. The outer surface of the firing mechanism block is threaded to engage threads in the firing mechanism housing into which it is screwed, to prime the gun. Before priming, the head of the primer is inserted into a slot in the forward end of the primer seat plug. The primer and the firing mechanism block are then inserted into the breech, the body of the primer extending into the vent in the spindle.

Q. How is the primer ignited? *A*. By causing the percussion hammer to strike the firing pin. The hammer is on the upper end of a shaft which is mounted in journals projecting from the face of the block carrier below the firing mechanism. On the lower end of the percussion hammer shaft, below the journals, is a projection to which the lanyard is attached. At rest, the hammer falls to the rear and away from the firing pin, bringing the lower end of the shaft forward against the block carrier. When the lanyard is pulled to the rear, the hammer flies forward and strikes the firing pin with enough force to compress the firing pin spring and strike the primer, igniting it. The firing pin is then pushed back out of contact with the primer by the firing pin spring.

Q. What prevents the powder gas from escaping through the vent when the gun is fired? *A*. The pressure of the gas expands the primer body and pushes it tightly against the wall of the vent, sealing the opening.

Q. Describe the safety features on the firing mechanism and state the purpose of each. *A*.

(1) A safety plunger is provided in the firing mechanism housing to prevent insertion of the firing mechanism block until the breech is fully closed. This plunger is mounted just above the opening in which the firing mechanism block is screwed. When the breechblock is not rotated to its fully closed position, the upper end of the plunger is in contact with a cam surface on the inside of the breechblock and extends down into the opening in the housing that receives the firing mechanism block. This prevents the firing mechanism block from being screwed home. When the breechblock is fully closed, the plunger is free to move up out of the way, and is caused to do so by a spring placed between the plunger and the housing.

(2) The firing mechanism block is flanged to prevent the hammer from striking the firing pin except in one position. The flange has a groove which must be opposite a lug on the percussion hammer shaft before the hammer can go forward far enough to strike the firing pin. When the firing mechanism block is screwed all the way home, the groove is in the proper position for firing.

(3) A safety latch is placed on the rear face of the block carrier to lock the firing mechanism block in position and prevent it from being unscrewed and blown out by the pressure of the powder gas. The latch engages the outer end of the firing mechanism block handle when the block is screwed all the way home.

(4) A lock bolt is mounted on the carrier just above the percussion hammer shaft journals. When this bolt is pushed to the right, it prevents the hammer from going forward far enough to strike the firing pin. The bolt may be withdrawn to the left when the piece is ready to fire.

Q. Do these safety features actually prevent firing the gun before the breech is fully closed? *A*. No. The safety plunger does not prevent the *partial* insertion of the firing mechanism block into the housing. Furthermore, since the firing mechanism block must be rotated several times before it is screwed home, the groove in the flange is opposite the lug on the percussion hammer shaft once during each rotation. It is therefore possible to insert the firing mechanism block in the housing and line up the groove and the lug with the breech open. If the lanyard is pulled while the firing mechanism is in this position, the hammer will strike the firing pin with enough force to ignite the primer. The percussion hammer lock bolt will, however, prevent firing if it is placed in the locking position.

Q. What safety precautions should be observed when using this type of firing mechanism? *A*.

(1) The firing mechanism block must not be inserted in the housing until the breech is fully closed.

(2) The percussion hammer lock bolt must be moved into its locking position immediately after firing and must not be unlocked until the gun is pointed and ready to fire.

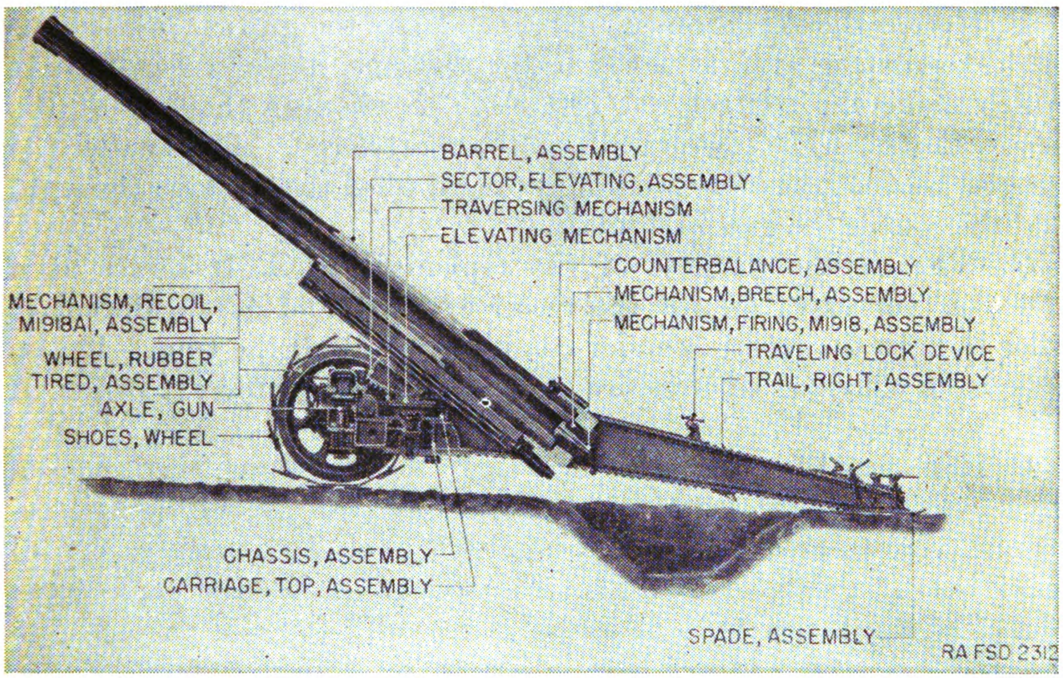


FIGURE 4.—155-mm gun carriage—longitudinal section in battery.

Q. How is the gun secured to the cradle? *A*. The gun is fitted with two rows of clips which run along the jacket and A-hoop, with short extensions farther forward on the clip hoop. These clips rest in guides in the upper part of the cradle. This supports the weight of the gun but allows it to slide on the cradle. It is held in firing position by the recoil and recuperator piston rods which are attached to the recoil lug, a projection on the under side of the breech ring.

Q. What is the purpose of the recoil mechanism? *A*. To take up the energy of recoil and stop the gun gradually as it recoils.

Q. How does the recoil mechanism operate? *A*. The recoil mechanism consists of a piston rod and piston which slide over a control rod, all contained within a cylinder filled with oil. The piston has holes or ports that connect with narrow openings or grooves between the piston rod and the control rod. The piston rod is bolted to a lug on the breech ring. The cylinder and control rod are attached to the cradle. When the gun recoils, the piston is pulled to the rear and the oil, in order to flow to the other side of the piston, has to pass through the ports in the piston and the grooves between the piston rod and the control rod. This causes friction which absorbs the energy of recoil and gradually stops the gun.

Q. Does the 155-mm gun have a constant length of recoil? *A*. No; the recoil system allows longer recoil at low angles of elevation than at high angles. The length varies from about 5 feet at minimum elevation to about 3½ feet at maximum elevation. It is automatically controlled by the elevation of the gun.

Q. How is the variation regulated? *A*. As the gun is elevated the recoil regulating arm, attached to the carriage, moves a set of gears which make the control rod rotate. This changes the size of the grooves between the piston rod and the control rod. The smaller the grooves become, the more friction is caused when the oil flows through, and the sooner the gun is stopped.

Q. What is the purpose of the replenisher? *A*. It serves as a reservoir for extra oil for the recoil cylinder and as an automatic filler to keep the recoil cylinder completely full all the time. It also acts as an equalizer of pressure by providing room for expansion of oil.

Q. How does the replenisher operate? *A*. The replenisher consists of a cylinder which holds extra oil in front of a piston. The replenisher piston is kept pressed against the oil by a spring. If oil leaks out of the recoil cylinder, the spring pushes the replenisher piston forward, forcing some of the extra oil through a passage into the recoil cylinder. If, due to rapid firing, the oil in the recoil cylinder expands, the replenisher piston moves back against the spring.

Q. Can you tell how much oil is in the replenisher? *A*. Yes, by the position of the spindle on the replenisher piston.

Q. How do you check this? *A*. By putting a gage into the rear end of the replenisher cylinder until it touches the spindle.

Q. What are the normal limits between which this gage should read? *A*. From 100 to 200 millimeters.

Q. What does a gage of less than 100 millimeters mean? *A*. That there is more oil in the cylinder than necessary.

Q. Can firing be permitted when the gage reads less than 100 millimeters? *A*. Yes; in an emergency, firing may be permitted until the reading is down to 50 millimeters. If it is expected that prolonged rapid fire will become necessary, the replenisher should be drained until the gage reading is 200 millimeters. This will provide enough reserve oil for proper functioning and will allow added room for the expected expansion.

Q. What is the purpose of the counterrecoil or recuperator mechanism? *A.* To return the gun to battery after recoil.

Q. How does the recuperator operate? *A.* The recuperator mechanism consists of two cylinders connected by a passage, one containing a piston and piston rod and filled with oil, the other containing a

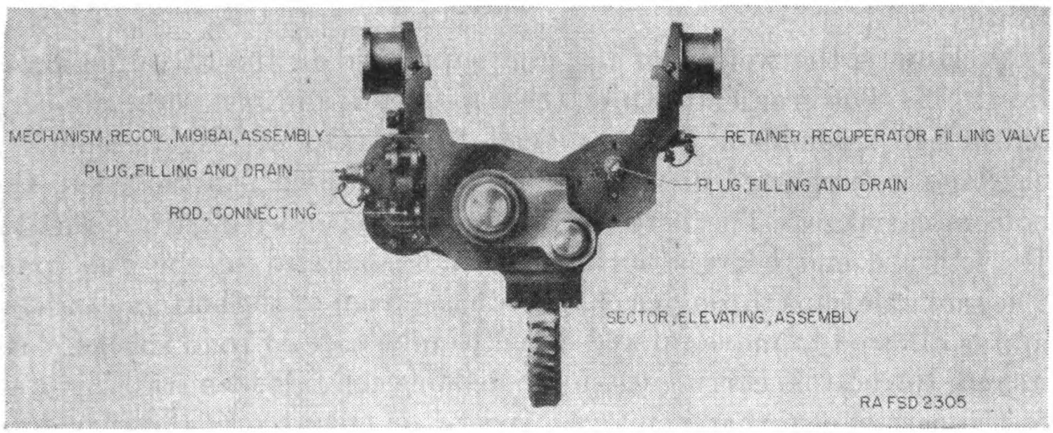


FIGURE 5.—Recoil mechanism, 155-mm gun M1918—rear view.

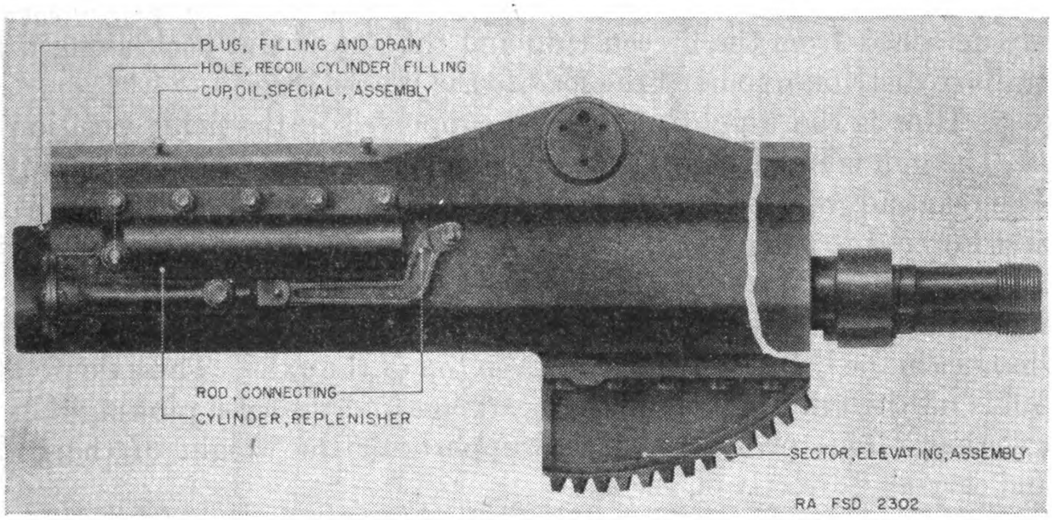


FIGURE 6.—Recoil mechanism, 155-mm gun M1918—side view.

regulator valve and a floating piston and filled partly with oil and partly with compressed nitrogen. The floating piston separates the gas in the forward end from the oil in the rear end. As the gun recoils, the recuperator piston moves to the rear and pushes oil into the second cylinder where it flows freely through the regulator valve and pushes the floating piston forward, compressing the gas additionally. When the gun stops recoiling, the gas expands and pushes it back into battery.

Q. What controls the counterrecoil of the gun? *A*. The oil flow back through the regulator valve has to pass through small openings that slow up the flow. Near the end of counterrecoil the counterrecoil buffer, a projection on the rear end of the recoil counter rod, traps oil in the end of the recoil piston rod and gradually stops the gun.

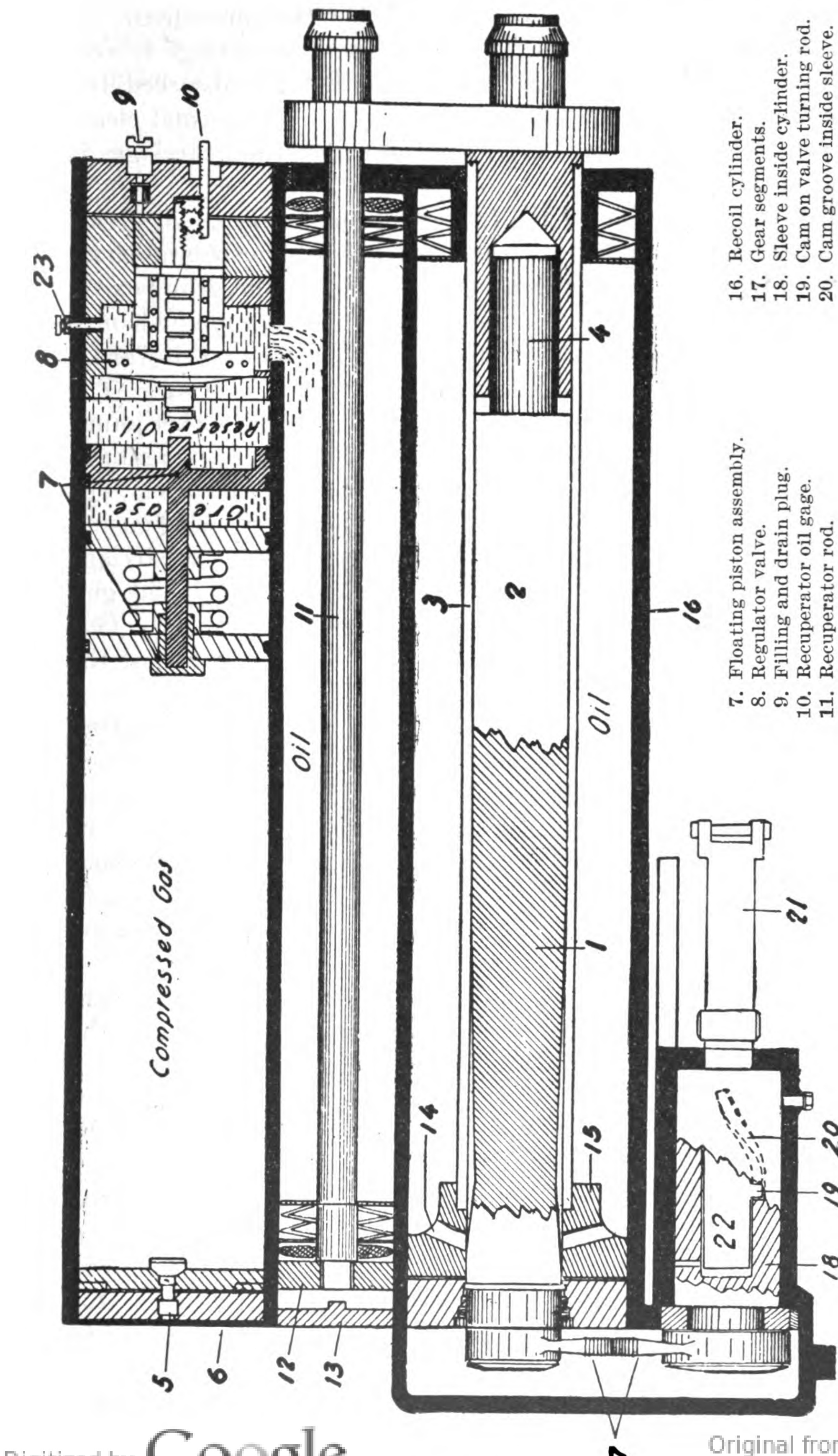
Q. How can one tell when the recuperator needs filling? *A*. By the position of the oil gage in the rear end of the recuperator cylinder. If it extends less than 5 millimeters, the recuperator needs filling.

Q. How is the weight of the gun supported in the traveling position? *A*. The cradle, in which the gun, recoil, and recuperator mechanism are assembled, is trunnioned to the top carriage. The top carriage is supported on a small steel pivot which is attached to the bottom carriage. The bottom carriage is suspended at three points. Its forward end bears a spring which is shackled to the gun axle. The gun axle runs through a channel in the front of the bottom carriage and is allowed to move up and down to take care of road shocks. At its rear the bottom carriage is supported on each side by a trail, pivoted to the carriage so that it may be spread or closed. In the traveling position, the rear ends of the trails are supported by two springs attached to the limber axle. The recoil and recuperator piston rods are detached from the breech ring and the gun is slid back along the trails to distribute some of the load to the limber axle.

Q. How is the weight of the gun supported in the firing position? *A*. The gun is in battery with piston rods attached to the breech ring. The rear ends of the trails are removed from the limber and are spread and lowered to the ground. The weight of the gun and carriage are raised from the gun axle spring until the spring can be unshackled from the axle. The carriage is then lowered until the top of the channel in the bottom carriage rests on top of the axle. The axle pivot pin is inserted through the bottom carriage and the axle, pinning them together. This provides a rigid support for the weight of the gun and carriage, directly on the axle.

Q. What is the purpose of the antifriction mechanism? *A*. To lessen the friction between the top carriage and the bottom carriage and make the traversing easier.

Q. How does it operate? *A*. When the gun is fired, the top and bottom carriages must be in direct contact to withstand the shock of firing. However, when they are in contact, it is very hard to traverse the gun. To make the traversing easier, the weight of the gun and top carriage are lifted off the bottom carriage and supported by a small steel pivot, which is held up by eight Belleville springs



1. Control rod.
2. Control rod.
3. Hollow recoil rod.
4. Counterrecoil buffer.
5. Air valve.
6. Recuperator cylinder.
7. Floating piston assembly.
8. Regulator valve.
9. Filling and drain plug.
10. Recuperator oil gage.
11. Recuperator rod.
12. Recuperator piston.
13. Recuperator cylinder.
14. Port in recoil piston.
15. Recoil piston.
16. Recoil cylinder.
17. Gear segments.
18. Sleeve inside cylinder.
19. Cam on valve turning rod.
20. Cam groove inside sleeve.
21. Regulating arm.
22. Valve turning rod.
23. Recuperator filling plug.

FIGURE 7.—Diagram of recoil and recuperator systems, 155-mm gun.

NOTE.—The replenisher cylinder is not shown in this diagram. (See fig. 8.)

placed between it and the bottom carriage. When the gun is fired, the Belleville springs compress enough to allow the top carriage to rest on the bottom carriage. As soon as the shock of firing is absorbed, the springs automatically lift the top carriage again. The normal clearance between the bearing surfaces of the top and bottom carriages is 0.012 inch.

Q. Explain the operation of the traversing mechanism. *A.* Rotation of the traversing handwheel is transmitted to a horizontal shaft and a helical driving pinion which are contained in the gear box on the left side of the top carriage. This drives a gear mounted on a short shaft, in the gear box, pointed downward and forward toward a pinion shaft in a box in the lower front part of the top carriage. The two are connected by a long shaft or spindle with ball and socket joints. From the pinion box the rotation is transmitted horizontally again to a worm in the center of the forward rim of the top carriage. The traversing worm meshes in a rack on the rear side of the axle housing on the bottom carriage. Rotation of the worm causes the top carriage to turn about the steel pivot in the antifriction mechanism. The gun may be traversed through 30° on either side of the midposition. One turn of the traversing handwheel causes about 0.70° traverse of the gun.

Q. Explain the operation of the elevating mechanism. *A.* Rotation of the elevating handwheel is transmitted through a similar system of shafts and gearing to a worm in the lower part of the top carriage. The elevating worm meshes with a rack attached to the bottom of the cradle. Rotation of the worm causes the cradle to turn about the axis of the trunnions. The gun may be elevated from zero to 35°. One turn of the elevating handwheel causes about 0.5° elevation of the gun.

Q. What is the purpose of the limber? *A.* To support and secure the rear ends of the trails and provide a coupling attachment to the tractor when transporting the carriage.

Q. How is the limber steered? *A.* The front axle is of the automobile type. The wheels are mounted on spindles secured to the ends of the axle by kingpins and provided with steering arms. A steering lever is pivoted at the center of the frame and is connected by drag links to the steering arms. The front end of the steering lever ends in two pronged forks in which the drawbar is pivoted, to permit up and down motion. The drawbar is connected to the tractor when traveling. The drag links are provided with universal joints to prevent binding.

Q. How are the seats secured to the limber? *A.* By the seat assembly. The base of the latter is tied laterally across the ends of the trails and held in position by two trail clamping bolts. The clamping bolts are held firmly in position by locking bolts when the carriage is in the traveling position.

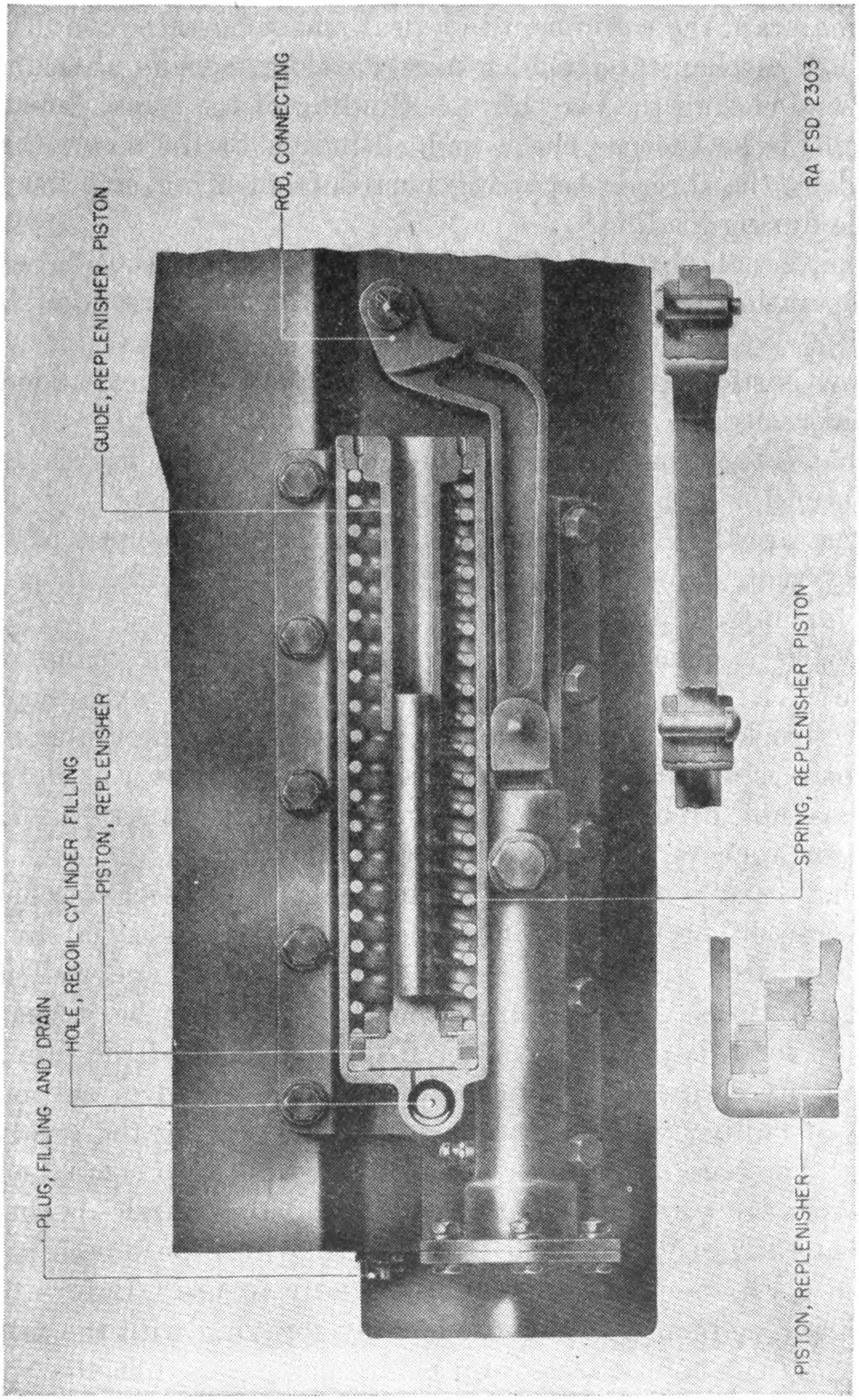


FIGURE 8.—Replenisher, 155-mm gun M1918—assembled view.

Q. What is the over-all length of gun and 10-ton tractor in traveling position? *A*. About 42 feet.

Q. What is the maximum width? *A*. About 9 feet.

4. Inspection and maintenance.—*Q*. For what measures of maintenance is a gun commander responsible? *A*. Periodic lubrication and painting, adjustments and repairs of a minor nature, having major repairs made, and such constant general attention as is necessary to maintain the equipment in a neat and serviceable condition.

Q. What mechanical troubles may develop, causing difficulty in opening and closing the breech? *A*. Binding of the screw threads or expansion of the the gas check pad. Binding of the screw threads is caused by the threads becoming burred from being struck by the projectile during loading.

Q. What action should be taken when the breech cannot be opened by the operating lever? *A*. Ordnance Department personnel should be notified.

Q. How is sticking of the breechblock caused by an expanded gas check pad remedied? *A*. By replacing the gas check pad.

Q. What is the purpose of the filling-in disk? *A*. It prevents wear of the obturator pad during rotation of the breechblock.

Q. What are the causes of misfires? *A*. Defective primer or firing pin, dirty vent, damp powder charge, or priming charge in powder bag too far in front of the obturator head.

Q. How is it determined whether the primer or the firing pin is defective? *A*. The primer is first withdrawn and examined. If properly struck by the firing pin the indentation in the center of the primer base is apparent. This shows that the primer was defective (if it has not fired) and a new one should be inserted. If no indentation appears, the firing pin is examined.

Q. What care is required in maintaining the breech mechanism and the gun in proper working order? *A*. It is essential to keep all moving parts, guides, and bearing surfaces clean and well lubricated at all times. The obturator mechanism must be dismantled frequently for this purpose. After firing, the bore of the gun must be thoroughly cleaned. A solution of one-half pound of sal soda in 1 gallon of boiling water is satisfactory for removing the residue of powder. The bore is wiped dry and oiled with a thin coat of engine oil. Covers are provided for the breech and the muzzle of the gun to prevent rust, grit, and water from getting into the breech mechanism and bore, when the gun is not actually in use. Before firing, all oil should be removed from the bore by spraying with the sal soda solution. If the bore is free of oil before firing, less difficulty will be experienced in cleaning after firing.

Q. What operations are the battery personnel permitted to perform on the recoil and recuperator mechanisms? *A*. Draining and filling of cylinders only. Dismounting, assembly, or repairs of these mechanisms will be done only by ordnance mechanics especially designated.

Q. How is the recuperator refilled? *A.*

(1) Remove plug from recuperator filling hole, located on right side of recuperator.

(2) Screw the drain tube into recuperator filling hole, and drain the system.

(3) After oil has stopped flowing off, remove the drain tube.

(4) Prepare pump, making sure that the union is clean and pump is primed.

(5) Screw union at end of copper pump tubing into recuperator filling hole.

(6) Give *exactly* 100 full strokes to the oil pump. Thirty full strokes of pump will cause the indicator to project 5 millimeters from the rear face of the recuperator cylinder, but 100 full strokes are required for a normal supply of oil in the recuperator.

NOTE.—*The above operations must be performed in the exact order and manner stated.*

Q. How can the recuperator be filled if no pump is available? *A.* The special grease gun provided for filling the recoil and recuperator mechanism may be used. To use the grease gun the recuperator is drained in the same manner as when the pump is used and the following operations are performed:

(1) Unscrew piston of grease gun as far as threads will permit.

(2) Unscrew head of grease gun from the body.

(3) Fill the body three-fourths full with cylinder oil.

(4) Replace the head.

(5) Insert nozzle of grease gun in filling hole, taking special care not to damage threads of filling hole when nozzle is screwed in.

(6) Force piston forward by turning the handle of the grease gun.

(7) Unscrew grease gun and replace filling plug.

Q. How many times is it necessary to refill the grease gun for filling the recuperator properly? *A.* Five fillings of the grease gun are necessary, each filling being three-fourths of the capacity of the grease gun.

Q. What is the cause of excessive recoil and how is it remedied? *A.* Excessive recoil is usually caused by insufficient oil in the recoil cylinder. A test is made for proper functioning of the replenisher piston and measurement of the spindle rod is verified. If the distance between the spindle rod and rear face of the replenisher is more than 200 millimeters, oil is added until proper reading is obtained. If recoil is excessive, the recoil system containing sufficient oil, repairs by ordnance mechanics are necessary before further firing.

Q. How is the replenisher piston tested for proper functioning? *A*. The drain tube is inserted in the recoil cylinder filling hole and a small quantity of oil run off. At the same time a scale is held against the end of the spindle rod. If the replenisher piston recedes, the location of the end of the spindle rod may be taken as the correct indication of the amount of oil in the recoil cylinder.

Q. What is the usual cause of improper functioning of the replenisher piston? *A*. The packing on the piston may expand, causing the piston to bind against the replenisher walls.

Q. What care is required when filling the recoil system, in order that the replenisher piston spindle rod may correctly indicate the amount of oil in the system? *A*. That no air is in the system.

Q. How is the air eliminated from the system. *A*. The drain tube is inserted in the drain hole located on the left front end of the recoil cylinder. With pump or grease gun connected to the filling hole, oil is forced into the cylinder until a steady stream of oil runs from the drain tube. The gun should be slightly elevated for this operation.

Q. How is the recoil cylinder filled? *A*.

(1) Clean the pump union and prime the pump.

(2) Insert drain tube in recoil cylinder drain hole.

(3) Attach union at end of copper tubing of oil pump into recoil cylinder filling hole, located at left front side of replenisher, *without* the use of a wrench. (Extreme care must be taken to prevent injury to the threads of the recoil cylinder filling hole, as such damage may put the entire recoil system out of order.)

(4) Work the oil pump until the end of the piston spindle rod in the opening in rear end of the replenisher is 150 millimeters from the rear face of the replenisher.

(5) Eliminate air from recoil system.

(6) Remove copper tubing and drain tube and insert filling and drain plugs.

Q. What is the cause of short recoil and how is it remedied? *A*. Usually too much oil in the recoil cylinder. Bleed the recoil cylinder by use of the drain tube until spindle recedes to 150 millimeters from the rear face of the replenisher. If the recoil remains too short or becomes shorter after proper bleeding, an ordnance machinist should be called to remedy the defect.

Q. What is the cause of incomplete return to battery? *A*. Too much oil in the recoil cylinder, or too little in the recuperator.

Q. What is the cause of too violent return to battery? *A*. Too little oil in the recoil cylinder, or too much in the recuperator.

Q. How may the total traverse of the gun be made greater than 60°? *A*. By the construction of a concrete emplacement.

Q. Should a steel hammer ever be used directly on any part of a gun? *A*. No. Use a copper hammer, or place a piece of copper or wood between the hammer and gun.

Q. What parts of guns and carriages are painted? *A*. All steel and iron nonbearing surfaces and large unfinished bronze pieces will be painted. Bearing surfaces, oilholes, handles of handwheels and cranks, gear teeth, guides, rollers and surfaces on which they travel, racks and pawl teeth, direction plates, sight holders, scales and pointers, and stuffing box followers will *not* be painted.

Q. What color paint is used? *A*. Olive drab, except for oilholes, grease cups, and similar lubricating devices, which are painted red.

Q. If paint as issued is too thick, how should it be thinned? *A*. Use turpentine as a thinner, but not to a greater extent than 2 percent by volume; if still too thick, thin with linseed oil.

Q. How are the surfaces prepared for painting? *A*. All parts to be painted should be free from dirt or grease. They may be washed in a solution of one-half pound sal soda in 8 quarts of warm water, then rinsed with clean water and wiped thoroughly dry.

Q. What is the method of painting matériel that is in fair condition and marred only in spots? *A*. The marred places should be primed with olive drab paint, second coat, and permitted to dry. Then the whole surface should be sandpapered with No. 1½ sandpaper and a coat of paint applied and allowed to dry thoroughly before use.

Q. What is the method of painting material that is in bad condition? *A*. All parts should be thoroughly sandpapered with No. 2½ sandpaper, given a coat of paint, and permitted to dry for at least 24 hours; then sandpaper with No. 00 sandpaper, apply a finishing coat, and permit the parts to dry thoroughly before use.

Q. In general, how many coats of paint a year are necessary to keep the matériel in good condition? *A*. Two coats per year.

Q. If after repeated painting, the paint becomes so thick as to scale off in places or give an unsightly appearance, how may it be removed for repainting? *A*. By the use of scaling hammers, putty knives, or scrapers made locally from old files, tool steel, etc., or the following will sometime help if the old paint is not too thick. Dissolve 1 pound of concentrated powdered lye in 6 pints of hot water and add enough lime to give the solution the consistency of paint. Use freshly mixed and apply to the parts where paint is to be removed with a brush or with waste tied to the end of a stick. When the solution begins to dry on the surface, use a scraper to remove the old paint and complete the cleaning of the surface with cloth and water. If one such treatment is not sufficient to loosen the paint, apply additional coats. Before painting, wash the surface with soda solution, rinse with clean warm water, and then wipe thoroughly dry. If prepared commercial paint remover is available, it may be used instead of the lye solution.

Q. What particular care must be taken in painting artillery matériel? *A.* Avoid interfering with the proper functioning of the moving parts and prevent the paint entering the oilholes and bearings.

Q. What is used for the base coat on iron or steel when the surface has been scraped down to the metal? *A.* Red lead.

Q. What are the different materials used in cleaning, polishing, and removing rust from the different parts of the gun and carriage? *A.*

(1) *Cloth, crocus (commercial).*—Used for cleaning and polishing finished surfaces, such as breechblocks, piston rods, and brass work.

(2) *Cloth, emery, No. 00 (commercial).*—Used for cleaning and removing rust from finished iron and steel surfaces. It is the coarsest abrasive permitted for work on breech mechanisms. Its use on soft metals such as brass, bronze, and babbit is prohibited.

(3) *Cloth, emery, Nos. 0 and ½ (commercial).*—Used in cleaning finished iron and steel surfaces where deterioration has occurred, and for removing burs and scratches.

(4) *Cloth, emery, Nos. 1 (medium) and 3 (coarse).*—Used in removing rust burs and other defects from unfinished surfaces of steel and iron and for preparing them for painting. Its use on finished surfaces is prohibited.

(5) *Sandpaper (commercial).*—Used for removing paint from metal or wooden surface. It should be used with caution on wooden surfaces. Its use on finished metal parts such as breechblocks, recoil piston rods, etc., is prohibited.

(6) *Gasoline.*—Used for cleaning purposes only. Never use kerosene for cleaning bores or bright parts.

Q. What kind of oil should be used as lubricant on breech mechanisms, threads of breechblocks, breech recesses, and gears, and in all oilholes? *A.* Oil, lubricating, class A, light.

Q. How much should be used? *A.* Just enough to cover the surface with a thin coat, and rubbed over with the hand. Excess of oil is to be avoided; but during firing, plenty should be used on the breechblock and in the breech recesses. This cleans the block and prevents it from sticking to the breech. Oil holes should be filled.

Q. What is used as a preservative of the finished surfaces of iron or steel if the gun is to remain unused for a considerable length of time (several months or more)? *A.* Rust-preventive compound, grade A (heavy), formerly called heavy slushing oil or cosmoline.

Q. How is this applied? *A.* Rust-preventive compound grade A is applied heated just sufficiently to melt. Surfaces to which it is to be applied should also be warm if possible. (If rust-preventive compound is heated about 180° F., separation of the ingredients may take place and destroy its usefulness.)

Q. What is used as a preservative of the finished surfaces of steel if the gun is to remain unused for a shorter length of time (few days to several weeks)? *A*. Rust-preventive compound, grade B (light), formerly called light slushing oil.

Q. What is used to apply rust-preventive compound to the surface? *A*. Paint brushes may be used.

Q. How may rust-preventive compound be removed? *A*. By waste or burlap soaked in gasoline.

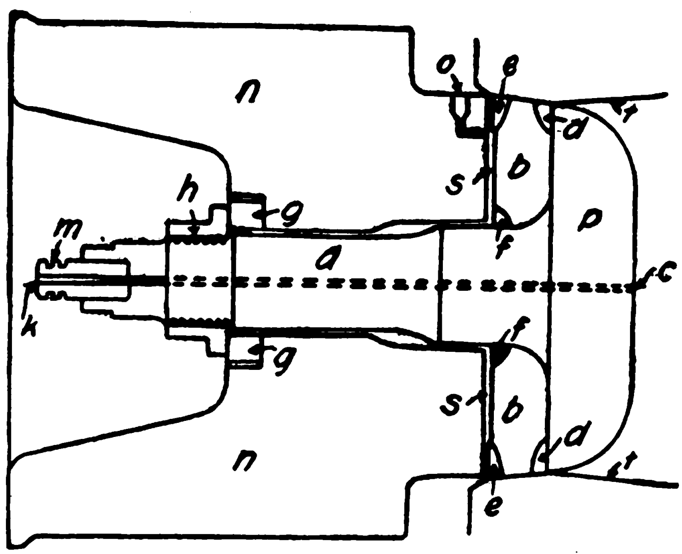
Q. How are the metal surfaces prepared for slushing with rust-preventive compounds? *A*. Metal surfaces should be clean and dry and free from all traces of corrosion.

Chapter 3

GUN AND CARRIAGE, RAILWAY ARTILLERY

5. Functioning of parts.—*a. General.*—*Q*. What is meant by obturation? *A*. Obturation is the prevention of escape to the rear of the gases that propel the projectile.

Q. What parts of the gun provide obturation? *A*. The breechblock and the obturating mechanism.



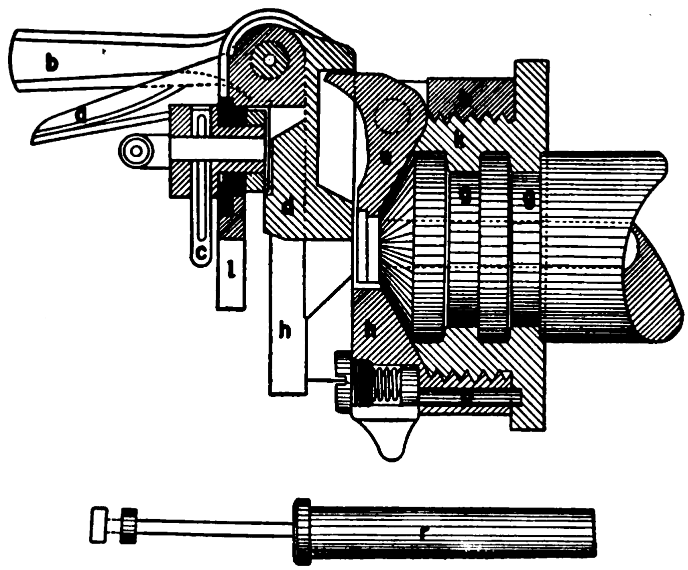
a. Obturator spindle.
b. Gas check pad.
c. Vent hole.
d. Front split ring.
e. Rear split ring.
f. Small split ring.
g. Ball bearing.
h. Split nut.
k. Primer seat.
m. Firing mechanism seat.
n. Breechblock.
o. Oil hole.
p. Mushroom head.
s. Filling-in disk.
t. Cannon tube.

Figure 9.—De Bange obturator.

Q. How do they work? *A*. The obturating mechanism consists of an obturator or mushroom head on a spindle that extends back through the middle of the breechblock, a gas check pad, three steel split rings, and a filling-in disk. The gas check pad is held between the obturator and the filling-in disk which is next to the front face of the breechblock. Two of the split rings are carried around the outer edge of the pad and the other is around the inner edge next to the spindle. When the gun is fired, the gases press back on the obturator. Since the breechblock cannot move backward, the gas check pad is squeezed between the obturator and the filling-in disk. It expands outward and inward, pushing the two outer rings up against the wall of the powder chamber and the inner ring against the spindle, sealing the gases in the powder chamber. After the pressure goes down, the gas check pad contracts and relieves the pressure from the split rings so the breech may be opened.

Q. Name the principal parts of the firing mechanism M1903. *A*. The hinged collar, housing, slide, and firing leaf.

Q. How does it work? *A*. The hinged collar fits over grooves in the rear end of the obturator spindle. It is prevented from opening by the housing which is screwed on over it. The hinged collar and hous-



a. Catch lever.
b. Slide handle.
c. Contact clip.
d. Slide.
e. Ejector.
g. Obturator spindle grooves.
h. Housing.
k. Hinged collar.
l. Firing leaf.
p. Spring pin.
r. Primer.

FIGURE 10.—Seacoast firing mechanism M1903.

ing are prevented from turning on the spindle by the guide bar which projects from the right side of the housing into a groove in the breechblock. The slide is attached to the housing in a groove which allows vertical movement. With the slide raised, a primer may be inserted into the primer seat in the end of the spindle. The slide is then lowered and holds the primer in place, allowing the button wire to extend to the rear. It is locked in this position by the slide catch. The firing leaf is pivoted to the slide at its upper end. It has a vertical slot cut in its lower edge through which the button wire extends when the slide is lowered. At the right-hand lower corner of the firing leaf is an eye into which the lanyard is hooked for firing by friction. When the leaf is pulled back it pulls the button wire back, igniting the primer. An electric firing circuit is provided through the arms of the contact clip on the firing leaf which also engages the button wire. A safety bar prevents accidental firing by lanyard before the breech is fully closed and locked. It engages the firing leaf and prevents it from moving to the rear, and it is not withdrawn until the last movement of the breechblock in closing. It is actuated by the safety bar slide in the block. The electric firing circuit is not closed until the breech is fully closed and locked.

Q. What safety precaution is prescribed for this type of firing mechanism? *A*. The primer must not be inserted in the primer seat until the breech is fully closed and locked.

Q. Put on and take off the firing mechanism. *A*. (Practical demonstration.)

Q. What prevents the powder gases from escaping through the vent when the gun is fired? *A*. The pressure of the gas expands the primer body and pushes it tightly against the wall of the vent, sealing the opening.

b. *8-inch railway gun.*—*Q*. Explain the construction of the gun. *A*. The gun consists of a forged steel tube surrounded and strengthened by a jacket and several hoops, all of forged steel. The supporting parts are first heated until they can be slipped on over the tube and are then allowed to cool and shrink into place. They are keyed to each other and to the tube to prevent slipping off when the gun is fired. This method of making a gun is called the "built-up" method. The breech bushing is screwed, cold, to the jacket. It forms the breech recess into which the block fits.

Q. Name the principal parts of the breech mechanism. *A*. The breechblock, obturating mechanism, breech plate, rotating crank and gear, tray translating mechanism, and hinge pin.

Q. Describe the breechblock. *A*. The breechblock (Army gun) is of the interrupted screw type; its surface is divided alternately into three threaded sectors and three plain or slotted sectors, the latter having a smaller diameter than the former. The same arrangement is made in the breech recess so that when the threaded sectors of the block are opposite the slotted recess the block may be moved forward into place. The threaded sectors are then engaged by rotating the block only one-sixth of a turn. There is a hole running through the middle of the block, from front to rear, in which the obturator is mounted.

Q. Explain the action of the breech mechanism (Army gun). *A*. The block, when withdrawn, is supported on the tray which is pivoted to the hinge pin, on the right side of the breech plate. The

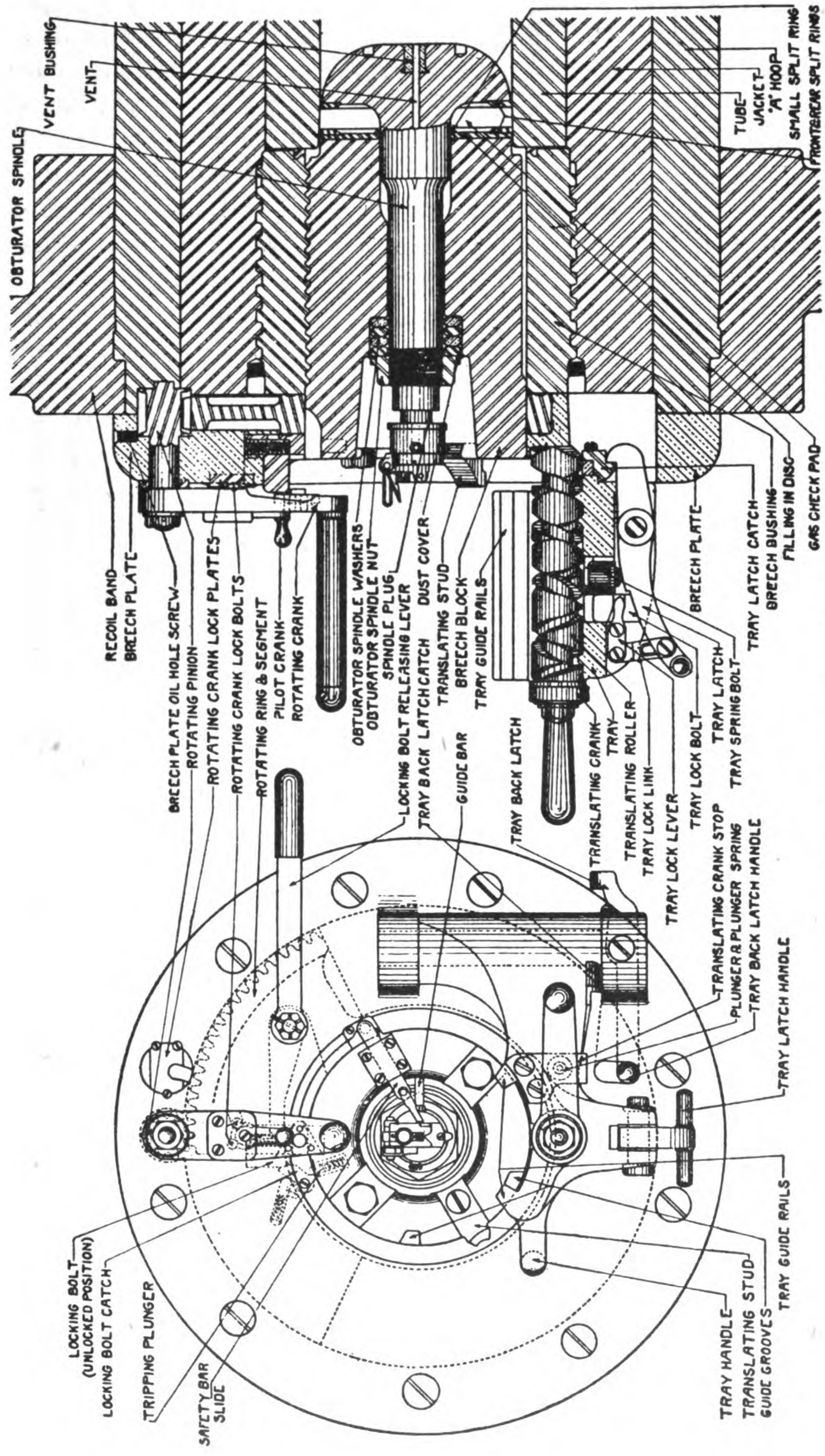


FIGURE 11.—Breech mechanism, 8-inch guns.

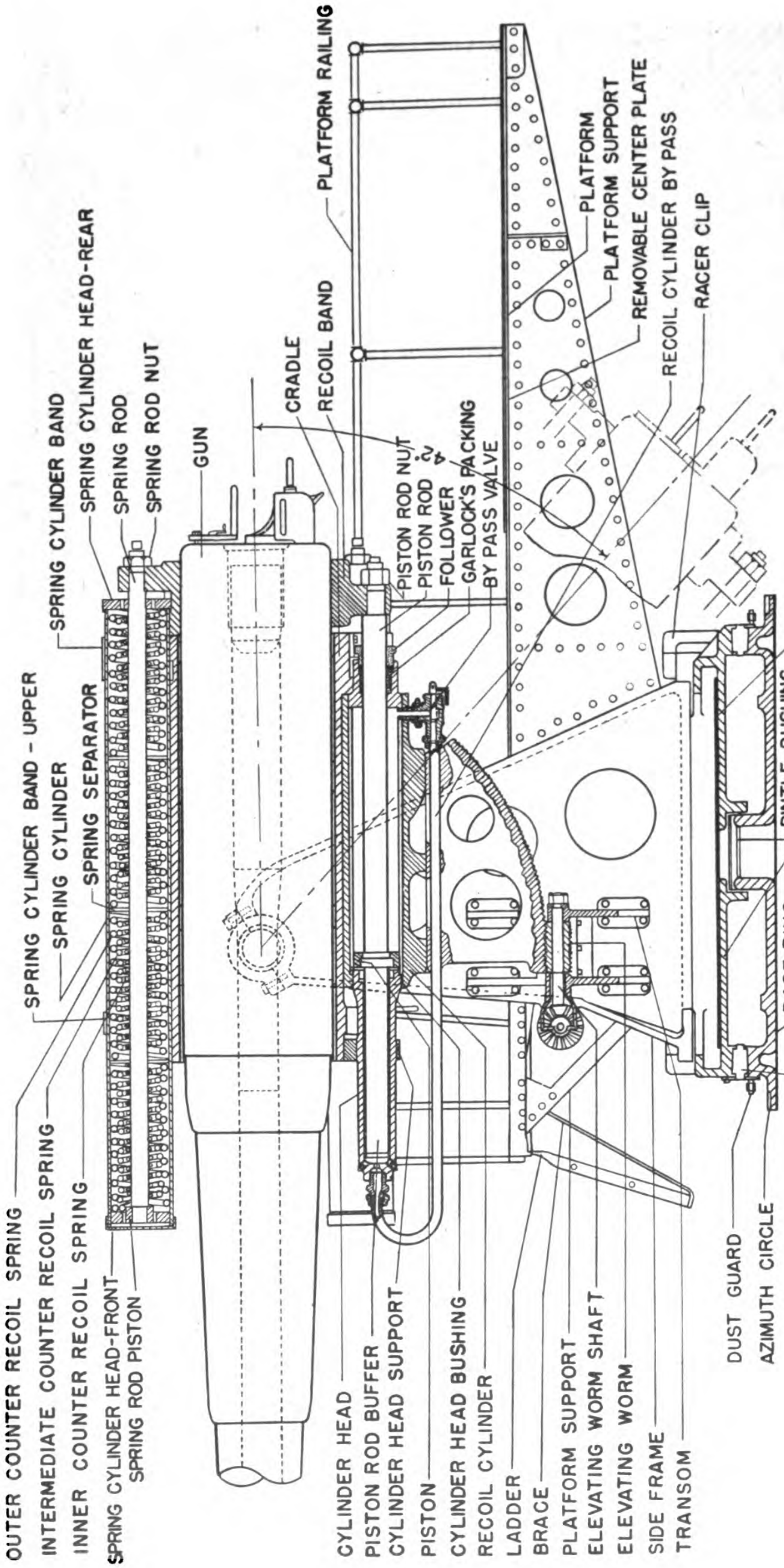


FIGURE 12.—8-inch barbette carriage M1918 and M1918M1 (longitudinal section).

breech plate is a steel casting screwed to the face of the breech. The translating mechanism consists of the translating stud on the bottom of the block and the translating roller and crank. The roller is seated in a right-handed thread in the upper part of the tray next to the block. It has two independent threads cut in opposite directions on its surface. The translating stud engages in the left-handed thread. Operation of the translating crank causes the roller to move in its right-handed thread and travel forward in the tray, drawing the block with it. At the same time the stud travels in the other thread, giving a double motion to the block and translating it by fewer revolutions of the crank. The tray is held in its open position by the tray back latch and in the closed position by the tray latch. This latter part also actuates the tray spring bolt which prevents translation of the block when engaged in the translating roller. The tray latch keeps it so engaged until the latch is itself engaged in the breech plate. The block is rotated by means of the rotating crank and pinion housed in the upper part of the breech plate, and the rotating ring attached to the upper part of the block. Operation of the crank causes the pinion, which is engaged in the ring when the breech is closed, to turn and rotate the block. The rotating crank lock consists of two locking bolts, each actuated by a spiral spring, which extends from the rotating crank into recesses in the breech plate. These bolts act alternately, that is, one is in the locking position when the breech is closed and ready for firing, and the other locks the crank in its horizontal position when the breech is open and ready for loading. They are controlled by the pilot crank.

Q. How is the gun secured to the cradle? *A.* One of the A-hoops has two flanges or splines, one at the top and the other at the bottom, which slide in corresponding grooves in the cradle. The gun is held in firing position by the recoil and recuperator piston rods which are attached to the recoil band on the rear of the gun.

Q. What is the purpose of the recoil mechanism? *A.* To take up the energy of recoil and stop the gun gradually as it comes back in recoil.

Q. How does the recoil mechanism work? *A.* The recoil mechanism consists of a piston and rod moving inside a cylinder filled with oil. The piston rod is attached to the recoil band on the gun and moves back with it in recoil while the cylinder remains fixed to the cradle. As the piston moves to the rear, the oil passes to the other side through three small orifices, called throttling grooves, in the wall of the cylinder. This causes friction which absorbs the energy of recoil and gradually stops the gun. There is also a small bypass which allows oil to flow from rear to front of the piston through a valve, to prevent the formation of a void in the front of the cylinder. The recoil cylinder is directly below the gun.

Q. What is the purpose of the counterrecoil or recuperator mechanism? *A*. To return the gun to firing position after recoil.

Q. How does the recuperator operate? *A*. The recuperator mechanism consists of four sets of cylinders, springs, pistons, and rods, placed symmetrically about the gun. The cylinders are attached to the cradle and the piston rods are attached to the recoil band. The springs are held between the piston and the rear end of the cylinder and are compressed when the gun recoils. After the recoil is stopped, the springs expand and move the gun back to firing position.

Q. What controls the counterrecoil? *A*. Near the end of counterrecoil the counterrecoil buffer, a projection on the front of the piston, traps oil in the forward end of the recoil cylinder and gradually stops the gun.

Q. Name the valves in the recoil and recuperator mechanisms and state the purpose of each. *A*. There are two valves in the bypass connection. The one located at the rear end of the cylinder functions during recoil. It should be open when firing the 200-pound projectile and closed when firing the 323-pound projectile. The one at the forward end works only when valve at the rear is open. On recoil, the forward valve slides open, allowing oil to pass through the bypass connection into the front of the recoil cylinder. On counterrecoil, the forward valve closes, preventing the oil from flowing through the bypass. There is also a special two-way valve in the bottom of the cylinder for filling and draining.

Q. Explain the operation of the traversing mechanism. *A*. The gun and carriage are supported on a railway car in the same manner as a fixed seacoast mount is supported on a concrete emplacement, with conical rollers between the base ring and the racer. Rotation of the traversing handwheel is transmitted through a system of shafts and gearing to a spur gear called the traversing pinion which extends down below the racer and meshes with the traversing rack on the base ring. When the gear is rotated, it travels along the rack, pulling the gun and carriage with it. The loading platform is attached to the carriage and traverses with it. The gun may be traversed through a complete circle. One turn of the traversing handwheel causes about 1° traverse of the gun.

Q. Is there a slip-friction device in the traversing mechanism? *A*. Yes.

Q. How does it operate? *A*. The upper end of the traversing pinion shaft is connected to the traversing worm wheel in the lower traversing gear case through a friction clutch which will slip if a sudden strain is put on the mechanism due to firing.

Q. Explain the operation of the elevating mechanism. *A*. The gun and cradle are attached to the carriage by two trunnions about which they are elevated. Rotation of the elevating handwheel is transmitted through several shafts and gears to the elevating worm which is attached to the carriage directly below the cradle. This worm meshes with the elevating rack on the bottom of the cradle. Rotation of the elevating worm causes the rack and the gun to move in elevation about the trunnions. The gun may be elevated from zero to 42°. One turn of the elevating handwheel causes about 2½° elevation of the gun.

Q. How is the shock of firing taken up in the elevating mechanism? *A*. By the worm which transmits it to the side frames.

Q. How is the friction during elevation reduced? *A*. On some carriages an antifriction device has been placed in each trunnion. It consists of a crutch, pin, and Belleville springs. A section of the main trunnion is cut away and the crutch inserted, with the pin on the top to act as a false trunnion. The lower end of the crutch rests on the Belleville springs which in turn rest on the side frames. They are raised enough to take the weight of the gun and cradle off the main bearings, allowing elevation about the false trunnions. Correct adjustment should give 0.003 inch clearance between the trunnion and its bearing. When the gun is fired the Belleville springs compress enough to allow the main trunnions to rest on their bearings and take up the shock. After the recoil is stopped the springs again expand and raise the weight off the main trunnions.

c. 12-inch railway mortar.—*Q*. Explain the construction of the mortar. *A*. The mortar consists of a forged steel tube surrounded and strengthened by a jacket and several hoops, all of forged steel. The supporting parts are first heated until they can be slipped on over the tube and are then allowed to cool and shrink into place. They are keyed to each other and to the tube to prevent slipping off when the mortar is fired. This method of making a cannon is called the "built-up" method. The breech bushing is screwed cold to the jacket. It forms the breech recess into which the block fits.

Q. Name the principal parts of the breech mechanism. *A*. The breechblock, obturating mechanism, rotating crank and gear, tray, translating mechanism, and hinge pin.

Q. Describe the breechblock. *A*. The breechblock is of the interrupted screw type; instead of being threaded around its entire circumference, its surface is divided alternately into three threaded sectors and three plain or slotted sectors, the latter having a smaller diameter than the former. The same arrangement is made in the breech recess so that when the threaded sectors of the block are opposite the slotted sectors of the recess the block may be moved forward into place. The threaded sectors are then engaged by rotating the block only one-sixth of a turn. If the whole surface were threaded, the block would have to be rotated several times to screw it into place. There is a hole running through the middle of the block, from front to rear, in which the obturator is mounted.

Q. Explain the action of the breech mechanism. *A*. The block, when withdrawn, is supported on the tray, which is pivoted to the hinge pin on the right side of the breech bushing. The translating mechanism consists of the translating stud on the bottom of the block and the translating roller and crank. The roller is seated in a right-handed thread in the upper part of the tray next to the block. It has two independent threads cut in opposite directions on its surface. The translating stud engages in the left-handed thread. Operation of the translating crank causes the roller to move in its right-handed thread and travel forward in the tray, drawing the block with it. At the same time the stud travels in the other thread, giving a double motion to the block and translating it by fewer revolutions of the crank. The tray is held in its open position by the tray back latch and in its closed position by the tray latch. This latter part also actuates the tray spring bolt which prevents translation of the block when engaged in the translating roller. The tray latch keeps it so engaged until the latch is itself engaged in the breech bushing. The block is rotated by means of the rotating crank and pinion carried on an extension on the rear of the block and the rotating rack which is cut in the rear face of the bushing. Operation of the crank causes the pinion, which is engaged in the rack when the breech is closed, to turn and rotate the block. The rotating crank lock consists of a bolt, actuated by a spring, which extends into a recess in the block extension.

Q. How is the mortar secured to the cradle? *A*. The mortar is held in a structure called a sleigh. It consists of two yokes, one in front and the other in rear around the mortar, and two side pieces or runners, all bolted together and fastened firmly to the mortar. The sleigh slides in corresponding runways in the cradle and recoils with the mortar. They are held in firing position by the recoil piston rods and the recuperator pull rods which are attached to the rear sleigh yoke.

Q. What is the purpose of the recoil mechanism? *A*. To take up the energy of recoil and stop the mortar gradually as it comes back in recoil.

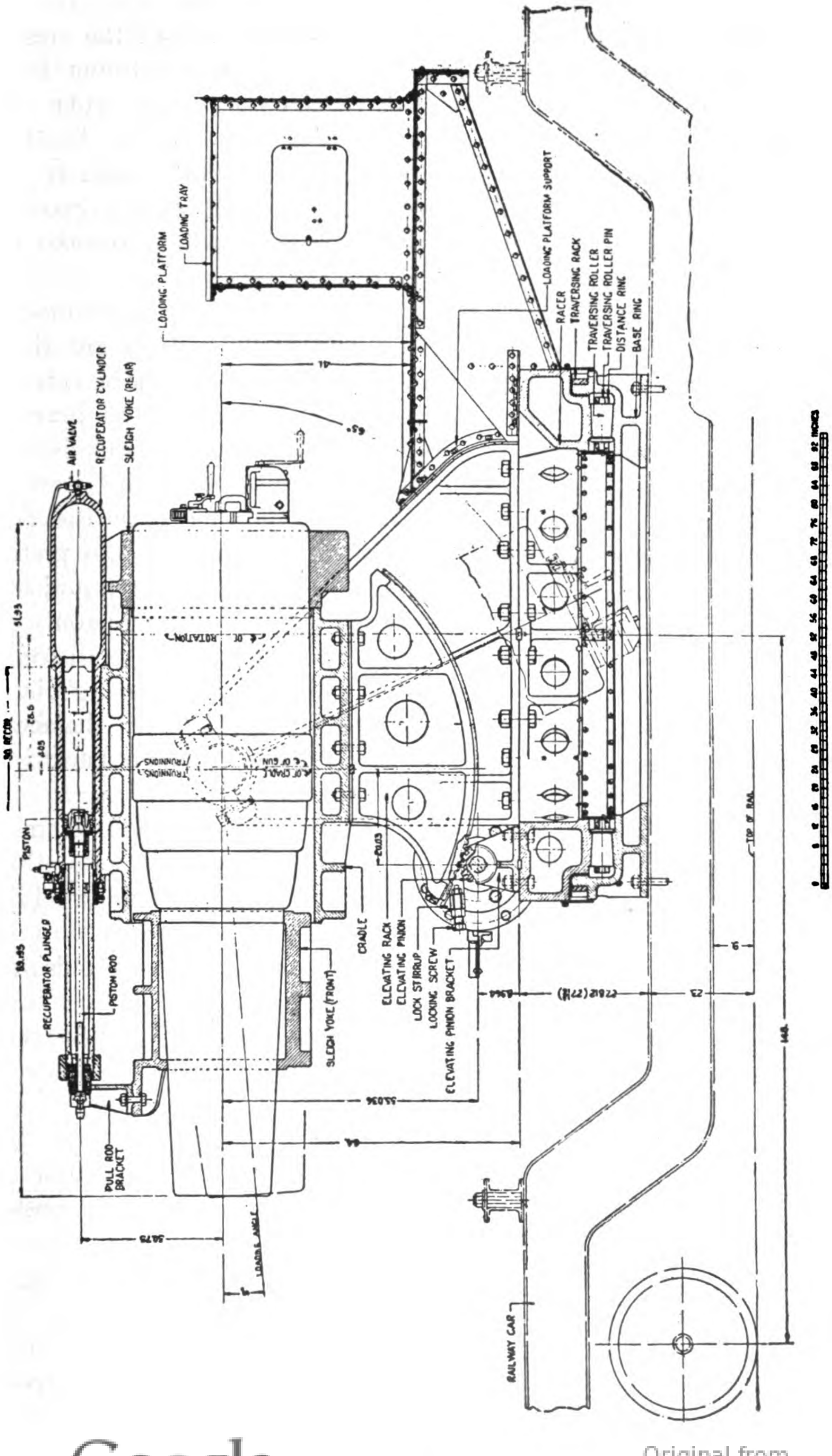


FIGURE 13.—12-inch mortar carriage M1918.

Q. How does the recoil mechanism work? *A.* The recoil mechanism consists of two identical units in the lower part of the cradle. Each unit consists of a piston and rod moving in a cylinder filled with oil. The piston rod is attached to the rear sleigh yoke and moves back with it in recoil, while the cylinder remains fixed to the cradle. As the piston moves to the rear, the oil passes to the other side through three small orifices, called throttling grooves, in the wall of the cylinder. This causes friction which absorbs the energy of recoil and gradually stops the mortar.

Q. What is the purpose of the counterrecoil or recuperator mechanism? *A.* To return the mortar to firing position after recoil.

Q. How does the recuperator work? *A.* The recuperator consists of a cylinder, floating piston, main piston, pull rods, and bracket. The cylinder is attached to the cradle, and the main piston is connected to the sleigh through the bracket in the top of the forward yoke. Two pull rods extend back from the bracket to the rear sleigh yoke and transmit the motion of the mortar to the piston. Between the main piston and the cylinder is a quantity of liquid and a quantity of compressed air, separated by the floating piston. As the mortar and sleigh move to the rear in recoil, the main piston is pushed along with it. This pushes the liquid and the floating piston to the rear against the air, compressing it further. When the recoil stops, the air expands and moves the mortar and sleigh back into firing position.

Q. What are the air and liquid pressures before recoil? During recoil? *A.*

(1) Before recoil or in filling, the air pressure should be 1,370 pounds and the liquid pressure 1,500 pounds per square inch.

(2) At full recoil the air pressure increases to 2,260 pounds and the liquid pressure to 2,475 pounds.

Q. How is the counterrecoil controlled? *A.* The counterrecoil buffers on the front of the recoil pistons trap oil in the ends of the recoil cylinders and gradually stop the mortar.

Q. Explain the operation of the traversing mechanism. *A.* The mortar and carriage are supported on a base ring on the railway car in the same manner as a fixed seacoast mount, with conical rollers between the base ring and the racer. Rotation of the traversing handwheel is transmitted through a system of shafts and gearing to the traversing pinion which extends down below the racer and meshes with the traversing rack on the base ring. When the pinion is rotated, it travels around the rack pulling the mortar and carriage with it. The loading platform is attached to the carriage and traverses with it. The mortar may be traversed through a complete circle. One turn of the traversing handwheel causes about 0.84° traverse of the mortar.

Q. Is there a slip-friction device in the traversing mechanism? *A*. No.

Q. Explain the operation of the elevating mechanism. *A*. The mortar and cradle are attached to the carriage by two trunnions about which they are elevated. Rotation of the elevating handwheel is transmitted through a vertical shaft, worm, and worm wheel to a horizontal shaft which extends from the gear case inward and under the cradle. A pinion on the end of this shaft meshes with the elevating rack on the bottom of the cradle. Rotation of the elevating pinion causes the rack and cradle to move in elevation about the trunnions. The mortar may be elevated from −5° to +65°. However, it cannot be fired at elevations below 20°, due to lack of stability at low elevations. One turn of the elevating handwheel causes about 1° of elevation of the mortar. The elevating mechanisms of some carriages have been modified by changing the gear ratio to give more rapid elevation, and including an antifriction device in each trunnion to reduce the work of elevating.

Q. Describe the antifriction device. *A*. The antifriction device consists of a crutch, pin, and beam. A section of the main trunnion is cut away and the crutch inserted, with a pin on top to act as a false trunnion. The beam is attached to the side frame under the crutch and is raised enough to take the weight of the mortar and cradle off the main trunnion, reducing the friction during elevation. When the mortar is fired, the beam bends enough to allow the main trunnion to rest in its bearing and take up the shock of firing. After the recoil is stopped, the beam again raises the weight off the main trunnion. The beams should be adjusted to give 0.003 inch clearance between the trunnions and their bearings.

Q. Is there a slip-friction device in the elevating mechanism? *A*. Yes.

Q. How does it work? *A*. The worm wheel is connected to the elevating pinion shaft through a friction clutch which will slip if a sudden strain is put on the mechanism due to firing.

d. 14-inch railway gun.—*Q*. Explain the construction of the gun. *A*. The gun consists of a forged steel tube surrounded and strengthened by a jacket and several hoops, all of forged steel. The supporting parts are first heated until they can be slipped over the tube and are then allowed to cool and shrink into place. They are keyed to each other and to the tube to prevent slipping when the gun is fired. This method of making a gun is called the "built-up" method. The breech bushing is screwed, cold, to the jacket. It forms the breech recess into which the block fits.

Q. Name the principal parts of the breech mechanism. *A*. The breechblock, obturating mechanism, block carrier, and operating mechanism.

Q. Give a brief description of the breechblock. *A*. The breechblock is of the stepped screw type divided into 12 threaded sectors and 4 plain sectors, thus giving three-fourths of the breech recess as bearing surface. The interior of the block is threaded and screws on the threaded ring on the pintle of the block carrier. It is bored in front to take the forward end of the obturator spindle assembly.

Q. Describe briefly the breechblock carrier. *A*. The block carrier is connected to the gun by its trunnions. It has a pintle carrying a threaded ring on which the breechblock is screwed and turns. This spindle also receives the rear end of the obturator spindle which is held by a nut.

Q. Explain the action of the breech mechanism. *A*. With this block mechanism there is no translation—only rotation and swinging. The block is mounted on the upper end of the carrier. The carrier is pivoted at its lower end and swings in the vertical plane. Closing is by power furnished by compressed air acting against a piston. When air is admitted to the cylinder behind the piston, the latter is pushed out, pivoting the carrier around its lower end and turning the breechblock into the breech recess. There two cam rollers on the block engage two cams which rotate the block the amount necessary to close it.

Q. What are the principal parts of the firing lock? *A*. The slide, the lock operating bar, the cocking lever, and the hammer.

Q. How does the firing lock work? *A*.

(1) When the breechblock is opened, a cam on the gun pulls down on the lock operating bar which lowers the slide until the primer seat is uncovered. As the slide is lowered, it works against the small extractor cam, rotating the extractor to the rear and ejecting the fired primer.

(2) When the breechblock is closed, the lock operating bar is automatically raised, which raises the slide until the firing pin is opposite the primer and the lock is ready to fire. For reasons of safety the primer is not inserted until the block is fully closed. Then the operating bar is pulled down by hand and the primer is inserted.

(3) For percussion firing the lanyard is inserted in the hole in the firing lever. The first part of the lanyard's travel cocks the hammer while the last part trips the hammer, allowing it to fly forward and

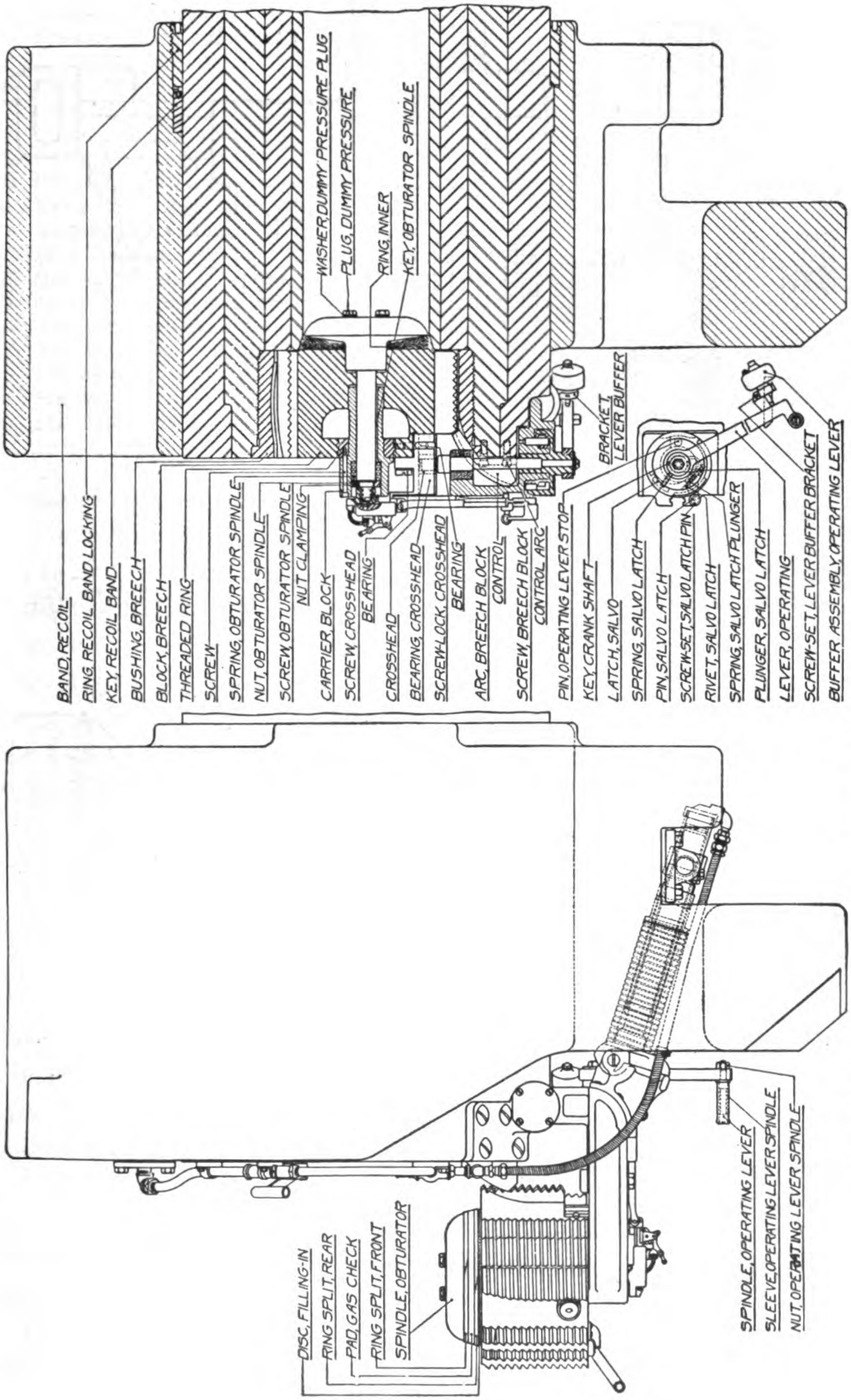


FIGURE 14.—Breech mechanism Mk. II, for 14-inch railway guns (plan and sectional views).

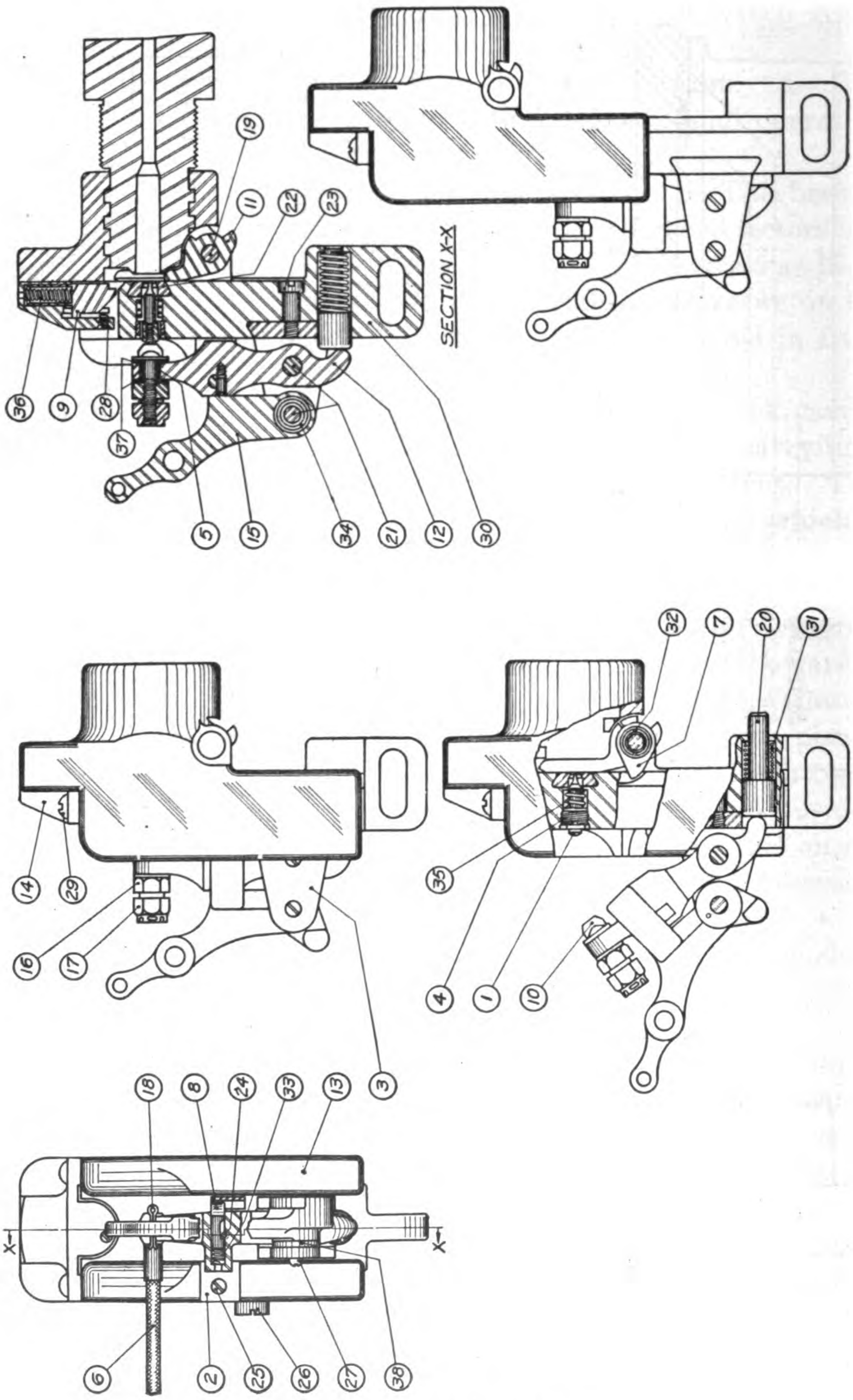


FIGURE 15.—Firing lock Mk. I.

1. Assembly, firing pin.
2. Block, firing lock hammer guide.
3. Bracket, firing lock hammer.
4. Bushing, firing pin.
5. Bushing installation, firing lock hammer contact.
6. Cable, firing.
7. Cam, firing lock extractor.
8. Catch, firing lock hammer.
9. Catch, primer retaining.
10. Contact, firing lock hammer.
11. Extractor, firing lock.
12. Hammer, firing lock.
13. Housing, firing lock.
14. Housing, primer retaining catch.
15. Lever, firing lock cocking.
16. Nut, firing lock hammer contact.
17. Nut, firing lock terminal.
18. Pin, cotter.
19. Pin, firing lock extractor.
20. Pin, firing lock hammer thrust.
21. Pivot, firing lock hammer and cocking lever.
22. Plate, firing lock slide face.
23. Screw, firing lock hammer bracket.
24. Screw, firing lock hammer catch.
25. Screw, firing lock hammer guide block.
26. Screw, firing lock slide stop.
27. Screw, firing lock torsion washer.
28. Screw, primer retaining catch guide.
29. Screw, primer retaining catch housing.
30. Slide, firing lock.
31. Spring, firing.
32. Spring, firing lock extractor cam.
33. Spring, firing lock hammer catch.
34. Spring, firing lock torsion washer.
35. Spring, firing pin.
36. Spring, primer retaining catch.
37. Washer insulation, firing lock hammer contact.
38. Washer, firing lock torsion.

---

strike the firing pin. The action is identical with that of a double action revolver.

(4) For electric firing, a current of electricity is sent through the insulated hammer and the insulated firing pin to the cap of the primer.

Q. How is the gun fastened to the cradle? *A*. The gun slides in the cradle, guided by splines and grooves. It is held in the firing position by the recoil and recuperator piston rods which are attached to the recoil band at the rear of the gun.

Q. What is the purpose of the recoil mechanism? *A*. To take up the energy of recoil and to stop the gun gradually as it kicks back.

Q. How does the recoil mechanism work? *A*. There are two long and two short recoil cylinders. The piston rods are attached to the recoil band on the gun, and the cylinders are mounted on the cradle. The short cylinders are simple hydraulic brakes while the long cylinders control both recoil and counterrecoil. Small counterrecoil throttling grooves are cut in the walls of these cylinders. These grooves are too small to affect the velocity of recoil appreciably. A sliding valve is mounted on the piston rod. During recoil this plays no part; but as soon as counterrecoil begins this valve rides against the recoil piston and closes the openings, thus forcing the oil to flow through the restricted counterrecoil openings, which produces an even and smooth return to the firing position.

Q. What is the purpose of the recuperator mechanism? *A*. To return the gun to its firing position.

Q. How does the recuperator operate? *A*. The recuperator cylinder is filled with gas under high pressure. As the gun recoils, the gas is still further compressed. As recoil ends, the gas expands again and by acting against the pistons forces the gun back into firing position.

Q. What is the purpose of the top carriage lifting mechanism? *A*. The center of gravity of the gun should be low for traveling but high for firing to give enough room for recoil at high elevations. These conflicting requirements have been met by making the top carriage movable with a position for traveling and another one for firing.

Q. In what ways may the gun be emplaced for firing? *A*. For land warfare it may be emplaced on a curved spur using a field emplacement on steel I-beams. For seacoast work it is emplaced on a previously prepared concrete block.

Q. How is the gun pointed in direction on the field carriage? *A*. pointing in direction is done mainly by placing the gun at the proper place on the curvey track. However, the front of the carriage may be moved 3½° either side of the center for adjustment of fire.

Q. How is the gun pointed in direction on the permanent emplacement? *A*. The mount revolves about a pedestal on rollers and base ring in the usual manner.

Q. Explain the operation of the elevating mechanism. *A*. It works in the usual way with a circular rack and spur gearing.

Q. How is friction during transversing reduced? *A*. The traversing rollers are attached to the traversing beam by means of Belleville springs heavy enough to support the weight ordinarily carried. When the gun fires, these springs are compressed enough to allow the beam itself to rest on the base ring.

6. Inspection and maintenance.—*Q*. For what measures of maintenance is a gun conmmander responsible? *A*. Periodic lubrication and painting, adjustments and repairs of a minor nature, having major repairs made, and such constant general attention as is necessary to maintain the equipment in a neat and serviceable condition.

Q. How often should the breech, elevating, and traversing mechanisms be operated between limits? *A*. At least once a week, in order to insure proper lubrication and detect any fault which requires attention.

Q. What care should be taken of recoil cylinders? *A*. They should be emptied and refilled at least once every 6 months and thoroughly cleaned every 12 months or oftener if conditions require.

Q. What care should be taken of the hydropneumatic counterrecoil mechanism? *A*. The recuperator cylinder and plunger should be emptied and refilled once every 6 months. The ordnance handbook pertaining to the particular armament should be consulted with reference to the proper protrusion from the stuffing box of the nut on the forward end of the piston rod.

Q. What parts of guns and carriages are painted? *A*. All steel and iron nonbearing surfaces and large unfinished bronze pieces will be painted. Bearing surfaces, oilholes, handles of handwheels and cranks, gear teeth, guides, rollers and surfaces on which they travel, racks and pawl teeth, direction plates, sight holders, scales and pointers, and stuffing box followers will *not* be painted.

Q. What color paint is used? *A*. Olive drab, except for oil holes, grease cups, and similar lubricating devices, which are painted red.

Q. If paint as issued is too thick, how should it be thinned? *A*. Use turpentine as a thinner, but not to a greater extent than 2 percent by volume; if paint is still too thick, thin with linseed oil.

Q. How are the surfaces prepared for painting? *A*. All parts to be painted should be free from dirt or grease. They may be washed with a solution of one-half pound sal soda to 8 quarts of warm water, then rinsed with clean water, and wiped thoroughly dry.

Q. What is the method of painting matériel that is in fair condition and marred only in spots? *A*. The marred places should be primed with olive drab paint, second coat, and permitted to dry. Then the whole surface should be sandpapered with No. 1½ sandpaper and a coat of paint applied and allowed to dry thoroughly before use.

Q. What is the method of painting matériel that is in bad condition? *A*. All parts should be thoroughly sandpapered with No. 2½ sandpaper, given a coat of paint, and permitted to dry for at least 24 hours, then sandpapered with No. 00 sandpaper, apply a finishing coat, and permit the parts to dry thoroughly before use.

Q. In general, how many coats of paint a year are necessary to keep the matériel in good condition? *A*. Two coats per year.

Q. If, after repeated painting, the paint becomes so thick as to scale off in places or give an unsightly appearance, how may it be removed for repainting? *A*. By the use of scaling hammers, putty knives, or scrapers made locally from old files or of tool steel. The following treatment will sometimes answer if the old paint is not too thick. Dissolve 1 pound of concentrated powdered lye in 6 pints of hot water and add enough lime to give the solution the consistency of paint. Use freshly mixed and apply with a brush or waste tied to the end of a stick. When the solution begins to dry on the surface, use a scraper to remove the old paint and complete the cleaning of the surface with cloth and water. If one application is not sufficient to loosen the paint, apply additional coats. Before painting, wash the surface with sal soda solution, rinse with clean warm water, and then wipe thoroughly dry. Prepared paint remover, if available, may be used instead of the lye solution.

Q. What is used for the base coat on iron or steel when the surface has been scraped down to the metal? *A.* Red lead.

Q. What particular care must be taken in painting artillery matériel? *A.* Avoid interfering with the proper functioning of the moving parts and prevent the paint entering the oilholes and bearings.

Q. What are the different materials used in cleaning, polishing, and removing rust from the different parts of the gun and carriage? *A.*

(1) *Cloth, crocus (commercial).*—Used for cleaning and polishing finished surfaces, such as breechblocks, piston rods, and brass work.

(2) *Cloth, emery, No. 00 (commercial).*—Used for cleaning and removing rust from finished iron and steel surfaces. It is the coarsest abrasive permitted on breech mechanisms. Its use on soft metals such as brass, bronze, and babbit is prohibited.

(3) *Cloth, emery, Nos. 0 and ½ (commercial).*—These cloths are used in cleaning finished iron and steel surfaces where deterioration has occurred, and for removing burs and scratches.

(4) *Cloth, emery, No. 1 (medium) and No. 3 (coarse).*—Used in removing rust, burs, and other defects from unfinished surfaces of steel and iron and for preparing them for painting. Its use on finished surfaces is prohibited.

(5) *Sandpaper (commercial).*—Used on the surfaces of wooden parts of matériel. It should be applied with caution.

(6) *Gasoline.*—Used for cleaning purposes only. Never use kerosene for cleaning bores or bright parts.

Q. What kind of oil should be used as lubricant on breech mechanisms, threads of breechblocks, breech recesses, and gears, and in all oilholes? *A.* Oil, lubricating, class A, light.

Q. How much oil should be used? *A.* Just enough to cover the surface with a thin coating, rubbed over with the hand. Too much oil is to be avoided, but during firing plenty should be used on the breechblock and in the breech recesses. This cleans the block and prevents it sticking to the breech. Oilholes should be filled.

Q. What is used as a preservative of the finished surfaces of iron or steel if the gun is to remain unused for a considerable length of time (several months or more)? How is it applied? *A.* Rust-preventive compound, grade A (heavy), formerly called heavy slushing oil, or cosmoline. Apply heat just sufficiently to melt. Surface to which it is to be applied should also be warm if possible. If rust preventive compound is heated about 180° F., separation of the ingredients may take place and destroy its usefulness.

Q. What is used as a preservative of the finished surfaces of steel if the gun is to remain unused for a shorter length of time (few days to several weeks)? How is it applied? *A*. Rust-preventive compound, grade B (light), formerly called light slushing oil. It is applied with a paint brush.

Q. How may rust preventive compound be removed? *A*. By means of waste or burlap soaked in gasoline.

Q. How are the metal surfaces prepared for slushing with rust preventive compound? *A*. They should be clean and dry and free of all traces of corrosion.

CHAPTER 4

POINTING

7. Pointing methods.—*Q*. What is meant by pointing? *A*. The operation of giving a gun a designated elevation and direction.

Q. What two general methods are used to point in elevation? *A*. The method which uses quadrant elevation and the method which uses angle of elevation.

Q. How is a gun pointed by quadrant elevation? *A*. By the use of a device which sets off the elevation of the gun from horizontal.

Q. How is the gun pointed by angle of elevation? *A*. By waterlining the target with a sight and elevating the gun above the line of sight an amount sufficient to correct for the curvature of the trajectory.

Q. How are 155-mm guns and railway guns pointed in elevation? *A*. By quadrant elevation.

Q. What two general methods are used to point a gun in direction? *A*. The direct and the indirect method.

Q. How is a gun pointed in direction by the direct method? *A*. The sight is pointed directly at the target and the axis of the bore is caused to diverge from the line of sight by an angular amount called the "deflection."

Q. How is a gun pointed in direction by the indirect method? *A*. The axis of the bore is pointed in azimuth.

Q. What two methods are used to point the gun in azimuth? *A*.

(1) By means of a panoramic telescope and a fixed aiming point other than the target.

(2) By means of an azimuth circle or dial.

Q. According to the combinations of pointing methods used, how many cases of pointing are there for seacoast artillery? *A*. Three.

Q. Name the three cases of pointing. *A*. Case I, case II, and case III.

Q. What is case I pointing? *A*. Pointing in which direction and elevation are imparted to the gun by means of the sight. Data are applied to the piece in the form settings of deflection and angle of elevation.

Q. What is case II pointing? *A*. Pointing in which direction is imparted to the gun by means of the sight and elevation is imparted by means of an elevation scale or graduate range drum. Data are applied to the piece in the form of settings of deflection and quadrant elevation, the latter being given in terms of range when a range drum is employed.

Q. What is case III pointing? *A*. Pointing in which direction is given the piece by means of an azimuth circle, "a match the pointer" indicator, or a sight pointed at an aiming point other than the target, and elevation by means of an elevation quadrant, a range disk, or a "match the pointer" indicator.

Q. What cases of pointing are used with 155–mm and railway guns? *A*. Either case II or case III pointing.

Q. What is the rule for pointing in direction to which all seacoast artillery pointing equipment conforms? *A*. "Right, raise; left, lower."

Q. What does the rule "Right, raise; left, lower," mean? *A*. If the deflection (or azimuth) is increased, the gun will be pointed farther to the right; if the deflection (or azimuth) is decreased, the gun will be pointed farther to the left.

8. Bore sighting, orienting, and clinometering.—*Q*. What adjustment of the sight is necessary for case II pointing? *A*. Bore sighting.

Q. What is bore sighting? *A*. Adjusting the gun sight so that when the normal reference number or zero deflection is set the line of sight and the axis of the bore either will be parallel or will converge beyond a certain minimum range.

Q. Is the sight normally bore sighted for convergence or for parallelism? *A*. When a point is available which is not too close, the sight is normally bore sighted for convergence.

Q. What determines the minimum range of a point suitable for use in bore sighting? *A*. The point must not be so close as to give a convergence angle greater than 0.03°. A point at greater range should be used when available.

Q. What is the minimum range of a point that would be suitable for bore sighting your battery? *A*. ——— yards.

Q. When it is necessary to adjust a gun sight for parallelism, what piece of equipment is used? *A*. A testing target.

Q. What is a testing target? *A*. A testing target is a chart on which are two marks separated by the same horizontal distance as that which separates the sight from the axis of the bore. This distance is: for the 12-inch railway mortar, 48.5 inches; for the 8-inch gun, M1918, 33.6 inches; and for the 155-mm gun M1918, 15.9 inches.

Q. How is a testing target used to bore sight? *A*. Place the testing target any convenient distance away from the gun, perpendicular to the axis of the bore, and level. Point the gun at one mark and the sight at the other so that the line of sight and axis of the bore are parallel.

Q. What adjustment of the sight is necessary for case III pointing? *A*. Orientation.

Q. How is a panoramic telescope oriented? *A*. By adjusting the azimuth scale to read the azimuth of the axis of the bore when the line of sight is on the aiming point.

Q. How may the azimuth of the axis of the bore be determined? *A*. By pointing the gun at a datum point of known azimuth or by measuring the azimuth with the panoramic telescope.

Q. Explain how to point the axis of the bore at a datum point or other object. *A*. Place a bore sight in the breech, a thread in the horizontal diameter of the muzzle, and another thread in the vertical diameter of the muzzle. Sight through the center hole of the bore sight and traverse and elevate the gun until the cross threads are on the object. If no bore sight is available, sight through the vent.

Q. What adjustment of elevation pointing equipment must be made? *A*. Clinometering.

Q. What is clinometering? *A*. Checking the quadrant sight (or the elevation quadrant) against a clinometer or a quadrant of known accuracy.

9. Adjustment of sights, aiming rule, and quadrants.—*a*. *Sights*.—*Q*. Before any adjustments or measurements are made with a panoramic telescope, what must be done on its compensating sight mount? *A*. The longitudinal level bubble and the cross level bubble must be centered.

Q. What is the purpose of the compensating sight mount? *A*. To correct the pointing in direction for errors due to any lack of level of the gun trunnions.

Q. Which would affect the pointing in direction most, a small error in adjustment of longitudinal level or a small error in adjustment of cross level? *A*. The small error in adjustment of cross level.

Q. How is the adjustment of the cross level checked in the field? *A*. Place a cross thread on the vertical center line of the muzzle. Establish a plumb line in front of the muzzle. With the bore approximately horizontal, bore sight the gun on the plumb line. Center both longitudinal and cross levels. Move the sight head and place the line of sight on a distant aiming point. Elevate the gun as high as possible to magnify any error that may be present and again bore sight on the plumb line, traversing the gun if necessary. Check level of sight, releveling if the bubbles are not centered. Check position on the line of sight. If it is on the aiming point, this is an indication that the cross level bubble is properly adjusted. If it is not on the aiming point, the cross level bubble is out of adjustment and must be readjusted.

Q. What model of telescope is used with the quadrant sight M1918, for 155-mm guns? *A.* The panoramic telescope M2A1. This is the old panoramic telescope M1917MII, modified so that the azimuth scale and micrometer may be moved to set any azimuth desired, and equipped with an auxiliary segment which provides for making individual gun corrections.

Q. What model of telescope is used with railway artillery? *A.* A panoramic telescope M1918MII (degrees), M1922, or M8.

Q. Explain the construction of a panoramic telescope. *A.* A panoramic telescope consists of a fixed elbow and a rotating head. A special device holds the telescope rigidly to its mount on the carriage.

(1) The elbow contains the eyepiece and the objective lenses and a reticle with horizontal and vertical cross wires. Other optical elements permit movement of the rotating head to change the direction of the line of sight without disturbing the line of collimation. The head may be moved also through a few degrees of elevation on both sides of the horizontal so that an aiming point slightly above or below the gun may be seen.

(2) The head is attached to and supported by a movable plate or limb which is housed in the upper part of the elbow. An azimuth circle carried on the limb shows through a window in the housing. On some models the azimuth circle is graduated in degrees with a least reading of 1°; on others, in mils with a least reading of 100 mils. Smaller readings are marked on the azimuth micrometer which is fastened to a handwheel geared to the movable limb. The index of the main azimuth circle is fixed to the housing. On older models the micrometer index also is fixed, but on newer ones it is carried on a movable piece which may be moved to apply individual gun corrections. Both the azimuth circle and the micrometer are so attached to the sight that they may be adjusted to read any desired azimuth for any position of the line of sight.

(3) The head may be rotated by turning the micrometer handwheel, or the handwheel may be disengaged by means of the throw-out lever and the head may be turned freely. On the movable limb, the diameter that coincides with the line of sight is indicated by a reference mark. The line of sight is parallel to the axis of the bore when the reference mark is opposite the index in the window of the housing. The exact position where the line of sight is parallel to the axis of the bore is indicated on the fixed index of the micrometer. The reading of the micrometer fixed index is not generally zero when the line of sight is parallel to the bore. The exact reading should be recorded.

(4) On all models made for use with seacoast artillery, the azimuth readings increase as the head is turned counterclockwise, that is, as the line of sight is turned to the left. There are other models similar in appearance to the seacoast type, on which the graduations are reversed. Telescopes should be examined to verify whether or not they are suitable for seacoast artillery firing.

Q. How may a panoramic telescope be oriented on an aiming point when the azimuth of the axis of the bore is known—for example, when the gun is bore sighted on a datum point? *A*. Leaving the gun pointed at the datum point, turn the telescope head until the line of sight is on

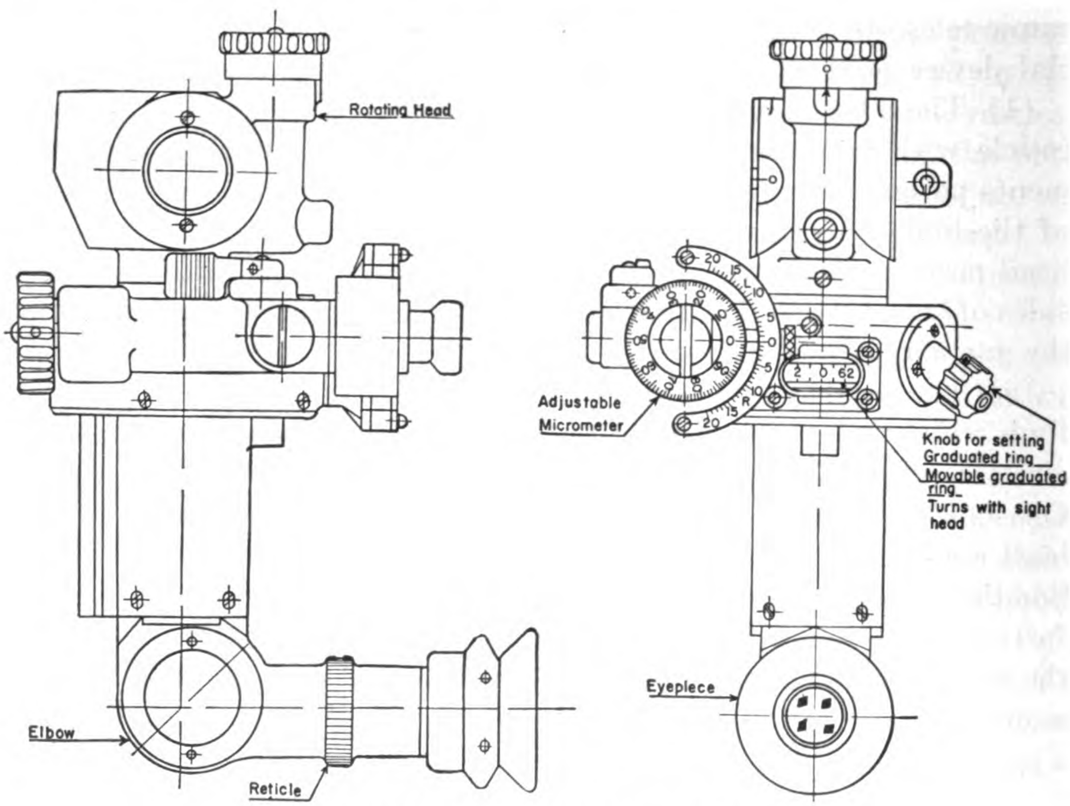


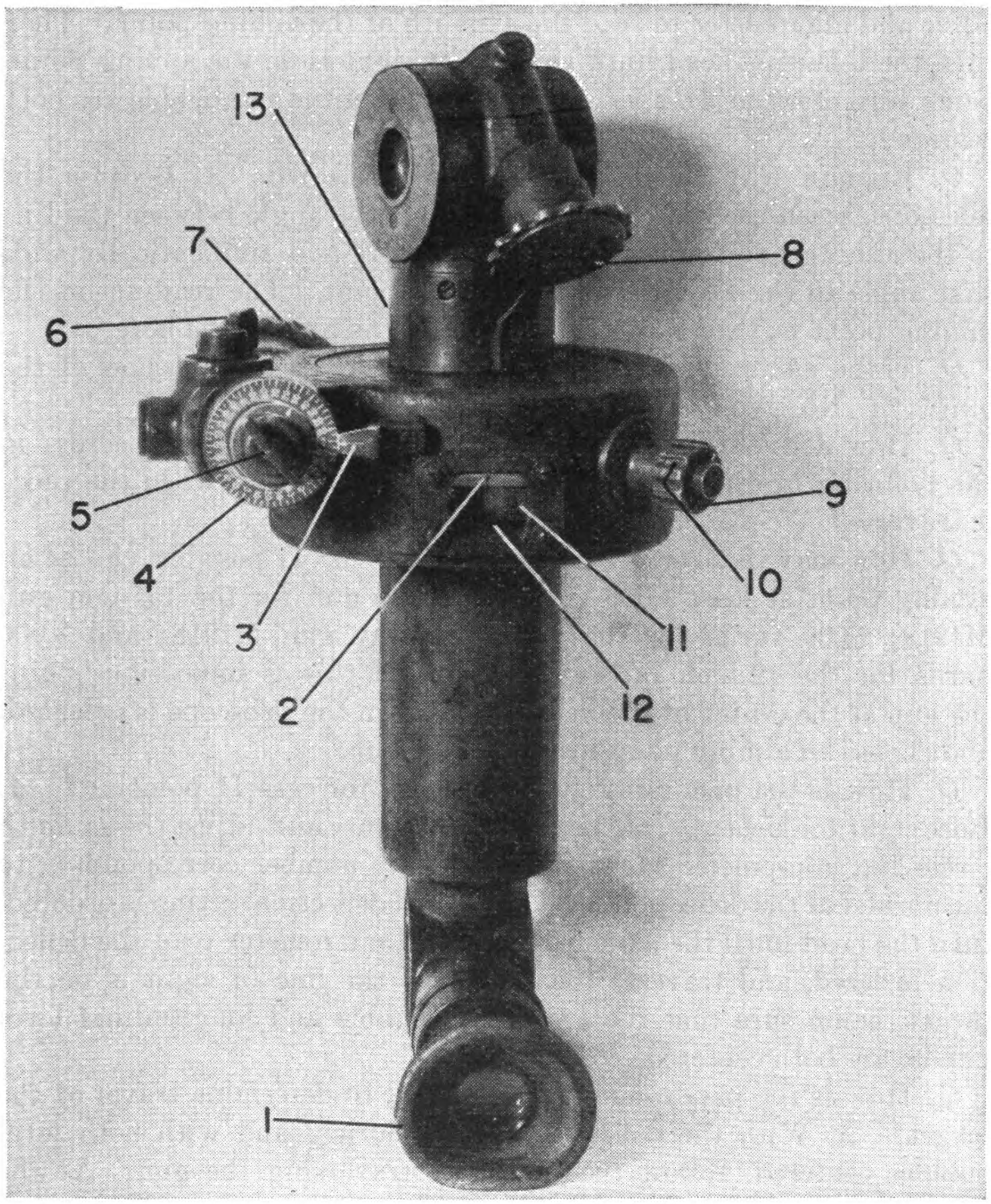
FIGURE 16.—Panoramic telescope M2A1.

the aiming point, being sure that the cross level bubble and the longitudinal bubble are both centered. Then adjust the azimuth scale and micrometer to read the azimuth of the axis of the bore (the azimuth of the datum point).

Movable index on brass plate (12) not shown. When this index and (11) are lined up, the line of sight and axis of the bore should be parallel.

Q. Can a panoramic telescope be oriented with the axis of the bore pointed in any direction if the azimuth of the aiming point is known? *A*. Yes.

Q. Explain the procedure. *A*. Turn the telescope head until the



1. Eyepiece.
2. Fixed azimuth index.
3. Fixed micrometer (azimuth) index.
4. Azimuth micrometer.
5. Micrometer wing nut.
6. Throw-out lever.
7. Azimuth circle wing knob.
8. Elevation micrometer.
9. Knob for setting azimuth circle (push in to engage).
10. Hole for cotter pin. (When pin is inserted, circle cannot be turned by this knob.)
11. Azimuth circle (turns with telescope or may be turned by 9).
12. Brass plate (always moves with head).
13. Head.

FIGURE 17.—Panoramic telescope, M1918MII.

line of sight is paralled to the axis of the bore and adjust the azimuth circle and micrometer to read the azimuth of the aiming point. Then turn the telescope head until the line of sight is on the aiming point, being sure that the cross level bubble and longitudinal bubble are both centered.

Q. Explain why the telescope is now oriented. *A*. Because the telescope, when used in this way, measures the angle between the line to the aiming point and the axis of the bore and automatically adds that angle to the azimuth of the aiming point. The reading on the aiming point is, therefore, the azimuth of the axis of the bore.

Q. Is the panoramic telescope directly over the pintle center of the gun? *A*. No.

Q. How does this affect the pointing? *A*. It may cause errors in the pointing in direction because the telescope moves when the piece is traversed.

Q. How may these errors be eliminated? *A*. If possible, choose an aiming point at least 1,000 yards from the gun for the 155-mm gun M1918; 2,000 yards for the 8-inch railway gun M1918; and 3,000 yards for the 12-inch railway mortar. If this is impossible, point the gun at the center of the field of fire when the telescope is oriented, and choose an aiming point in rear of the gun.

Q. How is the panoramic telescope used for case II pointing? *A*. Bore sight for either parallelism or convergence and adjust the azimuth circle and micrometer to read the reference number corresponding to the normal of the deflection scale. When a deflection setting is ordered, turn the head until the azimuth circle and micrometer read the deflection ordered, and traverse the gun until the line of sight is on the target, being sure that the cross level bubble and longitudinal level bubble are both centered.

Q. How is the panoramic telescope used to determine travel of the target? *A*. With the deflection setting normal and with both level bubbles centered, follow the target by traversing the gun. At the command READY, TAKE, halt the gun and follow the target by turning the head until the command READY, HALT is given. (The two commands are given by another man with a stop watch. He starts the watch at the command TAKE, and gives the command HALT at the end of the time of flight.) The deflection reading at the end of the operation is algebraically subtracted from the normal setting to give the amount and sign of the deflection correction for travel during the time of flight.

Q. What is the purpose of the operation called "jumping the splash?" *A*. To correct the deflection automatically for the lateral deviation of the splash, for case II pointing.

Q. Explain the operation. *A*. With the deflection setting used when the shot was fired, and with both bubbles centered, follow the target by traversing the gun until the splash occurs. Then turn the telescope head until the vertical cross wire is on the center of the splash. The telescope is now set at the corrected deflection.

Q. How is the panoramic telescope used for case III pointing? *A*. Orient the telescope by turning the head until the line of sight is on the aiming point with both level bubbles centered, and by adjusting the azimuth circle and micrometer to read the azimuth of the axis of the bore. When an azimuth setting is ordered, turn the head until the azimuth circle and micrometer read the azimuth ordered, and traverse the gun until the line of sight is on the aiming point, being sure that the cross level bubble and the longitudinal level bubble are both centered. Then keep the bubbles centered and the line of sight on the aiming point until the gun is fired.

Q. Why must the operation be continued until the gun is fired? *A*. Because any change in the elevation of the gun may change the pointing in direction.

Q. Which models of panoramic telescopes issued to 155-mm gun batteries are suitable for case III pointing? *A*. All models issued.

Q. Which models of panoramic telescopes issued to 155-mm gun batteries are suitable for case II pointing? *A*. Only the panoramic telescope M8 has optical qualities suitable for use for case II pointing.

Q. When models other than the M8 are issued, how can the guns be pointed by case II? *A*. By the use of a telescope M1909A1, which has excellent optical qualities (not a panoramic telescope), thus making it necessary to issue two telescopes per gun to provide for both case III and case II pointing.

Q. What mechanical features of the panoramic telescope M8 make it well suited for case II pointing? *A*. A set of scales, indices, and micrometers are provided for use in case II which are separate from those for use in case III pointing.

b. *Aiming rule*.—*Q*. What is the purpose of an aiming rule? *A*. To provide a moving aiming point which will eliminate pointing errors due to the movement of the gun telescope about the pintle center of the gun.

Q. Describe the aiming rule. *A*. It consists of a panoramic telescope mounted on a slide on a horizontal bar. The bar is supported by two upright steel stakes in a position some convenient distance in the rear of the gun and approximately perpendicular to the gun-aiming rule line.

Q. How does it work? *A*. When properly adjusted, the aiming rule telescope is pointing at the gun telescope. When the gun telescope moves off that line, the aiming rule telescope should also move off in the same direction and the same distance. This will establish a new line of sight parallel to the old one, automatically correcting for movement of the gun telescope. If the aiming rule telescope is kept pointed at the gun telescope by being slid along the horizontal bar, it will be moved through the proper distance. The gun pointer uses the aiming rule telescope as an aiming point.

Q. How is the aiming rule telescope adjusted. *A*.

(1) Traverse the gun into position for orientation.

(2) Place the aiming rule telescope at the proper point on the bar. If the gun is pointed in the center of the field of fire, the telescope

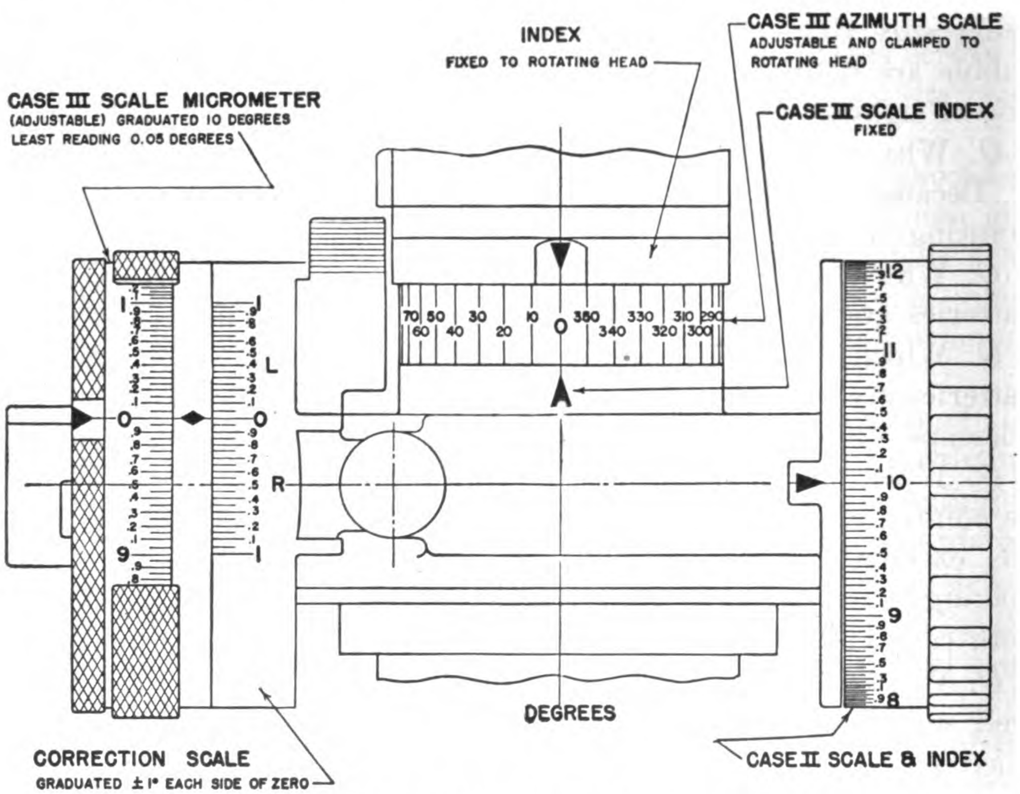


FIGURE 18.—Arrangement of scales, indices, and micrometers on panoramic telescope M8.

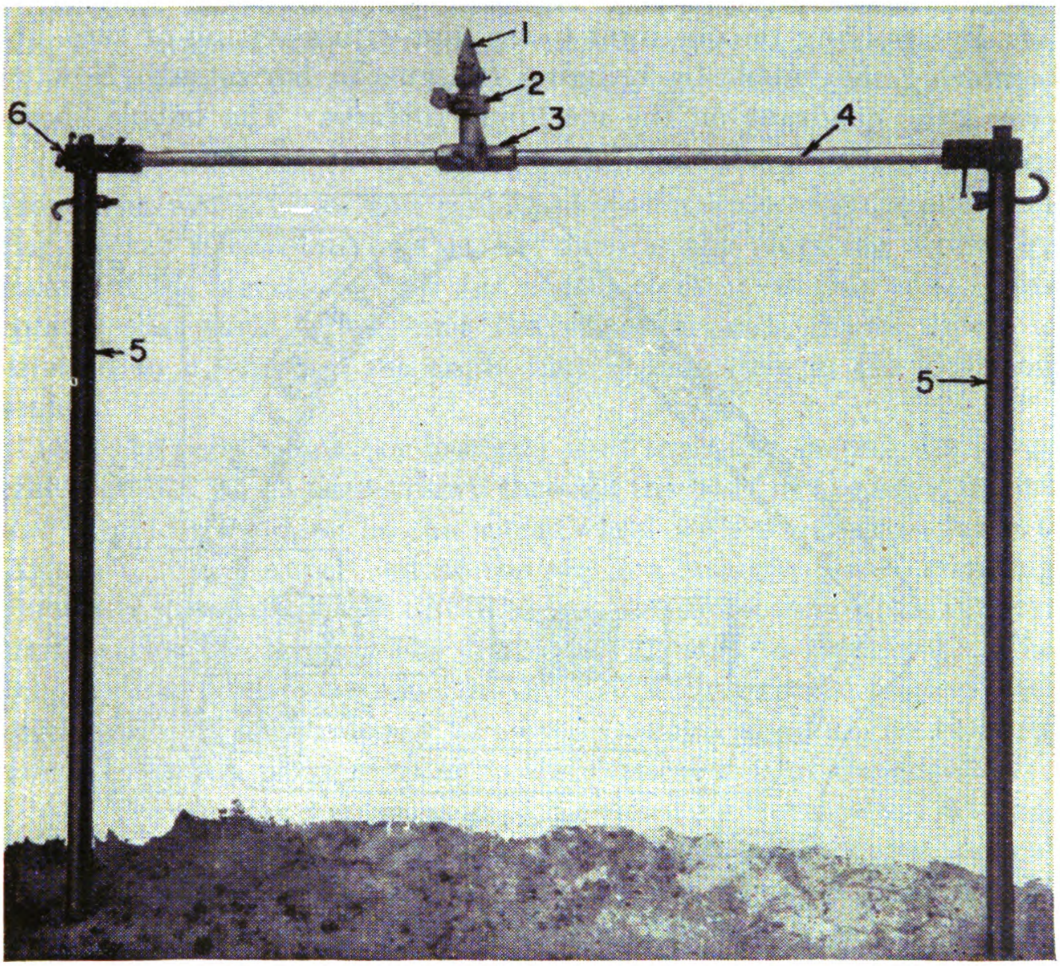
should be near the left end of the bar (looking from the aiming rule toward the gun); if the gun is pointed at either edge of the field of fire, it should be near the right end of the bar.

(3) Turn the head of the aiming rule telescope until the line of sight is on the gun telescope and note the reading of the azimuth circle and micrometer. At the same time orient the gun telescope, using the aiming rule telescope as an aiming point.

Q. How is the aiming rule operated? *A*. Keep the aiming rule telescope set at the azimuth recorded when adjusting, and keep its line of sight on the gun telescope by sliding the aiming rule telescope along the bar.

Q. How is the gun telescope operated when using an aiming rule as an aiming point? *A*. In exactly the same way as when using a fixed aiming point.

c. *Gunner's quadrant*.—*Q*. What is a gunner's quadrant? *A*. An angle-measuring instrument used for pointing a gun in elevation or for checking the elevation.



1. Targ.
2. Sight.
3. Sight mount.
4. Horizontal bar.
5. Uprights.
6. Horizontal bar clamp.

FIGURE 19.—Aiming rule with panoramic telescope. Targ attached to telescope.

Q. What angular unit is used to set quadrant elevation on the gunner's quadrant M1 (or M1919)? *A*. Mils.

Q. What is the least graduation on the elevation scales? *A*. 10 mils.

Q. Where are units of mils set? *A*. On the micrometer.

Q. How is the quadrant applied to the gun? *A*. By placing it on the machined surfaces provided.

Q. Set a quadrant elevation of 283 mils on the quadrant. *A*. (Practical demonstration.)

Q. Set a quadrant elevation of 947 mils on the quadrant. *A*. (Practical demonstration.)

Q. What is the standard method of verifying the accuracy of the quadrant? *A*. By comparing it with a clinometer or with a quadrant of verified accuracy.

Q. When neither a clinometer nor a verified quadrant is available, how may the bubble be checked for use on the 0–800-mil scale? *A*. By applying the quadrant to the gun with a setting of zero, and centering the bubble by bringing the gun to horizontal. Now reverse the quadrant on the machined surfaces. The bubble should remain centered.

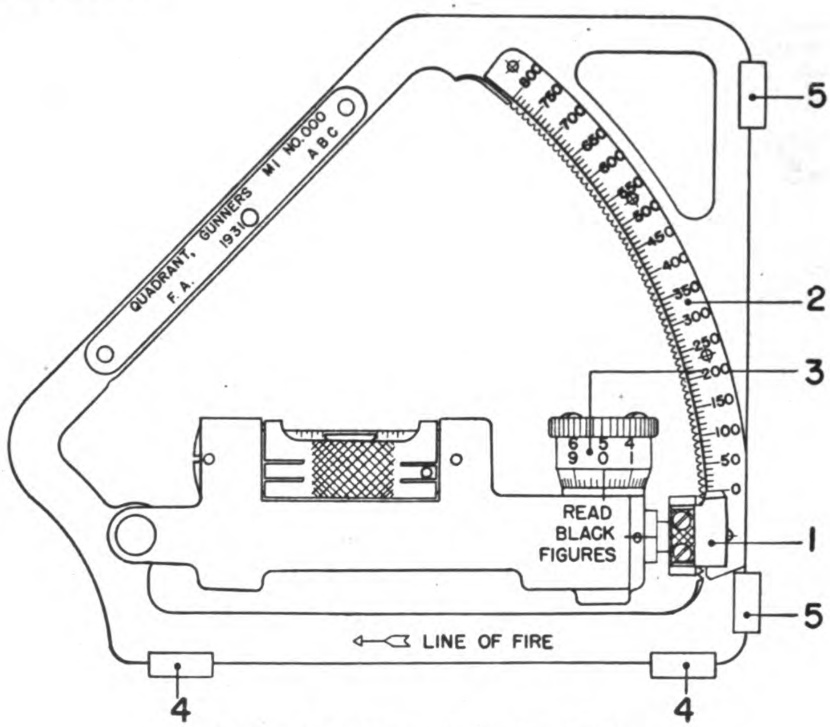


FIGURE 20.—Gunner's quadrant M1.

Q. How may the bubble be checked for use on the 800–1,600-mil scale? *A*. First check the bubble for use on the 0–800-mil scale, then, using the 0–800-mil scale, point the gun at an elevation of 800 mils. Now, without changing the gun or quadrant arm, reverse the quadrant so the quadrant elevation is indicated on the 800–1,600-mil scale. The bubble should remain centered.

Q. How does the gunner's quadrant M1918 differ from the gunner's quadrant M1? *A*. The M1918 quadrant has no ratchet device and no micrometer drum. The toothed sector at the end of the arm is engaged on the arc by shortening its length against a spring, moving it to the proper elevation, and releasing it. The level is carried in a slide on the arm. The arm is slightly curved, and the closer settings are made by moving the slide and bubble along the arm to the proper graduation.

d. Quadrant sight.—*Q.* Describe the quadrant sight M1918A1. *A.*

(1) This instrument is a combined sight mount and quadrant, and is used for pointing the 155-mm gun in both direction and elevation. It is permamently mounted on the left trunnion of the gun in a support that permits movement on an axis parallel to the axis of the bore for cross leveling. The cross level screw is under this support.

(2) The main parts of the elevation-indicating mechanism are the worm, worm wheel and pinion, elevation scale, sight shank, and the levels. Elevations are set by turning the elevating worm by means of the elevation screw (or micrometer) at its rear end. This rotates the worm wheel, and the elevation scale drum which is screwed to it, through the angle that is indicated on the elevation scale.

(3) The sight shank (or bracket) is of irregular shape. Its lower end is an arc which passes down through the body of the sight mount and around the pinion on the worm wheel with which it is meshed. Attached to the upper end of the arc is a straight piece extending vertically upward and out of the body. The lower end of this vertical part carries the levels. The cross level is fixed to the shank. The longitudinal level is attached to the shank through the angle-of-site mechanism, by which it may be moved through small angles from its normal position perpendicular to the vertical axis of the shank.

(4) The angular displacement of the elevating worm wheel is transmitted through the pinion and rack to the sight shank whose vertical part is displaced by a proportionate amount from the vertical. If the gun is then elevated until the longitudinal bubble is centered and the sight cross-leveled, the sight shank will be brought back to the vertical and the axis of the bore will be pointed at the quadrant elevation set on the elevation scale. Elevations are indicated in mils.

(5) The upper end of the sight shank forms a seat for a panoramic telescope by means of which the gun may be pointed in direction.

Q. How may the adjustment of the elevation scale be checked? *A.* Point the gun in direction at any azimuth. Point the bore, by means of an adjusted gunner's quadrant, to the desired elevation. Turn the elevation handwheel on the sight until the longitudinal bubble is centered, keeping the sight cross-leveled, and read the elevation indicated on the sight.

Q. How can an adjustment be made on the sight? *A.* Either by making a correction on the angle-of-site mechanism or by moving the elevation scale to make it read correctly.

Q. How may the adjustment of the cross level bubble be checked? *A*. Place the gun at about zero elevation and leave it there. Do not elevate or traverse the gun during the rest of the operation. Center the cross level bubble and the longitudinal level bubble, and push the sight shank forward until enough of the curved part is exposed to allow placing a machinist's cross level on its left side. Using that tool, see whether or not the curved part of the sight shank is vertical. If not, move the cross level screw on the sight until the bubble on the machinist's level is centered. Then pull the sight shank back and relevel the longitudinal bubble. If the cross level bubble does not return to center, it is out of adjustment and must be fixed by an ordnance machinist.

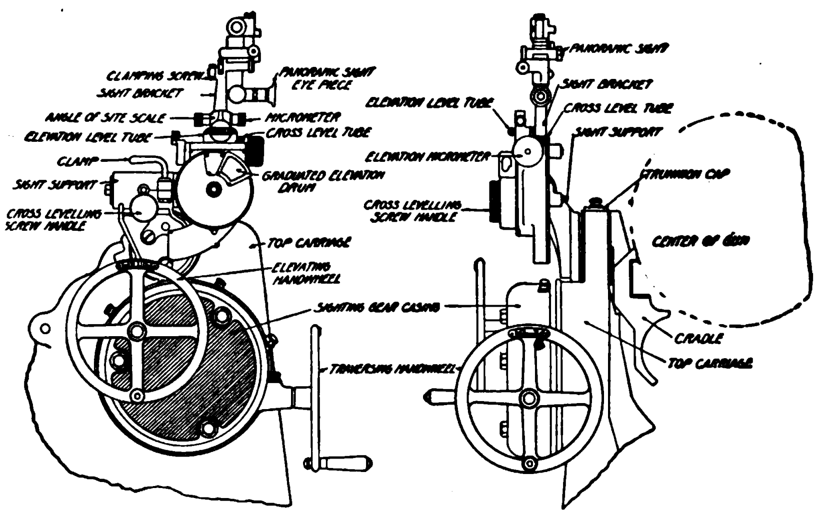
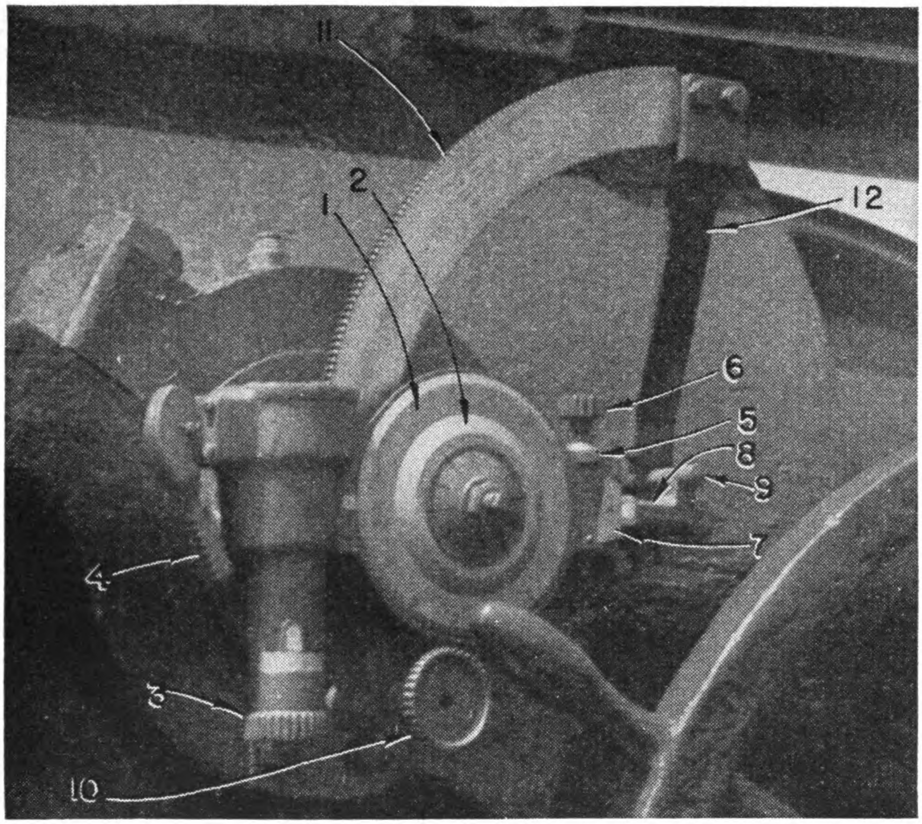


FIGURE 21.—Quadrant sight M1918A1.

Q. Explain the operation of the sight. *A*. Set the angle-of-site mechanism at the reading ordered. Set the quadrant elevation ordered on the elevation scale and micrometer and elevate the gun until the longitudinal level bubble is centered, being sure that the cross level bubble is also centered. Then keep the longitudinal level bubble centered until the gun is fired.

e. Elevation quadrant.—*Q*. Describe the elevation quadrant M1917. *A*. The elevation quadrant M1917 is used with railway artillery and is equipped with a cross level. The quadrant is attached by a fulcrum to a rocker arm. A tapered shank on the rocker fits in a groove in a support on the right trunnion of the cannon. The purpose of this arrangement is to permit movement of the quadrant about a longitudinal axis parallel to the bore for cross leveling. The elevating arc bears on its outer edge a worm rack that engages a worm fastened to the quadrant arm. The arm is set in elevation by rotating the worm by means of the micrometer screw at its lower end. For fast motion, the worm may be disengaged by lifting the throw-out lever. Degrees of elevation are indicated on the elevation disk which is geared to the inner edge of the elevating arc through a shaft and two friction disks. Minutes of elevation are indicated on the micrometer screw. The cross level and longitudinal level are carried on the quadrant



1. Elevation disk.
2. Outer friction disk.
3. Elevation micrometer.
4. Throw-out lever.
5. Level micrometer.
6. Level micrometer screw handle.
7. Angle-of-site scale.
8. Elevation level.
9. Cross level.
10. Cross level screw handle.
11. Rocker arm.
12. Rocker arm support.

FIGURE 22.—Elevation quadrant M1917.

arm. The cross level bubble is centered by means of the cross level screw. An angle-of-site mechanism is included at the front of the quadrant arm, by which the longitudinal level bubble may be displaced through small angles from its normal position. This machinism may be used to apply individual gun corrections.

Q. How may the adjustment of the quadrant be checked? *A.* Point the gun in direction at any convenient azimuth. Point the bore, by means of an adjusted clinometer or gunner's quadrant, to the desired elevation. Keeping the cross level bubble on the quadrant centered by means of the cross level screw, center the longitudinal level bubble by changing the elevation setting on the quadrant, and read the elevation indicated.

Q. Explain the operation of the elevation quadrant. *A*. Set the angle-of-site mechanism to the reading ordered. Set the quadrant elevation ordered on the elevation disk and micrometer, and elevate the gun until the longitudinal level bubble is centered, being sure that the cross level bubble is also centered. Then keep the bubbles centered until the gun is fired.

CHAPTER 5

INSTRUCTION OF GUN SECTION

10. Instruction of members of gun section.—The candidate should be required to demonstrate practically his ability to instruct members of the gun section in drill at the gun and in the emplacement of the gun. Duties of members of the gun section are outlined in TM 4-315.

CHAPTER 6

AMMUNITION

SECTION I

BASIC

11. Storage and care.—*Q.* How are propelling charges stored? *A.* In airtight, waterproof storage cases in magazines.

Q. What are the general instructions regarding storage of powder containers? *A.*

(1) All dirt or foreign material should be removed from containers before they are stored.

(2) Powder charges in damaged containers should not be stored until the containers have been repaired or the powder repacked in serviceable containers.

(3) Charges should be separated into lots and all charges of one lot stored in the same room or under as similar conditions as possible.

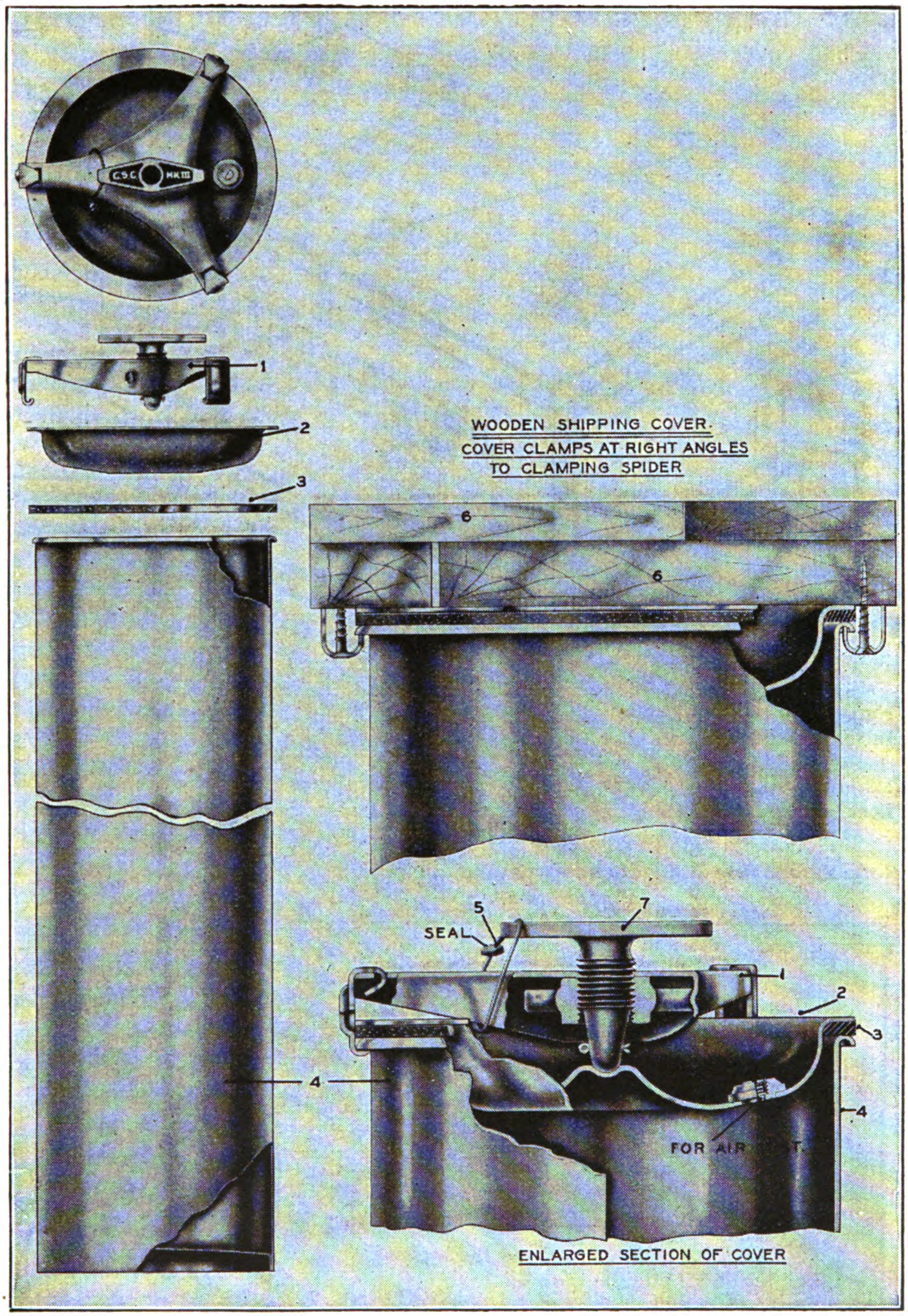
(4) Containers should preferably be stored on skids and with skids under them to permit air circulation. If piled on their sides, care should be taken to separate them by skids rounded to fit the case. Skids should be placed between all layers.

(5) Cases should be stored so that the covers can be readily inspected or removed.

(6) Metal containers should be cleaned and repainted whenever such action is necessary to prevent rusting. They should be removed from the magazine before painting.

(7) Storage cases should never be opened except in preparation for firing or as directed by competent authority.

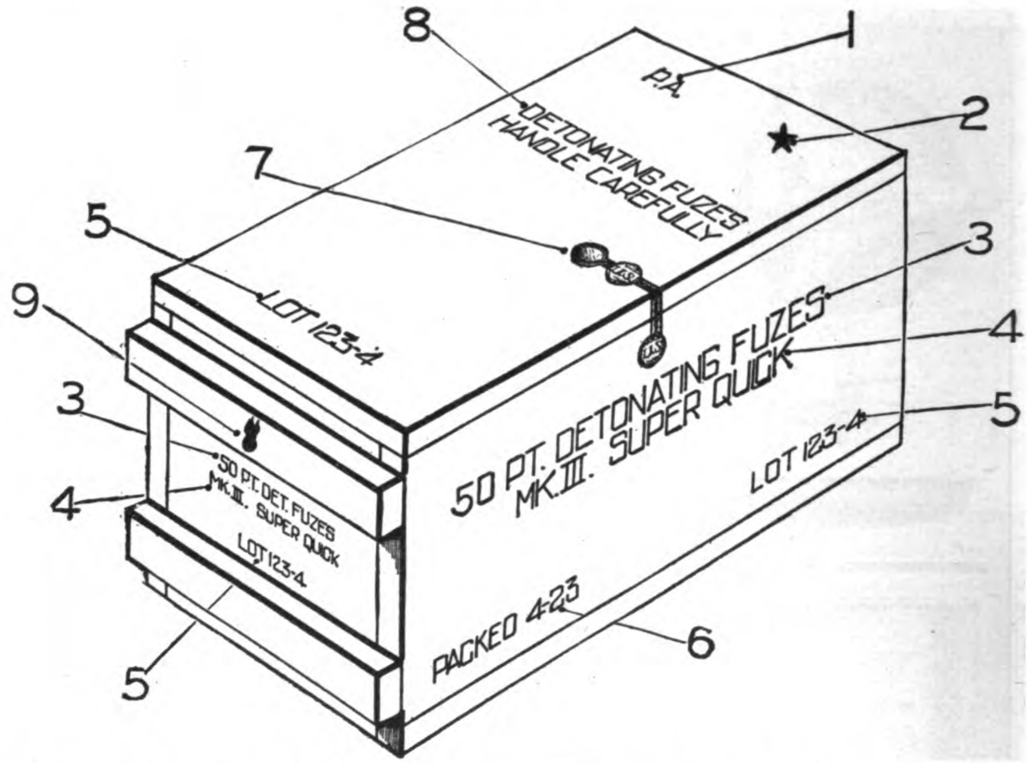
Q. What special precaution applies to the handling of powder storage cases? *A.* It is most important that powder storage cases be kept airtight until the powder is used. Special care must be used in handling them so as to avoid any strains that might cause air leaks.



1. Clamping spider.
2. Cover.
3. Rubber gasket.
4. Body.
5. Wire seal.
6. Shipping cover.
7. Clamp screw.

FIGURE 23.—Storage case for propelling charge.

Q. How are primers and fuzes stored? *A.* In airtight, waterproof containers usually packed in wooden boxes. The same precautions observed for propelling charges apply generally to the storage of primers and fuzes.



1. Name of place where packed.
2. Inspector's stamp.
3. Quality and kind of fuze.
4. Mk. number and type of fuze.
5. Lot number.
6. Month and year of packing.
7. Seal.
8. To comply with I. C. C. regulations.
9. Ordnance insignia.

FIGURE 24.—Packing box for point detonating fuzes.

NOTE.—Both ends of box are marked alike.

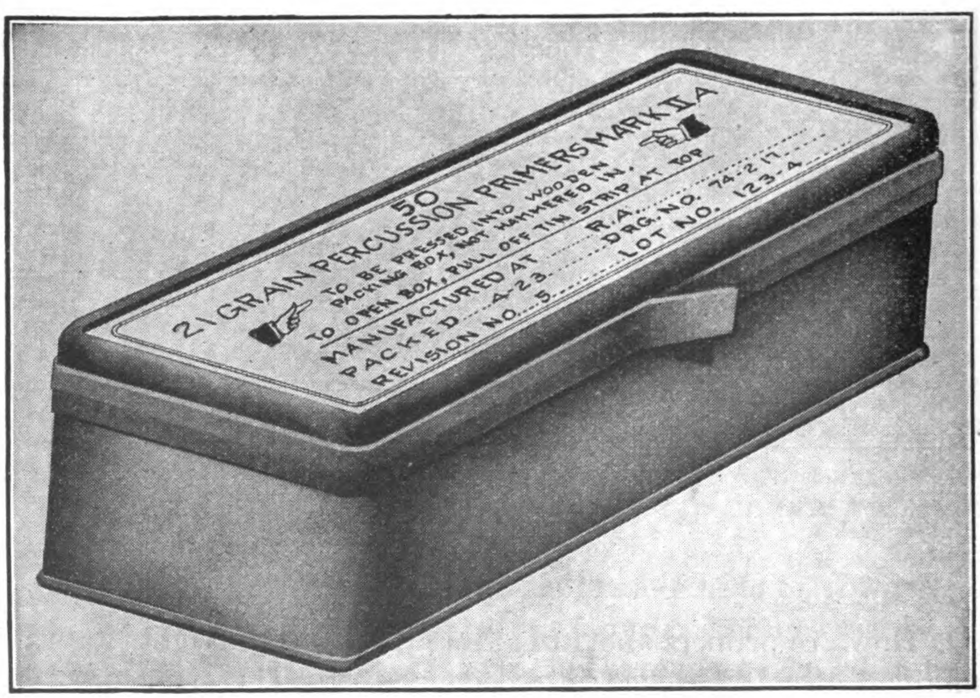


FIGURE 25.—Packing can for 21-grain percussion primers Mk. IIA.

Q. How should projectiles be stored? *A.* On their sides or their bases, with skids separating the pile from the floor and between layers. They should be handled carefully to avoid damaging the rotating bands.

Q. What is the purpose of the rope grommet placed on a projectile? *A.* To protect the rotating band.

Q. What are the general instructions applying to storage magazines? *A.*

(1) Magazines and the ground surrounding them should be kept absolutely clean.

(2) Magazines should be well ventilated, allowing free circulation of *dry* air around and under the explosives.

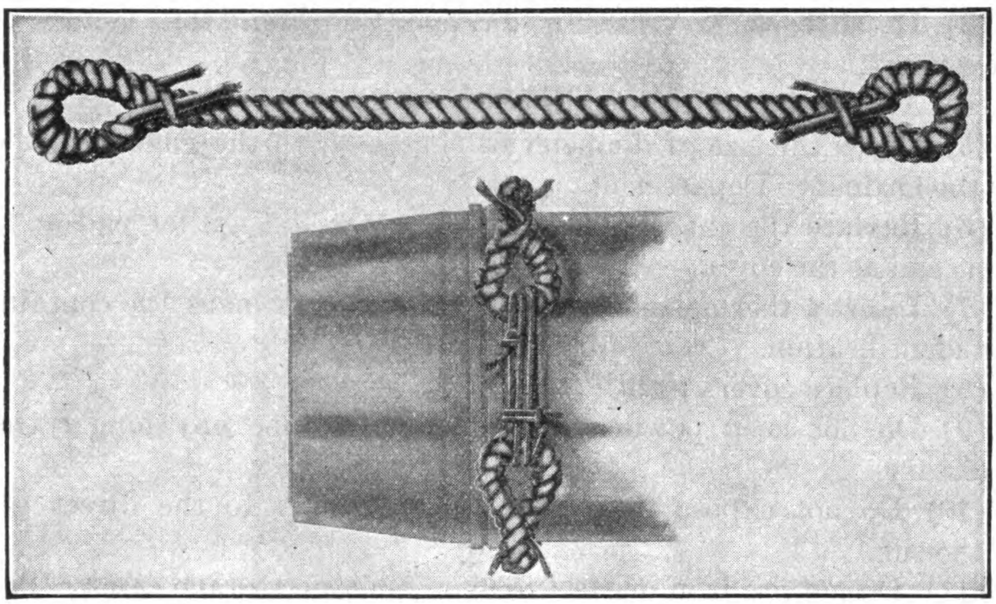


FIGURE 26.—Rope grommet.

(3) The temperature should remain as near 60° F. as possible. In no case should a magazine be used in which the temperature may exceed 95° F.

(4) Matches and unauthorized lights should not be permitted near a magazine.

(5) Piles of ammunition should be neat and stable, with ample aisle space between for ready inspection.

(6) Piles should not extend above the eaves of the magazine.

Q. May propelling charges, primers and fuzes, and loaded projectiles be stored together? *A.* No. Each of the three classes of components should be stored in separate magazines.

Q. How are the magazines of the (candidate's) battery ventilated? *A.* ———.

12. Preparation of powder charges.—*Q*. What is the most important information about a powder charge that the battery commander wants to know before a firing? *A*. The muzzle velocity it will develop when the temperature is normal or 70° F.

Q. How can the weight of a charge be determined? *A*. By removing it from the storage case and weighing it.

Q. How accurately should the weight of a charge be determined? *A*. To the nearest ounce.

Q. State the rules to be followed in preparing charges for target practice. *A*.

(1) Weigh the powder in a sheltered place near the magazine.

(2) Remove the powder tag, primer protector cap, and extra increments from the charge and container.

(3) If charges are loosely wrapped, tighten the lacings or wrappings.

(4) Attach the igniter pad in place for firing.

(5) Check the size of diameter of charges with the gage furnished by the Ordnance Department.

(6) Replace the charges in containers with the igniter pad at the same end as the cover.

(7) Insert a thermometer in one container and mark the container for identification.

(8) Replace covers tightly.

(9) Do not keep powder out of the magazine any longer than necessary.

(10) Do not expose the powder or container to the direct rays of the sun.

(11) Do not use iron or steel tools in opening storage cases. They may cause sparks.

(12) Do not open the containers again until the powder is used.

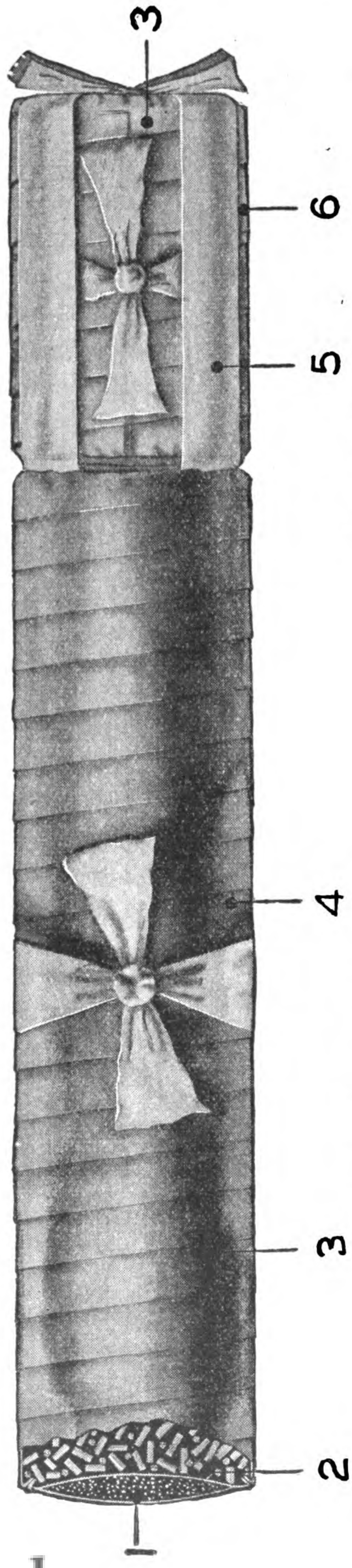
Q. On what does the temperature of the powder depend? *A*. On the temperature of the air in the place of storage and the length of time the powder has been stored in that place.

Q. How may the temperature of the powder be obtained? *A*. From a thermometer placed in a powder container, or in the magazine.

Q. How long must powder be stored in a magazine or other storage place in order to insure that the temperature reading is accurate enough to use? *A*. From 1 day to 2 weeks, depending on the size of the powder charge.

Q. Of what material are the powder bags made? *A*. Of raw silk or other material that burns completely without leaving smoldering pieces.

Q. What is the purpose of the igniter charge? *A*. To distribute



1. Igniter (black powder).
2. Smokeless powder.
3. Spiral wrapping.
4. Base section.
5. Tying straps.
6. Increment section.

FIGURE 27.—155-mm gun propelling charge (base and increment type).

the flame from the primer and start the propelling charge burning properly.

Q. What kind of powder is put in the igniter charge? *A*. Black powder.

Q. Where is the igniter charge placed on the propelling charge? *A*. Usually it is in the form of a pad that is sewed to one end of the charge, or provided with taps with which it may be tied in that place.

Q. What precautions should be taken when placing the propelling charge in the piece to insure against misfires? *A*. The propelling charge should be placed in the powder chamber in such a manner that the mushroom head of the breechblock will be in contact with the igniter charge when the breechblock is closed.

Q. What is a powder tag? *A*. A linen tag attached to the powder bag.

Q. What information does the powder tag give? *A*.

(1) Name of the loading plant.

(2) Date of loading (day, month, and year).

(3) Caliber and model of gun, mortar, or howitzer.

(4) Weight of projectile.

(5) Powder lot number.

(6) Name of manufacturer or powder.

(7) Weight of charge, weight of igniter, and velocity and pressure for each particular weight of projectile or for each increment of powder.

13. Filling, fuzing, and preparing projectiles for firing.—*Q*. How may projectiles used for target practice be brought up to weight? *A*. By filling with wet sand.

Q. What filler is used in armor-piercing projectiles? *A*. Explosive D.

Q. Is it sensitive to shock? *A*. No.

Q. Why do base plugs and base fuzes have left-handed threads? *A*. So that they will tend to tighten rather than to unscrew when the projectile rotates.

Q. What kind of fuzes are used at the (candidate's) battery? *A*. ———

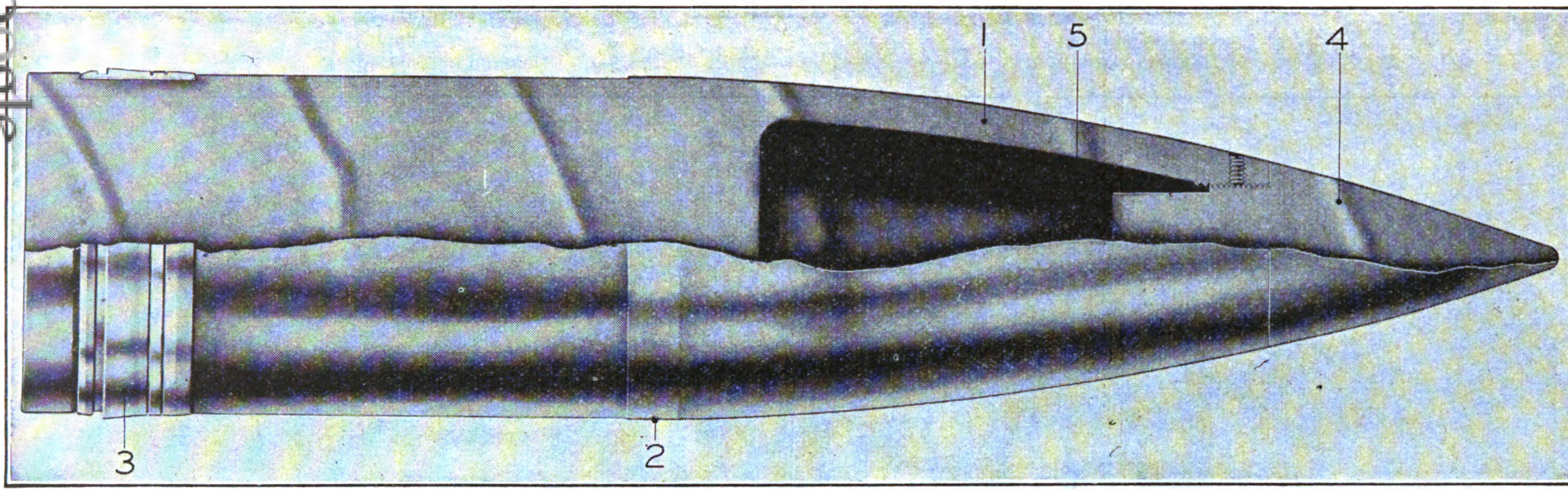
Q. May fuzes be taken apart by battery personnel? *A*. No.

Q. How are the fuze hole threads in a projectile cleaned? *A*. By the use of a stick wrapped with cloth.

Q. When an attempt is made to insert a fuze and it binds, what is done? *A*. The fuze is removed and the cause of binding determined.

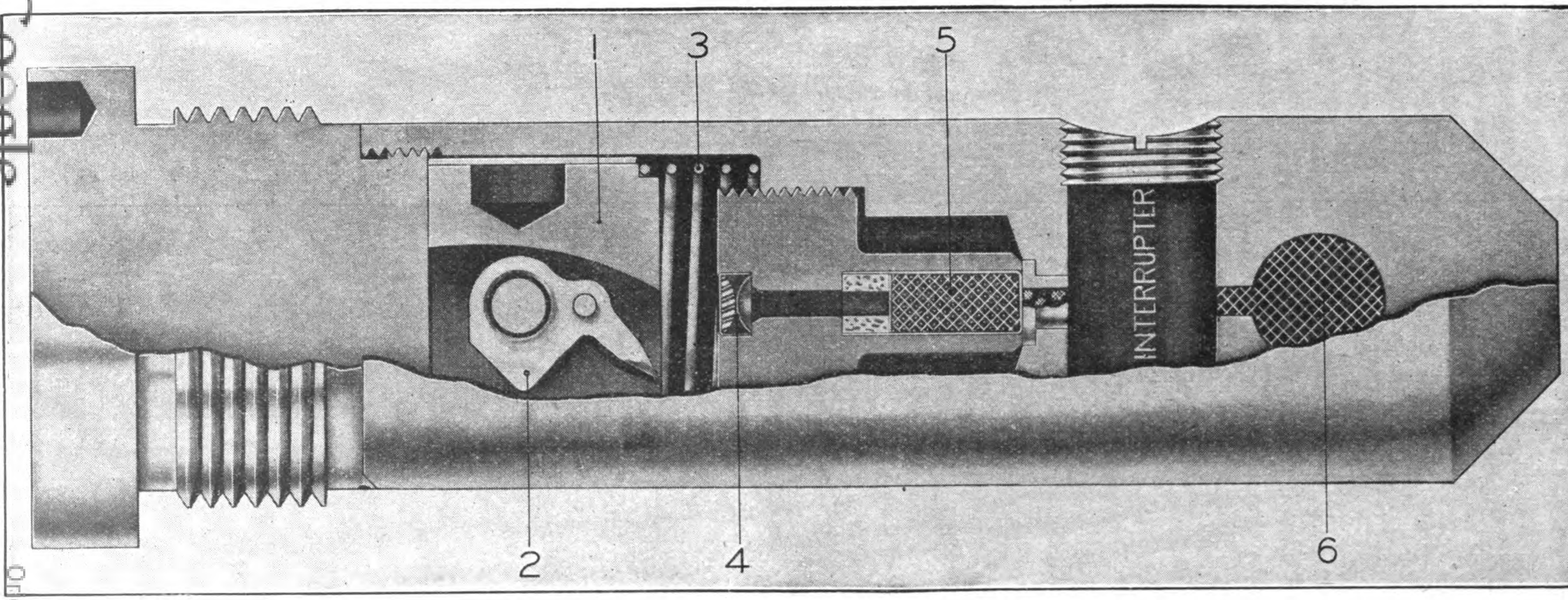
Q. How are fuzes issued to the service? *A*. In hermetically sealed (airtight) boxes.

Q. Should a box containing fuzes be opened before they are immediately needed? *A*. No.



1. Cast iron body.
2. Bourrelet.
3. Rotating band.
4. Nose plug.
5. Empty cavity.

FIGURE 28.—Target-practice projectile.



1. Percussion plunger.
2. Firing pin.
3. Restraining spring.

6. Booster charge.
4. Percussion primer.
5. Detonator.

FIGURE 29.—Base detonating fuze, Mk. V (medium caliber).

Q. Before a base cover is attached, what must be done to all wrench and other holes in the fuze and base plug? *A*. They should be filled with lead plugs.

Q. How are the lead plugs inserted? *A*. Insert, then strike or flatten out with a hammer, in order to seat the filling plug.

Q. What is meant by arming a fuze? *A*. A fuze is said to be armed when it is ready to fire, that is, when the safety devices have functioned and all parts are in or free to move to their proper positions at the proper time for the fuze to function.

Q. Of what does the base cover consist? *A*. Copper cover, lead disk, and lead calking wire.

Q. What is the purpose of the base cover? *A*. To keep the gases of the propelling charge from entering the projectile cavity through possible defects in the base.

Q. How is the base cover attached? *A*. Lay the copper cover, with the lead disk in place, over the base of the projectile, the turned-up edge of copper cover entering the undercut groove in the base of the projectile. Bend a strip of lead wire into a circle, place in groove, and flatten out.

Q. How should projectiles be prepared for target practice? *A*.

(1) Bring the projectiles up to the same weight and report the weight to the executive officer.

(2) Replace plugs and fuzes securely.

(3) Clean the projectiles, especially at the bourrelet and rotating band.

(4) Examine rotating bands for burring and looseness.

(5) Examine the design of projectiles carefully to determine whether or not they are all of the same lot. Frequently a small change in the design of the rotating band or tail changes greatly the ballistic efficiency of a projectile.

(6) If different lots are found, separate the lots and report the findings to the executive officer.

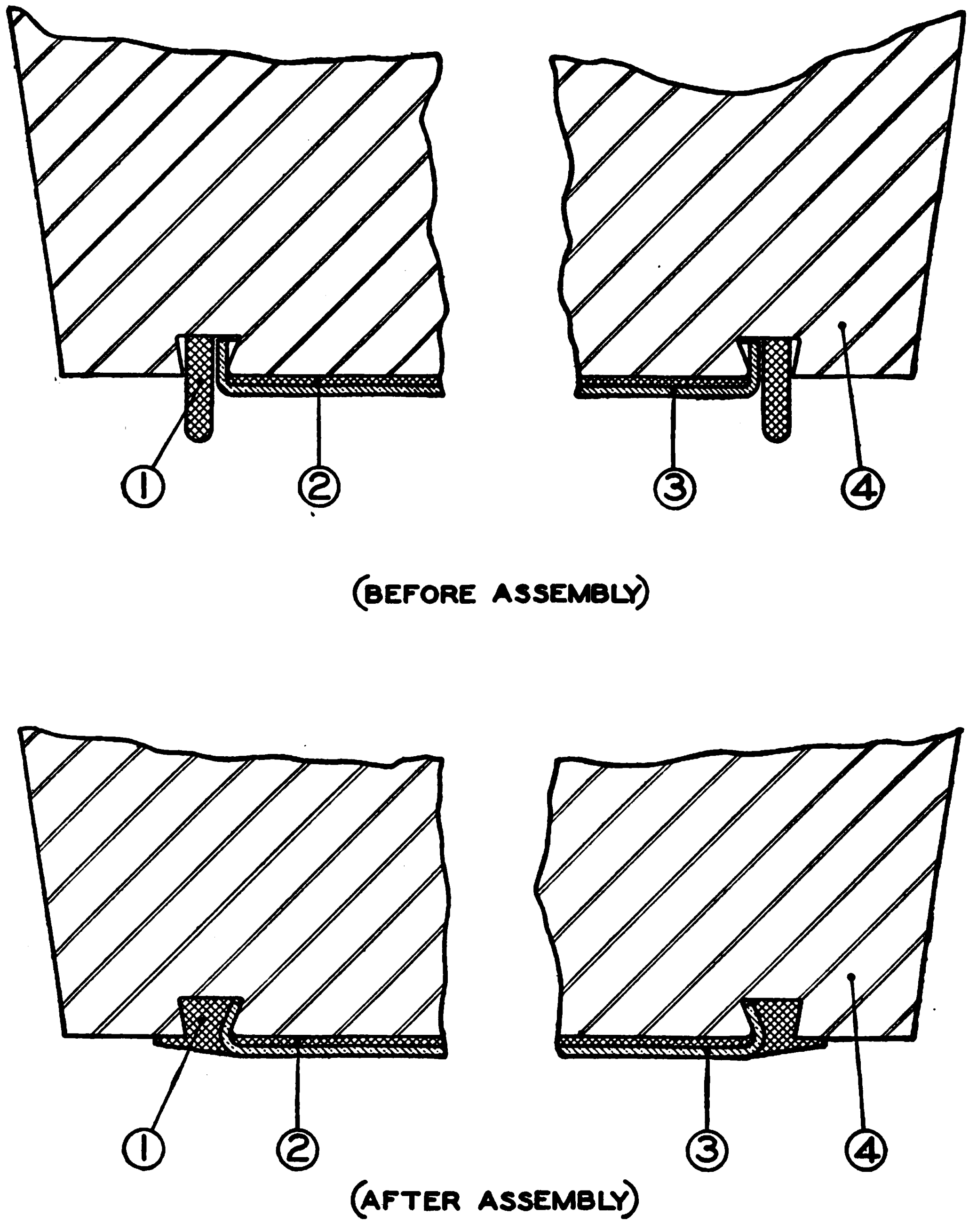
14. Painting projectiles.—*Q*. What indicates whether or not a projectile is filled or fuzed? *A*. Appropriate basic paint indicates that it is filled. Black longitudinal stripes from the rotating band to the base, 90° apart, indicate that it is not fuzed.

Q. What should be done to projectiles before painting them? *A*. Clean them thoroughly, removing all rust and grease.

Q. What parts are not painted? *A*. Rotating bands and bourrelet.

Q. What color are target-practice projectiles painted? How are they marked? *A*. Black. Stenciled "Target practice".

Q. What do the basic colors on the projectiles indicate? *A*. The type of explosive filler: Yellow, high explosive; red, shrapnel; gray, chemical.

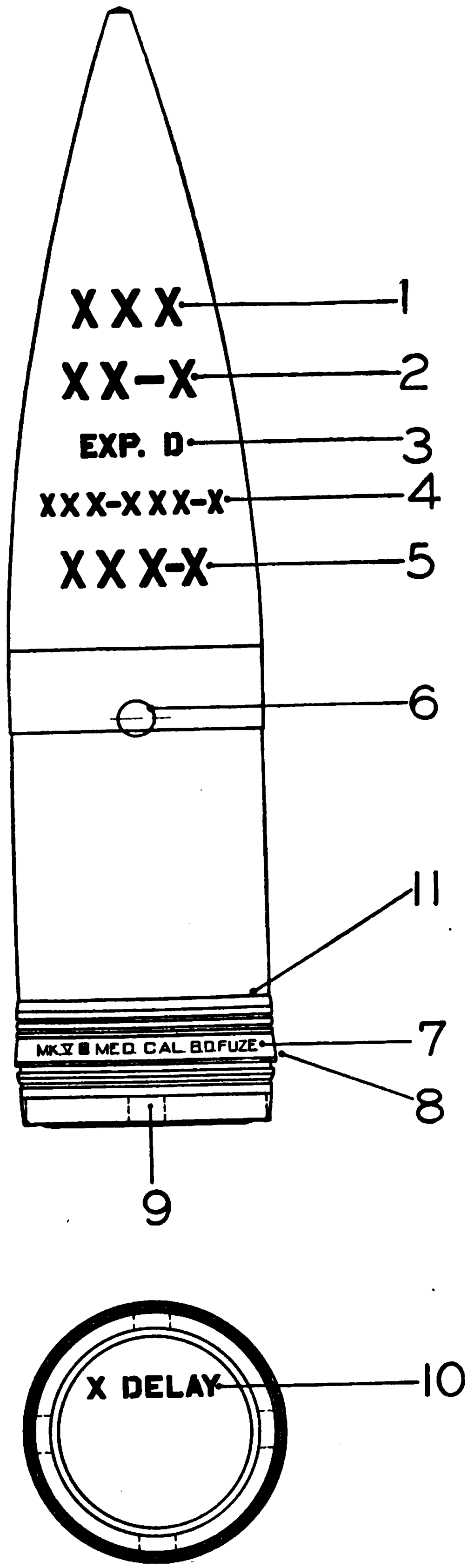


1. Lead calking wire.
2. Lead disk.
3. Copper cup.
4. Base of projectile.

FIGURE 30.—Base cover.

Q. What additional information or marks are found on projectiles? *A.*

(1) Weight zone marks.
(2) Weight of loaded and fuzed (or unfuzed) shell in pounds.
(3) Caliber and type of cannon.
(4) Filler. Initials indicate the type of explosive.
(5) Lot number of filled shell.



1. Weight of loaded and fuzed projectile (in pounds).
2. Caliber and type of cannon as, 10G, 12G, 12M, 14G, 16G, and 16H.
3. Explosive filler—EXP. D. (Initials indicate kind of explosive.)
4. Lot number of filled projectile.
5. Mk. number of projectile.
6. Location of center of gravity of loaded and fuzed projectile. (On armor-piercing projectiles and on target-practice projectiles the type and Mk. number—e. g., Armor-piercing Projectile, Mk. XVI or Target-practice C. I. Projectile, Mk. VII—are stenciled at the center of gravity.)
7. Mk. number, type, and caliber of fuze applicable, to be followed when fuze is assembled and projectile is not to be immediately fired, by lot number of fuze.
8. The ammunition lot number of filled and fuzed projectile to be stamped on band opposite fuze marking.
9. Four black stripes, 2 inches wide, indicate that the fuze has not been assembled, and the amount of delay of fuze stenciled on base cover.
10. When the fuze has been assembled and projectile is not to be fired immediately, the four stripes mentioned in 9 are painted out, and there is stenciled on the base cover (as shown at 10) the amount of delay action of the assembled fuze, as non-delay, short delay, long delay, or equivalent initials. In addition, there is stamped on base of projectile outside of base cover: Caliber and type of gun, Mk. number and type of projectile, weight of filled projectile, initials or symbol of machining plant, and inspection stamps.
11. Caliber and type of cannon, Mk. number of projectile, lot number of unfilled projectile, initials or symbol of machining plant, and inspection stamp (stamped on projectile, under paint).

NOTE.—For high-explosive, common steel, point-fuzed shell for 10-inch, 12-inch, 14-inch, and 16-inch cannon omit 7, 8, 9, and 10.

FIGURE 31.—Marking of projectiles for 10-inch, 12-inch, 14-inch, and 16-inch cannon.

(6) Mk. number of shell.

(7) Caliber and type of cannon, Mk. number of shell, initials or symbol of machining plant, and inspection stamps (stamped on shell under paint).

Section II

ADVANCED

15. Procuring, handling, and storage of ammunition.—*Q*. What regulations govern the handling of ammunition? *A*. TM 9-2900 and AR 30–1270, 30–955, and 700–10, and such local regulations as may be prescribed; for example, many localities require a special placard or flag to be displayed.

Q. Where may detailed regulations prescribing rules governing the transportation of explosives be obtained? *A*. From the Interstate Commerce Commission through The Quartermaster General or the Chief of Ordnance. These regulations permit the Government to prescribe its own shipping regulations, marking, packing, and storing, but the War Department regulations comply in general with the Interstate Commerce Commission regulations.

Q. How are the necessary labels obtained? *A*. On requisition through The Quartermaster General.

Q. What responsibilities must the shipping officer assume? *A*. That all regulations are complied with. In case of fire or accident, the shipping officer is responsible.

Q. May explosives be carried as a deck load on Army transports? *A*. No.

Q. When transporting explosives by truck, what procedure shall be followed? *A*.

(1) Comply with Government and local regulations.

(2) Contact local authorities and select safe routes.

(3) Take every precaution against fire.

Q. What precautions must be taken against fire? *A*.

(1) Inspect trucks daily, particularly for wiring, lights, brakes, gasoline tanks, and gasoline lines.

(2) Keep vehicle and engine clean.

(3) Permit no smoking.

(4) Keep safety matches in a metal container in tool box.

(5) Provide each truck with a sand box—3 cubic feet—and a shovel.

(6) Instruct all drivers in fire fighting. Ammunition requires considerable heat before it will explode, and a fire, if discovered in time, can usually be put out with safety.

(7) Do not transport detonating agents with other explosives.

(8) Lay boards over all iron parts of the truck.

(9) See that load is well braced and stayed and is covered with a tarpaulin to prevent fire by sparks.

Q. When ammunition is being transported by convoy, what precautions should be taken? *A*.

(1) Keep a safe distance between trucks to avoid danger of collision.

(2) Stop once each hour and inspect the load.

(3) Do not stop in populous areas.

(4) Permit no unauthorized riders.

(5) If a truck breaks down, transfer its load to another truck. Do not attempt to tow. Leave a guard with the truck until the load can be transferred.

(6) In case of fire, move all other vehicles to a safe distance and post a guard at a safe distance from the fire to ward off other traffic.

Q. How is artillery ammunition packed in a truck for transportation? *A*. It is laid on its side parallel to the sides of the truck. If more than one layer is to be placed in the truck, strips of planking should be laid to protect the rotating bands.

Q. Under whose supervision should ammunition be handled? *A*. Under a competent person who understands thoroughly the hazards and risks involved.

Q. Name some hazardous explosives. *A*. Detonators, bulk explosives, and smokeless powder.

Q. In case explosives are spilled from a container, what should be done? *A*. All work must be stopped until the explosives have been swept up and the area has been neutralized.

Q. Where may damaged containers be repaired? *A*. In the open, or in a building especially designated for this purpose, at least 100 feet from the magazine, boat, or truck containing ammunition.

Q. If ammunition must be stored outside, what must be done? *A*. It must be covered to protect it from the direct rays of the sun. However, air must circulate freely through the pile.

Q. What ammunition may be stored in a battery storeroom? *A*. The small quantity of small-arms ammunition required for current use.

Q. Where may small-arms ammunition be stored *A*. In any magazine or warehouse which offers good protection from the weather.

Q. Where must all other ammunition be stored? *A*. In special magazines such as described in Technical Manuals.

Q. How is ammunition segregated in storage? *A*. Ammunition is placed in neat, stable piles by lot number, and raised off the floor on 2-inch battens.

Q. How high may ammunition be piled? *A*. This depends on the strength of the container, but piles should not exceed the height of the eaves in magazines.

Q. What does an acid odor in a powder magazine indicate? *A*. Danger—powder is decomposing.

Q. What testing instruments are placed in powder and ammunition magazines? *A*.

(1) Maximum and minimum thermometer.

(2) Hygrometer.

(3) Litmus paper.

Q. How is air circulation provided in ammunition storage? *A*. By dunnage or by cleats on the boxes.

Q. In case of doubt of the condition of ammunition in storage, who is notified? *A*. The local ordnance officer.

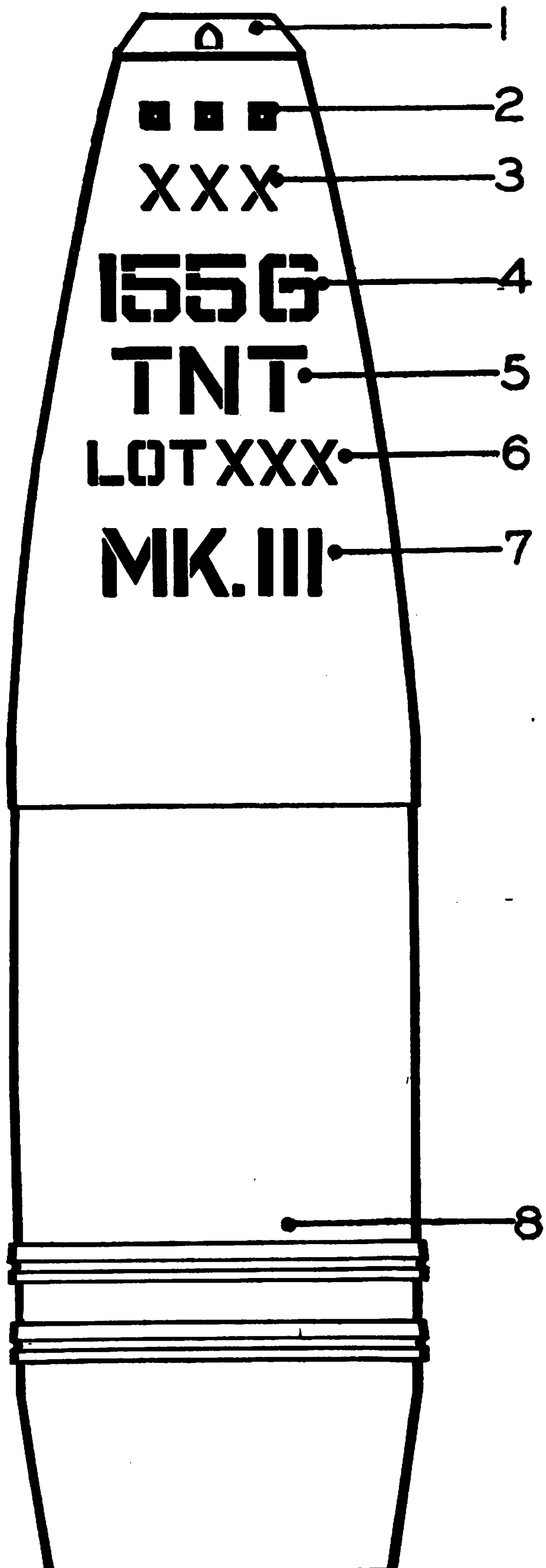
Q. How are allocations of ammunition obtained under field service conditions? *A*. The munitions officer prepares a daily ammunition expenditure report which is sent to the regiment or next higher commander. In each higher headquarters the reports are consolidated. The corps commander sends in his consolidated report to the Army. Based on these reports, the Army allocates ammunition to the corps, and so on down until the battalion is informed of how much ammunition it will get and when and where to go for it.

Q. How are seacoast artillery projectiles marked? *A*. Every round is marked, by painting, stenciling, or stamping, so that certain essential information will be available to permit intelligent handling, storage, and issue. This information covers the type of ammunition, loading, lot numbers of components and complete rounds, gun for which the round is intended, muzzle velocity, etc. (Figure 32 shows these markings applied to a 155-mm gun projectile.)

Q. Should the components of separate loading ammunition be transported together? *A*. Fuzes or detonating agents should not be carried with propelling charges.

Q. Where should ammunition dumps be located and how should ammunition be stored in them? *A*. The dump should be located on good roads, somewhat removed from congested highways, and should provide circulation and turn-around space for the trucks. Woods will give protection from aerial observation, but camouflage methods must be employed for protection in any event. The intervals between piles of ammunition should be ample to prevent destruction of the entire dump by explosion of a single projectile.

16. Records, reports, and forms.—*Q*. How is ammunition obtained in peacetime? *A*. Requisitions are submitted through the regimental munitions officer who submits a consolidated requisition on the post ordnance officer. When the requisition has been approved,



1. Adapter may or may not be painted.
2. Weight zone marks (▣▣, ▣▣▣, ▣▣▣▣, ▣▣▣▣▣, ▣▣▣▣▣▣).
3. Mean or normal weight of shell (unfuzed) in pounds.
4. Caliber and type of cannon (G for gun; H for howitzer; GH is the authorized marking for shell interchangeable in gun or howitzer.
5. Filler. Initials indicate kind of explosive. (May be as shown or AM 50–50 or AM 80–20, for amatol loaded shell.)
6. Lot number of filled shell.
7. Mk. number of shell.
8. Caliber and type of cannon, Mk. number of shell, initials or symbol of machining plant, and inspection stamps (stamped on shell under paint).

NOTE.—All stenciling is with black paint.

FIGURE 32.—Marking for high-explosive shell for 155-mm gun.

the battalion munitions officer makes the necessary arrangements to draw the ammunition and deliver it to the batteries.

Q. What record of issue is sent to the regimental munitions officer? *A*. A shipping ticket.

Q. What check must he make? *A*. He checks it for quantity as listed and for condition.

Q. If the shipment does not agree with the shipping ticket, what does he do? *A*. He submits an O. S. and D. report, W. D., Q. M. C. Form No. 445 (Over, Short, and Damaged Report).

Q. What receipts does the regimental munitions officer obtain on issuing ammunition? *A*. When the battalion munitions officer distributes it, he has each battery commander sign a memorandum receipt, and returns the receipt to the regimental munitions officer. Sometimes the regimental munitions officer issues ammunition direct to the batteries and takes their receipts.

Q. How does the firing battery commander secure credit for ammunition he has fired? *A*. He submits a certificate of expenditure and is given credit for the amounts shown thereon, by the regimental munitions officer.

Q. What is the system of ammunition supply in the field during war? *A*. Daily reports of ammunition expenditure are forwarded by the battalion munitions officer. This shows how much ammunition is left in the unit and indicates its rate of expenditure. Based on these reports, allocation of ammunition is made to the battalion, which then draws it. Sometimes ammunition credits are issued for ammunition at a certain point, which can be drawn against as needed.

Q. What further records are necessary? *A*. Receipts for the ammunition must be signed as drawn, but no further accountability is required. As ammunition is such a vital need, the responsibility for its care and preservation is assumed by all concerned in handling it.

Q. What duties relative to ammunition records must a chief of section of an ammunition train perform in the field? *A*.

(1) He may be required to draw and sign for the ammunition at the distributing point.

(2) He must obtain a receipt for that issued to the batteries, and return same to the munitions officer.

Q. What other duties has the chief of section in this connection? *A*.

(1) He must keep himself informed of available ammunition at the distributing point.

(2) He must act as liaison agent between the battalion munitions officer and the firing batteries, keeping the former informed of

ammunition on hand, rate of expenditure, care, and preservation, and furnishing any additional data he may require.

Q. What should be done in the way of checking? *A*. One should be sure to count and inspect what he signs for. When complete rounds of separate loading ammunition are called for, he should check for each component of the round.

Q. What else should be watched in checking ammunition? *A*. See that it is all loaded. Know how many rounds to put on a truck and how to load the truck. See that it is the kind called for.

CHAPTER 7

GUNNERY

SECTION I

ELEMENTARY GUNNERY

17. Firing tables.—*Q*. What are firing tables? *A*. Books which give information used in preparing firing data for cannon. There is a different book for each type of cannon.

Q. What is meant by standard conditions? *A*. In computing the elements of the trajectory as listed in table A, part 2, Firing Tables, certain assumptions must be made. Some of these are—

(1) There is no wind.

(2) The temperature of the air is 59° F. at the muzzle of the gun and varies regularly with the altitude in a particular manner.

(3) The density of the air is that corresponding to the temperature at 59° F., a barometer reading of 29.528 inches, and a humidity of 78 percent, and the density varies regularly with the altitude according to certain fixed laws.

(4) The temperature of the powder is 70° F., and that the powder will give the normal muzzle velocity at that temperature.

(5) The target is at the same level as the gun.

(6) The earth is not rotating.

Q. Will these assumptions be true for any particular firing? *A*. Some or all of these assumptions will not be true for any particular firing.

Q. What provision is made in firing tables to meet this situation? *A*. Tables in part 2 of firing tables give corrections to be applied when conditions are not standard.

NOTE.—The introduction portion of the firing tables will be of material benefit when using the tables and should be consulted freely.

18. Charts and scales for fire-control instruments.—*Q*. Why are firing tables not consulted during seacoast artillery firing? *A*. Because the data from these firing tables have been made up in a more convenient form for use in the battery. Charts and scales for such instruments as range correction boards and deflection boards are based on values taken from the firing tables. When it is suspected that these scales or charts are inaccurate due to shrinkage or some mistake in making or mounting them, they can be checked against the values in the firing tables. Range or elevation scales at the guns may also be checked against the values given in the firing tables. However, a special range-elevation relation is usually recorded in the emplacement book for a fixed battery and it is more convenient to use it than to use the firing tables.

19. Corrections for variations in range.—*Q*. What position corrections are made for variation in range? *A*.

Correction for—	Effect on range	Nature of correction to range	Usual method of correction
Motion of earth (long-range fire):			
Firing east of north-south line.	Decrease	Plus	Range correction board.
Firing west of north-south line.	Increase	Minus	
Height of site (mobile batteries):			
Gun above target	Increase	Minus	Range correction board.
Gun below target	Decrease	Plus	
Height of tide (fixed batteries):			
Tide above mean low water	Decrease	Plus	Range correction board.
Tide below mean low water	Increase	Minus	

Q. What matériel corrections are made for variations in range? *A.*

Correction for—	Effect on range	Nature of correction to range	Usual method of correction
Muzzle velocity:			
Above standard	Increase	Minus	Range correction board.
Below standard	Decrease	Plus	
Weight of projectile, effect on range:			
Above standard	Decrease for short range, increase for long range.	Plus Minus	Range correction board.
Below standard	Increase for short range, decrease for long range.	Minus Plus	

Q. What corrections are made for variations in range due to nonstandard weather conditions? *A.*

Correction for—	Effect on range	Nature of correction to range	Usual method of correction
Wind:			Determined on wind component indicator and applied on range correction board.
Head wind	Decrease	Plus	
Tail wind	Increase	Minus	
Density of atmosphere:			
Above standard	Decrease	Plus	Range correction board.
Below standard	Increase	Minus	
Temperature of air:			
Above standard	Increase[1]	Minus	Range correction board.
Below standard	Decrease[1]	Plus	
Temperature of powder:			
Above standard	Increase	Minus	Converted to correction for muzzle velocity by range officer and applied through range correction board.
Below standard	Decrease	Plus	

[1] For some guns this changes at the longer ranges. (Examination should be made of the firing table for the gun to which the battery is assigned to determine whether "elasticity" curves on the range correction board cross.)

20. Corrections for variations in direction.—*Q*. What direction corrections are made? *A*.

Correction for—	Effect on direction	Nature of correction to direction	Usual method of correction
Cross wind:			
Wind from right	Left	Right	Deflection board.
Wind from left	Right	Left	
Drift	Right [1]	Left [1]	Deflection board.

[1] The 37-mm subcaliber gun is an exception to this rule.

Q. Should the actual range as read from the plotting board, or the corrected range corresponding to the elevation for firing, be used on the deflection board in working out the direction correction? *A*. The corrected range should be used in finding the direction corrections. This is usually furnished to the deflection board operator in the form of the range drum or elevation scale setting taken from the percentage corrector.

21. Meteorological message.—*Q*. What is a meteorological message? *A*. A statement in code form, containing groups of figures, of data as to atmospheric conditions sent out from the meteorological station. Column (1), below, is a sample meteorological message, and column (2) is the translation of the message.

(1)	(2)				
MFS MFS 30570	Meteorological message from station FS for low-angle fire. Altitude of m. d. p., 500 feet. Temperature at m. d. p. 70° F.				
	Altitude zone	Upper limit of altitude zone in feet	Direction of ballistic wind in mils from north	Speed of ballistic wind in mph	Density in percent of normal
0411298	0	0	4, 100	12	98
1401298	1	600	4, 000	12	98
2461498	2	1, 500	4, 600	14	98
3471498	3	3, 000	.4, 700	14	98
4501699	4	4, 500	5, 000	16	99
5531799	5	6, 000	5, 300	17	99
6561699	6	9, 000	5, 600	16	99

Q. Is this message intended for use by mortars? *A*. No. The figure 3 in the first group means that the message is for low-angle fire, that is, fire below about 45° elevation. A message for high-angle fire, such as mortar fire, and for antiaircraft artillery would have 2 as its first figure.

Q. What is the meaning of MFS in the message given? *A*. Meteorological message from station FS.

Q. Explain the first group of five digits. *A*. The first digit is 3 and means that this message is suitable for use by artillery having low-angle fire, that is, firing at angles less than about 45°. The next two digits are 05, and means that the meteorological station FS is 500 feet above mean low water. The elevation of the station, in this case 500 feet, is called the mean datum plane (m. d. p.) of the station. The last two digits are 70 and mean that the temperature at the station FS, or at the m. d. p., is 70° F.

Q. What do the groups of seven digits mean? *A*. The ballistic winds and densities for the maximum ordinates corresponding to the altitude of the zones indicated by the first digit of the group.

Q. Explain the group whose first digit is number 2. *A*. The digit 2 indicates that the data in this group are for altitude zone 2, which extends to an altitude of 1,500 feet above the mean datum plane. The digits 46 mean that the ballistic wind is blowing from the direction 4,600 mils from north. The digits 14 mean that the ballistic wind is blowing at 14 miles an hour. The digits 98 means that the ballistic density is 98 percent of normal.

Q. What is meant by ballistic wind and density? *A*. The actual wind speed and direction are measured for the several layers of atmosphere included in the zone represented by the first digit of the seven-digit group, and an average constant wind is computed from the different zone data. These fictitious values would have the same effect as the different actual values of wind on a projectile traveling through the zone. Ballistic density is a fictitious density having the same effect as the several actual densities and is obtained from a set of tables.

Q. What parts of this message are used in the plotting room? *A*. The group of five digits, and the group of seven digits the altitude for which is nearest to but not less than the maximum ordinate. For example, if the maximum ordinate for the range at which the battery is firing is 4,600 feet, the seven-digit group of the meteorological message beginning with 5 will be used; if the maximum ordinate is 5,900 feet the same group will be used; if the maximum ordinate is 6,100 feet, the group beginning with 6 will be used.

Q. How is the maximum ordinate determined. *A*. It is given in table A of the firing table opposite each range. If no firing table is available, the value of the maximum ordinate may be taken roughly as four times the time of flight of the projectile squared ($4t^2$).

Q. If the battery position is more than 100 feet higher or lower than the meteorological station, what correction should be made to this data? *A.* No correction of wind data is made. The temperature and density should be corrected to the altitude of the battery using the formulas in the firing tables. These formulas are—

$\frac{1}{5}°$ F.=decrease in temperature for each 100 feet increase in altitude.

$\frac{1}{5}°$ F.=increase in temperature for each 100 feet decrease in altitude.

0.3 percent=decrease in air density for each 100 feet increase in altitude.

0.3 percent=increase in air density for each 100 feet decrease in altitude.

In using these formulas, the difference in altitude between the battery and the meteorological station is taken to the nearest 100 feet.

Q. The first line of the meteorological message is 30365; the battery is 140 feet above sea level. What temperature of the air should be used? *A.* The increase in temperature of the air given by the formula is $1/5° \times (3-1) = 2/5°$. Since this is less than $\frac{1}{2}°$ it is disregarded.

Q. The following is part of a meteorological message:

30671	2371302
0341202	3381501
1361302	4381501

The battery is 360 feet above sea level. The maximum ordinate is 2,560 feet. What density should be used? *A.* Meteorological data for the third zone should be used. The formula 0.3 percent $\times$ $(6-4)$ = 0.6 percent increase in density. Since this is more than one-half of 1 percent, increase the density by 1 percent. The density to be used is then $101 + 1 = 102$.

Section II

USE OF FIRING TABLES, CHARTS, AND SCALES

NOTE.—This topic will include the material contained in paragraphs 17 to 21, inclusive, of the preceding section and in addition the material contained in this section.

22. Special charts and scales.—*Q.* What is an operations map? *A.* Normally a Coast and Geodetic Survey chart properly mounted and showing the unit positions and stations, sectors of fire, water areas, and other pertinent data. It is usually combined with the intelligence map.

Q. What is the intelligence map? *A*. A map upon which all available information of the enemy is graphically recorded.

Q. What other map may be used in a command post? *A*. A chart for plotting, showing areas and zones covered by the fire of the armament.

Q. What should be shown on this chart? *A*.

(1) Seaward limit of gun fire.

(2) Water areas and a system of coordinates.

(3) Azimuth circles around the principal observation posts to facilitate location of targets by range and azimuth.

(4) Area of inshore patrols.

(5) Positions of supporting troops.

(6) Areas of enemy activity, with courses if known.

Q. What equipment is used with this chart? *A*. Tracing cloth, a scale of yards and miles arranged to pivot around centers located at the principal observation posts, a protractor, and a series of time-travel scales, for ships at various speeds.

Q. What officer of the staff has supervision of the operations map or battle chart? *A*. The operations officer (S–3).

Q. What is a dead area chart? *A*. One showing areas that cannot be reached by fire due to covering masks. It may be incorporated in the battle chart.

Q. When would it be necessary to show the minimum range of a gun on a chart. *A*. When a gun is emplaced so that there is a mask in front of it that would prohibit firing against targets which could otherwise be engaged.

CHAPTER 8

POSITION-FINDING SYSTEM

23. General.—*Q*. What are the four main steps in the operation of determining firing data for moving targets? *A*.

(1) Tracking the target.

(2) Location of the set-forward point.

(3) Relocation.

(4) Calculation of firing data.

Q. Of what does each step consist? *A*.

(1) Tracking consists of observing and plotting successive positions of the target.

(2) Location of the set-forward point consists of predicting the position at which the target will be when the projectile lands.

(3) Relocation consists of determining the range and direction of the future position of the target from the directing point.

(4) Calculation of firing data consists of converting the relocated data into corrected firing data for use in pointing the guns.

24. Tracking.—*Q*. What are the three standard methods of tracking the target? *A*.

(1) Horizontal base.

(2) Vertical base.

(3) Self-contained base.

Q. How is a target tracked by horizontal base? *A*. Two observation stations are selected and the azimuth and distance from one to the other determined by surveying. The line connecting the two stations is called the base line. The direction and distance of the directing point of the battery from one or both of the stations is also determined. These three points are then located, to a small scale, on a plotting board in the same relation to each other as on the ground. An observer with an azimuth instrument is located in each observation station. Each observer determines the azimuth of the target from his station at the end of equal time intervals and telephones it to the plotting room. Arms on the plotting board, which are pivoted at each of the positions representing the stations, are set to the azimuths received from the observers, and the intersection of the arms represents the position of the target (see fig. 33). Such a position is marked on the board. It is called a "plotted point." Several plotted points will mark out the track or path of the target.

Q. State the factors governing the establishment of a base line. *A.* (1) It should be from one-fourth to one-third as long as the maximum range to be measured by the base line.

(2) It should be nearly at right angles to a line drawn from the battery through the center of the field of fire to be covered by the base line.

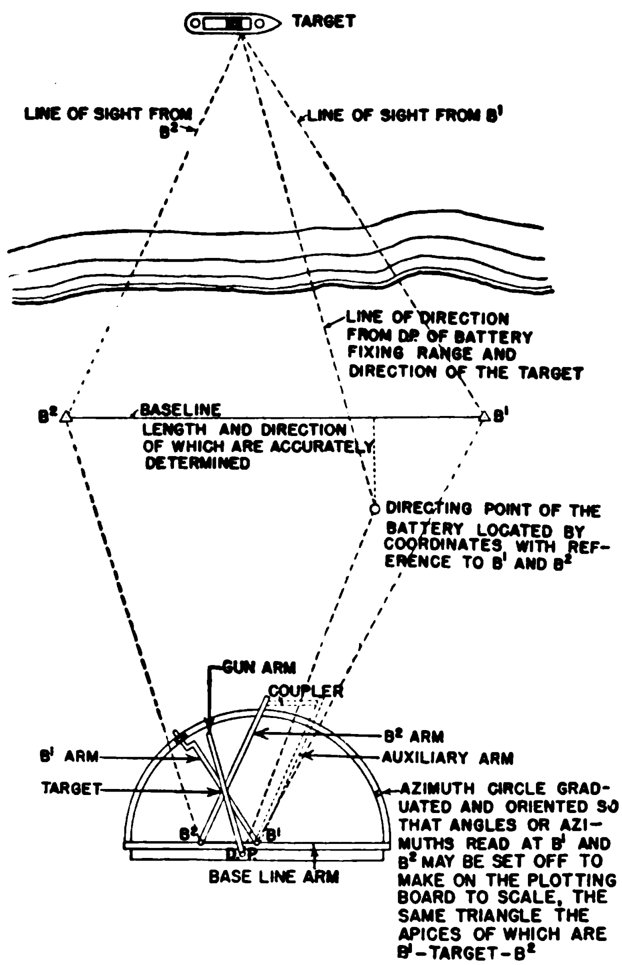


FIGURE 33.—Principles of horizontal base position finding.

(3) The base-end stations should be so located that the observer will have an unobstructed view to seaward and high enough to allow observation beyond the maximum range to be measured by the base line.

(4) The length and direction of the base line and the position of the directing point should be accurately determined.

Q. How is the target tracked by vertical base? *A.* Only one observation station is used. The observer is furnished with a depression position finder with which he can determine the azimuth and range to the target. He telephones these data to the plotting room where the station arm is set in azimuth. The plotted point is then located at the proper range by means of a range scale on the edge of the arm.

Q. Explain briefly the range-finding principles of the depression position finder (D. P. F.). *A*. The D. P. F. solves a vertical right triangle of which one of the legs is the height of the instrument above the target (water level), the other leg is the horizontal distance, or range, to the target, and the hypotenuse is the line of sight. A right triangle may be solved if one leg and one acute angle are known. In this triangle the leg representing the height of instrument is known, and the instrument is used to measure one of the angles. The angle measured is the one at the instrument between the horizontal and the line from the instrument to the waterline of the target. It is called the "depression angle." In measuring the depression angle

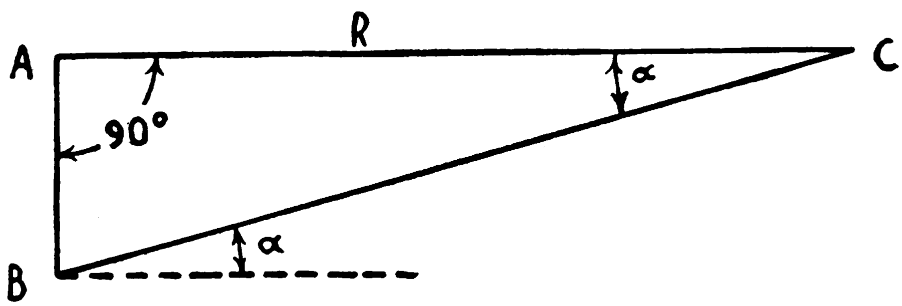


FIGURE 34.—Geometric principles of the self-contained range finder.

the instrument automatically indicates on a range scale the range to the target.

Q. How does the height of the instrument affect the accuracy of range finding? *A*. The greater the height, the greater the accuracy of the ranges read. For a given height, the greater the range, the less the accuracy of the ranges read.

Q. How is the target tracked by self-contained base? *A*. Only one observation station is used, as in the vertical base system. The observer is furnished with a self-contained base range finder with which he can measure the range and, with some types, the azimuth to the target. With the older instruments it is necessary to measure azimuths with a separate instrument. The data are telephoned to the plotting room and the plotted points are located as in the vertical base system.

Q. Explain briefly the range-finding principles of the self-contained horizontal base instrument. *A*. The modern horizontal base self-contained range finder is designed to determine the range to a target by the same geometric principles as those used in the depression position finder. The triangle solved is shown in figure 34. AB is the base line (contained in the instrument), C is the target, and AC is the range R. In the instrument the base line AB and the angle at A are maintained constant. The measured angle a is indicated on a scale which is graduated to read directly in range. There are two types of self-contained instrument, the coincidence type and the stereoscopic type, named from the method used to measure the angle involved. In one the angle is measured by obtaining coincidence between duplicate images of the target; in the other it is measured by obtaining steroscopic contact, that is, plac-

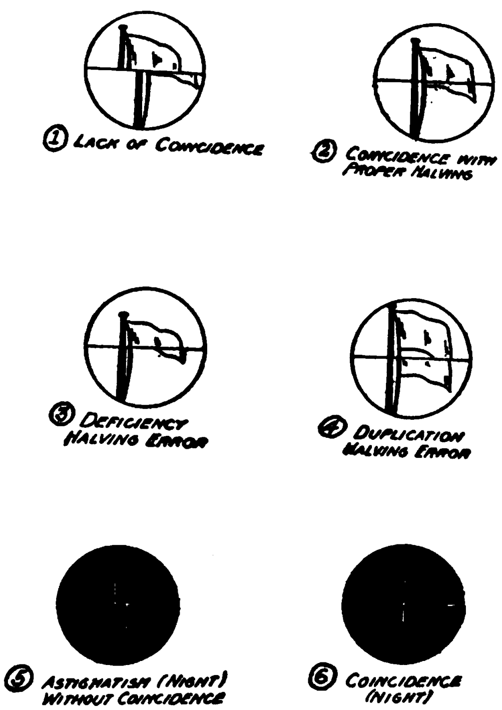


FIGURE 35.—Appearance of target in coincidence range finding.

ing the observed image of the target at the same apparent depth as the markings that are visible on the reticule of the instrument.

25. Prediction.—*Q.* What is a predicted point? *A.* The point at which it is expected that the target will arrive at the end of the dead time.

Q. What is a set-forward point? *A.* A point on the expected course of the target at which it is expected the target will arrive at the end of the predicting interval plus the time of flight. It is the point for which firing data are calculated.

Q. What three things must be known before the set-forward point can be located? *A.*

(1) The expected path of the target.

(2) The length of time from the instant the target was at the last plotted point to the instant of impact.

(3) The rate of travel.

Q. Where is this information obtained? *A*.

(1) The expected path of the target is obtained by extending the plotted path ahead.

(2) The elapsed time consist of the dead time plus the time of flight. The dead time is selected before tracking commences. It is the length of time from the instant the target was at the last plotted point to the instant the gun is fired, and is usually the same as the observing interval. The time of flight is usually obtained from the time of flight corresponding to the range to the last set-forward point.

(3) The rate of travel is obtained by measuring the rate between the last two or three plotted points.

Q. How is this information used to find the set-forward point? *A*. The elapsed time is multiplied by the rate of travel, giving the

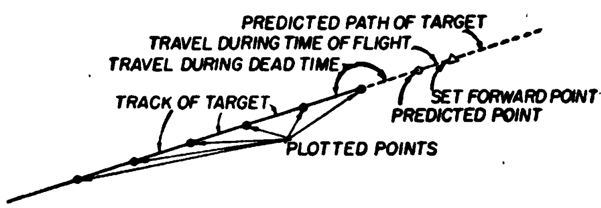


FIGURE 36.—Positions of target.

distance ahead of the last plotted point that the target will be when the projectile lands. This distance is measured off on the expected path of the target, and set-forward point is marked on the plotting board. There are several methods and instruments used to make this prediction.

26. Calculation of firing data.—*Q*. What are the firing data? *A*. The corrected range (or elevation) and the corrected azimuth (or deflection).

Q. How is the corrected range (or elevation) calculated? *A*. The range to the set-forward point is read from the plotting board to the operators of the range correction board and the percentage corrector. The operator of the range correction board makes the range corrections according to the data given him by the range officer and calls off the correction to the percentage corrector operator. The percentage corrector operator applies it to the uncorrected range and telephones the corrected range to the guns, or if necessary, changes the range into an elevation and telephones it to the guns.

Q. How is the corrected azimuth (or deflection) calculated? *A*. The azimuth to the set-forward point is read from the plotting board to the deflection board operator who makes the lateral corrections according to the data given him by the range officer, applies the corrections to the uncorrected azimuth, and telephones the corrected azimuth to the guns. If deflections are being used, the travel of the target is read to the deflection board operator who computes the corrected deflection and telephones it to the guns.

Q. On what does the accuracy of the firing data depend, so far as personnel is concerned? *A*. On the accuracy and skill of each individual operator in adjusting and operating his board and transmitting the data. One inaccurate operation or one mistake in transmission of data by any member of the team may mean the difference between a hit and a miss.

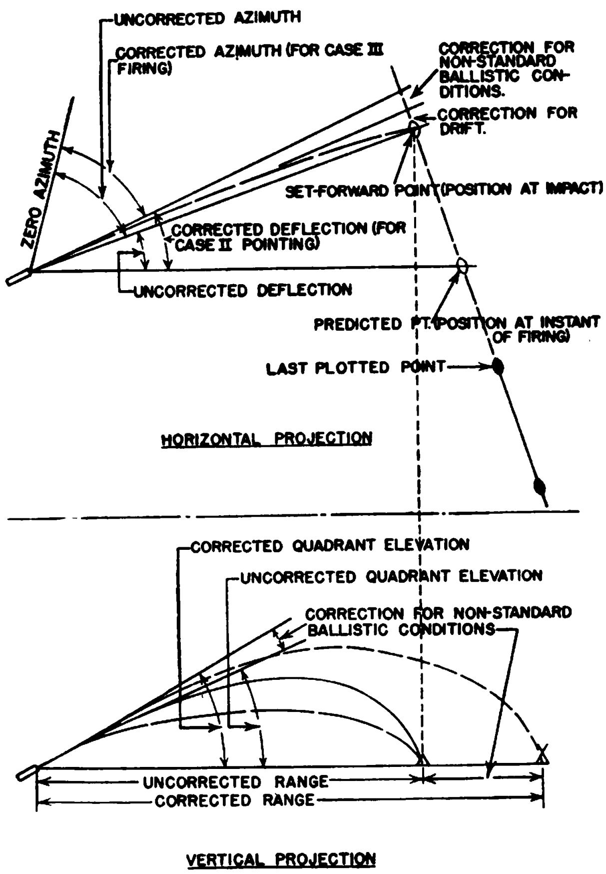


FIGURE 37.—Elements of corrected firing data.

Q. What is the system of position finding ordinarily used in the (candidate's) battery? *A*. ———.

Q. Is there an auxiliary or emergency system in the (candidate's) battery? If so, describe it. *A*. ———.

Q. Will an emergency system be successful without drill? *A*. No.

It is as necessary to drill with an emergency system as it is with the standard system if successful operation is expected.

Q. Trace the range (or elevation) and the azimuth (or deflection) data from the plotting board to the gun, stating the operation performed at each step. *A.* (Description of local method.)

(1) In addition, the candidate should be questioned as to his knowledge of the entire position-finding system in use in the battery, to include the method of spotting. He should also familiarize himself with such emergency systems as are provided for use by his particular battery.

(2) The organization and general duties of the members of the range section of a gun battery are to be found in TM 4-315.

CHAPTER 9

POSITION-FINDING APPARATUS

SECTION I

PLOTTING ROOM APPARATUS

NOTE.—This section contains information on the equipment usually found in the plotting room. The candidate should be required to demonstrate his proficiency in the operation of all of the various boards, instruments, and computing devices used in the plotting room of his battery.

27. Plotting boards, general.—*Q*. What is meant by orienting a plotting board? *A*. Setting up the board so that the parts representing the directing point (or guns) of the battery and the base-end stations will have the same relative positions on the board as they have on the ground, and adjusting the azimuth circle so that it indicates the azimuths of those points from each other, and of points in the field of fire.

Q. What are check points? *A*. Selected points within the field of fire, or points for which data have been computed, used to check the orientation of the plotting board.

Q. How are check points used? *A*. The ranges and azimuths to the check points from each observation station and from the directing point are computed from the coordinates. The station arms are then set at the azimuths computed and the points are plotted on the board.

If the orientation of the board is correct, the measured ranges from the various stations to the check points should agree with the computed ranges, and the measured azimuths from the directing point to the check points should agree with the computed azimuths.

28. Plotting and relocating board M1923 (Cloke).—*Q.* What is the main difference between this type of board and all other types? *A.* On all other types of boards the points representing observation stations and directing point are held fixed and the point representing the target (the intersection of the arms) moves about the board. In other words, the plotted points are target positions. On the plotting and relocating type of board, the point representing the target (the intersection of the arms) is fixed and the observation stations and directing point move about the board. In this case the plotted points are successive positions of the directing point. Since to an observer stationed at the target the apparent movement of the directing point about the target is the same as the actual movement of the target about the directing point, those plotted points may be assumed to represent the course of the target.

Q. As a result of this difference in operation, there are two general rules that must be followed in interpreting the data obtained from the board. What are they? *A.*

(1) In visualizing the relative positions of the various elements and the target as they appear in the field of fire, and in orienting the board, one must place himself at the outer rim of the board and look toward the center. The azimuths of all lines considered, as indicated on the azimuth circle, will be from the outside toward the center.

(2) In visualizing the relative movement of the target about the directing point, and in measuring the azimuth of the course, one must place himself at the center of the board and look outward.

Q. What difference does this make in the procedure for orientation? *A.* During orientation one must set azimuths from points on the plotting surface toward the center. For instance, if the B^2 station is being represented at the center of the board during orientation, the relocating arm must be set at the azimuth from B^1 to B^2 to locate the position of B^1, and at the azimuth from DP to B^2 to locate the position of DP. Furthermore, the platen once oriented must be maintained, during plotting, parallel to its position at orientation. Therefore, the orientation is not complete until the base line stop has been adjusted against the platen to provide a means of keeping it oriented.

Q. What difference is there in the plotting? *A.* There is no difference in the principles of plotting. The plotter treats the plotted points as successive target positions whose movement about the center of the board duplicates the movement of the target about the directing point in the field of fire.

Q. What is the "reading edge" of an arm? *A*. The edge that, if extended, would pass through the center of the board; that is, the point at which the arms are pivoted.

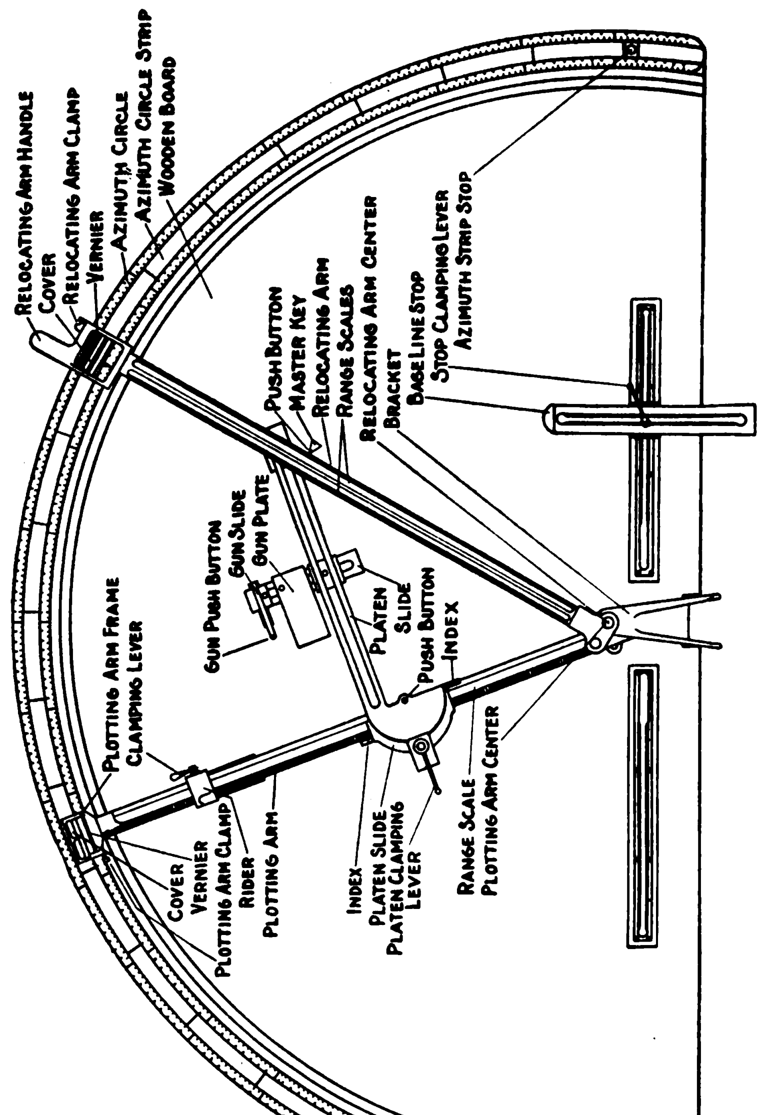


FIGURE 38.—Plotting and relocating board M1923 (Cloke).

Q. What precaution is necessary in placing the arms on their pivot? *A*. Each arm has two holes so that either edge may be used as the reading edge. The arms must be so placed on the pivot that the proper edges will be in position as reading edges.

Q. What is the rule for this? *A*. If the relocating arm is on the right of the plotting arm, the right edges of both arms should be used as the reading edges; if the relocating arm is on the left, the left edges of both arms should be used.

Q. What precaution is necessary in setting azimuths? *A*. Each arm has two azimuth verniers, so that either edge may be set in azimuth. The vernier belonging to the edge that is in position as the reading edge must be used in setting azimuths.

Q. How is the azimuth circle adjusted? *A*. Slide the azimuth circle strips around in the groove until the graduations covered by the board include the field of fire; that is, put the azimuth of the center of the field of fire near the center of the arc. This adjustment can be made for both degrees and mils by placing opposite the longer lines on the azimuth circle those azimuths in degrees that are divisible by nine. Then azimuths may be set in either degrees or mils.

Q. What parts of the board represent the observation stations? *A*. The platen pivot and the master key.

Q. Must a particular part represent a particular observation station? *A*. No. Either observation station may be represented by either the platen pivot or the master key.

Q. What is the general rule? Why? *A*. The general rule is to put that station which is farthest from the directing point, usually B^1, at the platen pivot. This is to avoid mechanical interference on the board in setting up the position of the directing point.

Q. What part of the board represents the D. P.? *A*. The gun push button.

Q. What is the ordinary method of orientation? *A*. By means of the azimuth and the length of the base line, with the platen pivot (representing one of the stations) at the center of the board.

Q. How is the platen oriented by the ordinary method? *A*.

(1) Release the platen clamp and slide the platen along the plotting arm until the slide touches its stop at the inner end of the plotting arm. This position is called the orienting position. Keep the platen in this position throughout the process of orientation.

NOTE.—The azimuth at which the plotting arm is set is immaterial.

(2) Set the relocating arm at the azimuth of the base line and clamp it. According to the general rule, the azimuth set should be that from the station represented by the master key to the station represented by the platen pivot.

(3) Swinging the platen about its pivot and moving the master key along the platen, set the master key on the reading edge of the relocating arm and opposite the length of the base line. Clamp the platen and secure the master key to it in this position.

(4) Bring the base line stop against the edge of the platen and clamp the base line stop.

(5) Set the relocating arm at the azimuth from the D. P. to the station represented by the platen pivot and clamp it.

(6) Moving the gun push button along the platen, set it on the reading edge of the relocating arm and opposite the distance from the D. P. to the station. Secure the gun push to the platen in this position.

Q. What may be done if it is impossible to set the relocating arm at the azimuth necessary for orientation? *A.*

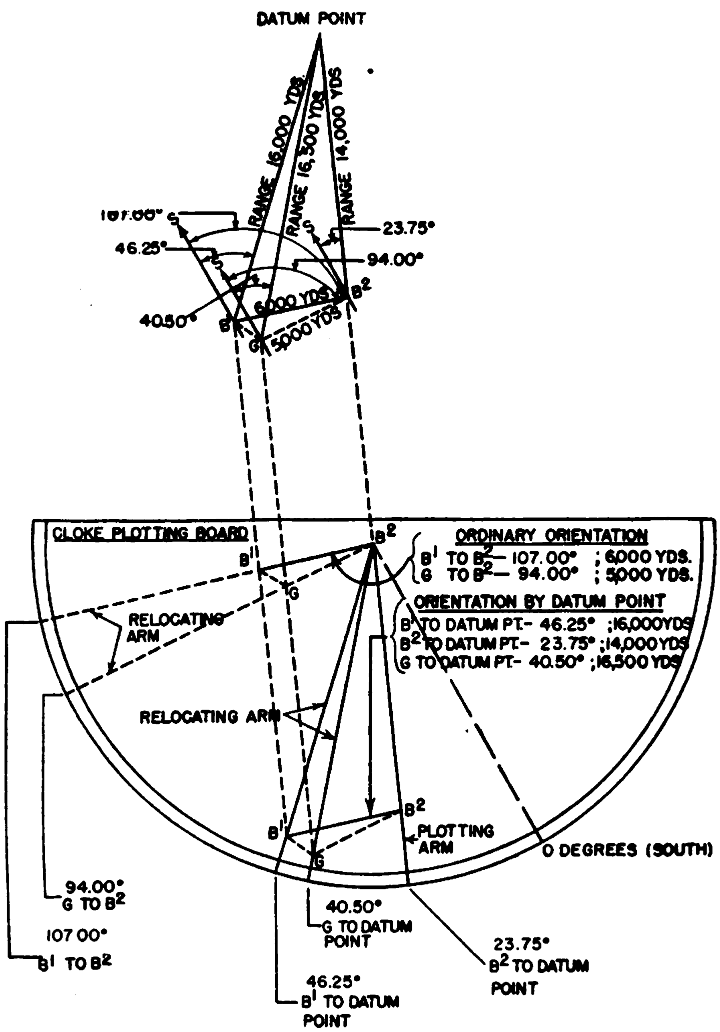


FIGURE 39.—Orientation of Cloke board, ordinary and datum point methods.

(1) Orient the platen, using false azimuths that differ from the true azimuth by a constant amount.

(2) Note the azimuth reading of the plotting arm when orienting.

(3) With the platen clamped and the base line stop out of the way, move the plotting arm through an angle equal to the constant difference used, and in the opposite direction.

(4) Bring the base line stop against the platen in its new position and clamp the base line stop.

Q. When using the vertical base or a self-contained base system, what part of the board represents the observation station and what part represents the D. P.? *A.* The platen pivot represents the observation station and the gun push button represents the D. P.

Q. How is the platen oriented for such a system? *A.* In the same way as for a two-station system, except that it is necessary to locate only the gun push button.

Q. What is "offset plotting"? *A.* A method of plotting used when different ranges and azimuths must be sent to each gun.

Q. What is used to represent the gun positions for offset plotting? *A.* A gun plate is put on the board in place of the gun push button.

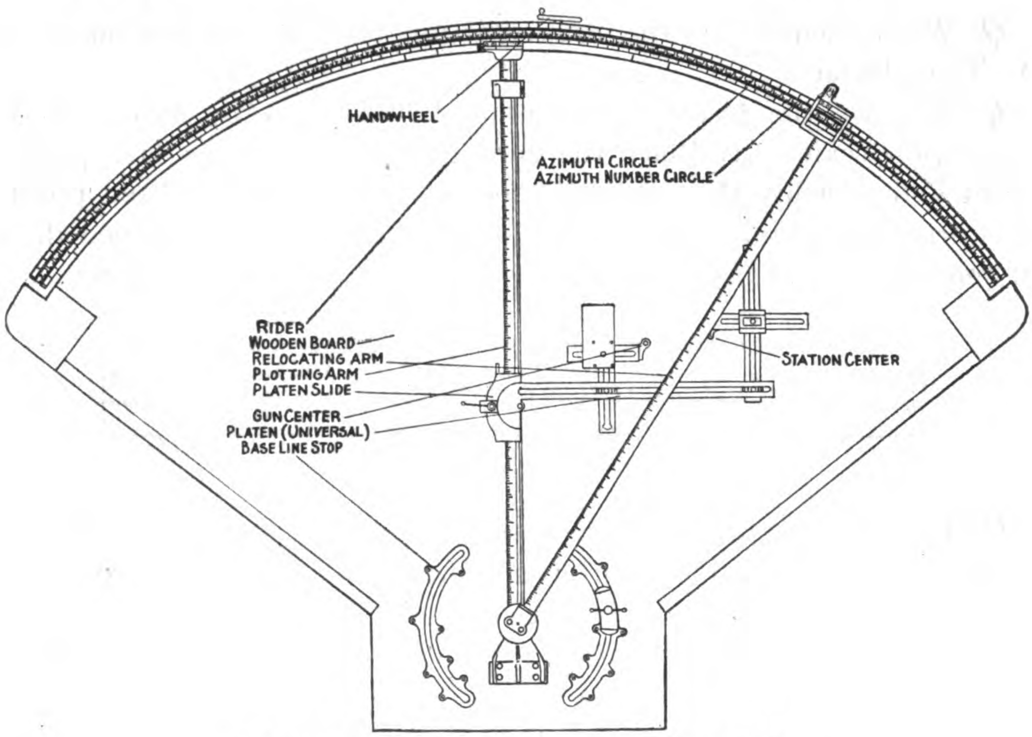


FIGURE 40.—Plotting and relocating board M1.

Q. How is the gun position located on the gun plate? *A.*

(1) Slide the platen to the orienting position.

(2) Set the relocating arm to the azimuth from the gun to the station represented at the platen pivot.

(3) Mark the gun position on the gun plate under the reading edge of the arm and opposite the distance from the gun to the station.

Q. If, when orienting the board, the gun position falls on the platen arm, how can the platen be oriented? *A.* Remove the platen from the slide, turn it upside down and replace it, remount the gun push button and the master key, and reorient.

29. Plotting and relocating board M1.—*Q.* Describe briefly the M1 plotting and relocating board. *A.* This board is similar in operation to the Cloke board. The principal differences are in the construction of the azimuth scale and the base line stop. The azimuth scale is in degrees only, and the readings are marked on an endless chain which can be adjusted by turning a handwheel to put any desired azimuth reading, from 0° to 360°, at the center of the arc; the arc subtended by the azimuth circle is about 120°. The base line stop has been redesigned to facilitate orientation.

30. Prediction scale.—*Q*. What instruments are used in obtaining predicted and set-forward points? *A*. (State those used locally.)

Q. What is the purpose of the prediction scale? *A*. The prediction scale is used for measuring the rate of linear travel of the target and, with a set-forward rule or chart, to locate the set-forward point.

Q. What member of the range section uses the prediction scale? *A*. The plotter.

Q. Explain the location of the predicted point by means of the prediction scale. *A*. Place the zero graduation at the last plotted point and measure the distance between the last two plotted points. The predicted point is located and marked at the same distance ahead of the last plotted point and on the expected path of the target.

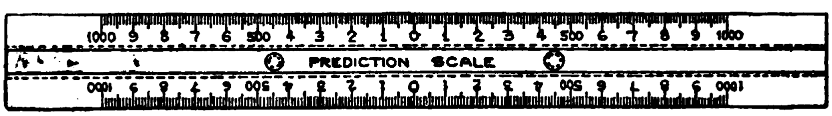


FIGURE 41.—Prediction scale.

Q. Explain how the prediction scale is used in location of the set-forward point. *A*. The plotter measures the distance between the last two plotted points as before, and calls off this distance to the operator of the set-forward device (either the set-forward rule or the set-forward chart). That operator calls back to the plotter the distance the target will travel during the next observing interval plus the time of the flight, and the plotter locates and marks the set-forward point at that distance ahead of the last plotted point and on the expected path of the target.

31. Set-forward rules.—*Q*. What is the purpose of the set-forward rule? *A*. The set-forward rule is for use with the prediction scale to determine the location of the set-forward point.

Q. What data are necessary for its operation? *A*. The range (or time of flight) to the last set-forward point and the yards of travel during one observing interval are obtained from the plotter.

Q. Explain the operation of the instrument used in the (candidate's) battery to accomplish this solution. *A*. (The explanation should cover in detail the operation of the particular device in use.)

Q. Will one rule be suitable for use under all conditions of firing?

A. No. A new rule must be used at any time that the observing interval of the dead time is changed.

32. Set-forward chart.—*Q*. Explain the purpose and method of operation of the set-forward chart. *A*. The set-forward chart serves the same purpose as the set-forward rule; that is, it gives the yards travel from the last plotted point to the set-forward point. To oper-

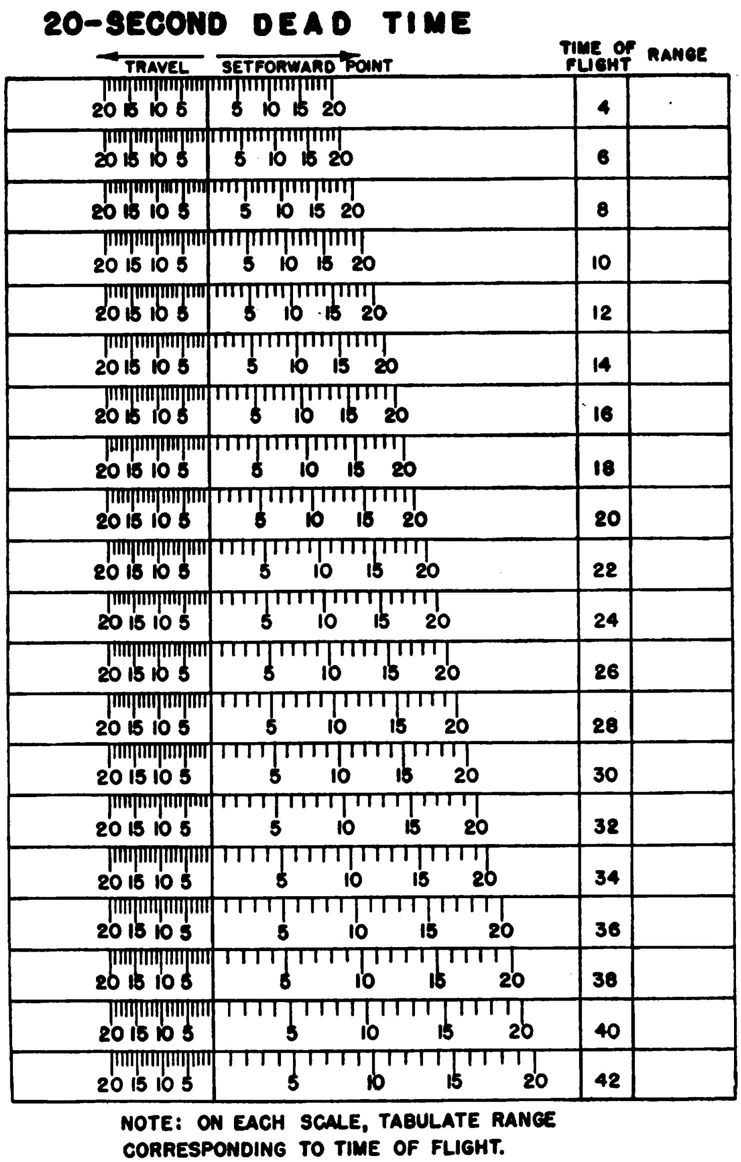


FIGURE 42.—Set-forward scales.

ate it, set the T-square opposite the range (or time of flight) to the last set-forward point; opposite the yards of travel as called out by the plotter, read the yards of travel to the set-forward point and transmit this information to the plotter.

33. Set-forward scales.—*Q*. What is the purpose of a set-forward scale? *A*. The set-forward scale is for the purpose of locating the set-forward point directly from the plotted course. It combines the functions of the prediction scale and the set-forward ruler or chart.

Q. Can the same scale be used for all ranges or values of time of flight. *A.* No. Separate scales are ordinarily furnished for each 2 seconds of time of flight.

Q. Explain the use of the set-forward scale. *A.* Select the proper scale for the current range. Place the zero of the scale at the last plotted point and measure the distance to the preceding point; mark the set-forward point the same number of graduations ahead of the zero mark, and on the expected course of the target.

NOTE.—In the discussions of prediction and set-forward devices it has been assumed that the predicting interval is equal to the observing interval. In some batteries this is not the case, and questions and answers must be modified to fit local conditions.

34. Range correction board M1.—*Q.* What is the purpose of the range correction board M1? *A.* The range correction board M1 is for the purpose of determining the algebraic sum of the range corrections due to prevailing nonstandard ballistic conditions. This sum of the range corrections is called the ballistic correction.

Q. How many men are required for the operation of this board? *A.* One man.

Q. List the nonstandard conditions for which corrections are made, the units in which expressed, and the source from which information as to each of these nonstandard conditions is obtained. *A.*

(1) Muzzle velocity, in foot-seconds, from the range officer.

(2) Atmospheric density, in percent of normal density, from the meteorological message (corrected for difference in elevation).

(3) Height of site or tide, in feet, from the range officer and tide station.

(4) Ballistic wind, in wind reference numbers, from the wind component indicator.

(5) Weight of projectile, in pounds, from the range officer (who gets the average weight from the battery executive).

(6) Elasticity, in degrees F, from the meteorological message (corrected for difference in elevation), or from a thermometer at the battery.

(7) Rotation of the earth, in degrees, from the plotter. (This setting is the azimuth to the set-forward point.)

Q. In what units is the ballistic correction obtained? *A.* In percent of range, usually in terms of reference numbers, with 300 as zero correction.

Q. To whom is the ballistic correction sent? *A.* To the operator of the percentage corrector.

Q. Explain the operation of the range correction board M1. *A*.

(1) The operation of the board is continuous during firing though performed periodically. The initial ballistic correction is determined in the following manner. It should be made under the direct supervision of the range officer.

(*a*) Turn the roller handle until the proper chart appears on the face of the board and adjust the correction ruler to bring it parallel to the range lines. This may be done by loosening the clamp screws and swinging one end of the ruler the necessary amount, then tightening the screws.

(*b*) Bring each pointer to the normal of its set of curves. This is done by turning the wing nut clamp to "M" and turning the knob at the bottom of the ruler until the pointer is opposite the normal line, and turning the wing nut clamp back to "S."

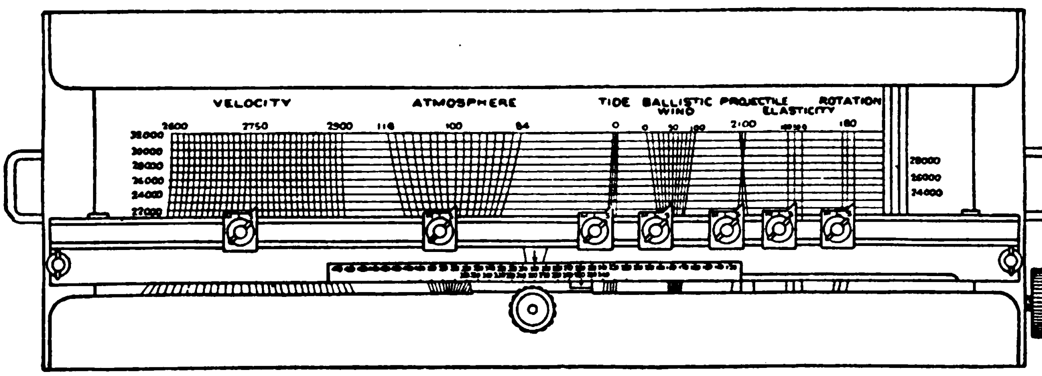


FIGURE 43.—Range correction board M1.

(*c*) After all pointers are at normal bring the index of the correction scale to the normal (300) of that scale.

(*d*) Record with chalk, in a convenient place in the space provided near the top of the board, the necessary data to indicate the curves representing the nonstandard conditions existing.

(*e*) As soon as a range is announced, move the chart to bring that range line under the correction pointers and set each pointer in turn to its proper correction curve.

(*f*) Call out to the percentage corrector operator the ballistic correction indicated on the correction scale.

(2) As the firing continues, the operator keeps the chart set at the range to the set-forward point and keeps the pointers set opposite their proper charts, moving the pointers separately. He announces a new ballistic correction whenever it changes by one unit (1/10 of 1 percent).

(3) The operator notes any change in the range wind reference number and in the azimuth of the set-forward point and changes the

record at the top of the board to indicate the new wind curve and the new rotation curve to be used, as necessary.

Q. In mortar and howitzer firing, how is a change of zones made? *A.* The operator must anticipate the change of zones, setting the board up for the new zone in time to have the new ballistic correction ready when the target enters the new zone. The range officer should designate the new muzzle velocity curve to use and, if necessary, the new elasticity, density, and wind curves (as dictated by the proper zone of the meteorological message). Other curves used should be the same curves as for the previous zone.

35. Deflection board M1.—*Q.* What corrections are applied on this instrument? *A.* Corrections due to wind, drift, rotation of the earth, travel of the target, and adjustment corrections.

Q. Can it be used for both case II and case III firing? *A.* Yes.

Q. Can it be used for both mobile and fixed seacoast artillery? *A.* Yes. It can be adjusted to operate in either degrees and hundredths, or in mils, by a replacement of gearing and a change of scales and correction curves.

Q. What is the purpose of the wind-resolving mechanism? *A.* It is for the purpose of splitting the ballistic wind up into its range and deflection components. It takes the place of the wind component indicator.

Q. Is it necessary to reset the wind-resolving mechanism as the azimuth of the target changes? *A.* No. Once the wind speed and direction are set, the wind arm rotates with the main azimuth plate and scale as the target moves in azimuth. The wind reference numbers, representing the range and deflection components, are read from the face of the top plate of the wind-resolving mechanism.

Q. Explain how to set and read the wind-resolving mechanism. *A.*

(1) Set the "read" pointer to the speed of the ballistic wind on the wind arm.

(2) Set the wind azimuth pointer to the azimuth (from zero north) of the ballistic wind using the index "N" on the same end of the wind arm as the wind speed scale if target azimuths are measured from north; if target azimuths are measured from south, use index "S" on the opposite end of the wind arm from the wind speed scale to set wind azimuth.

(3) Under the "read" pointer on the top plate, read the range and deflection components of the ballistic wind.

Q. Explain how to set uncorrected azimuth on the instrument. *A.* Rotate the main azimuth plate and scale until the proper number of hundredths and tens of the azimuth to be set are opposite the target index (on the wind-resolving mechanism); set the units and hundredths of the azimuth on the main azimuth scale opposite the azimuth setting index (above the wind and drift curves).

Q. What is the adjustment of the board, and what is its purpose? *A.* The adjustment of the board consists of establishing the proper relation between all "set" and "read" pointers such that the proper corrected azimuths or sight settings are obtained when corrections are applied to observed data.

Q. Explain how to adjust the board for case III pointing. *A.*

(1) Set the rotation pointer on the zero deflection line of the rotation curves (the zero deflection line is the reference line running

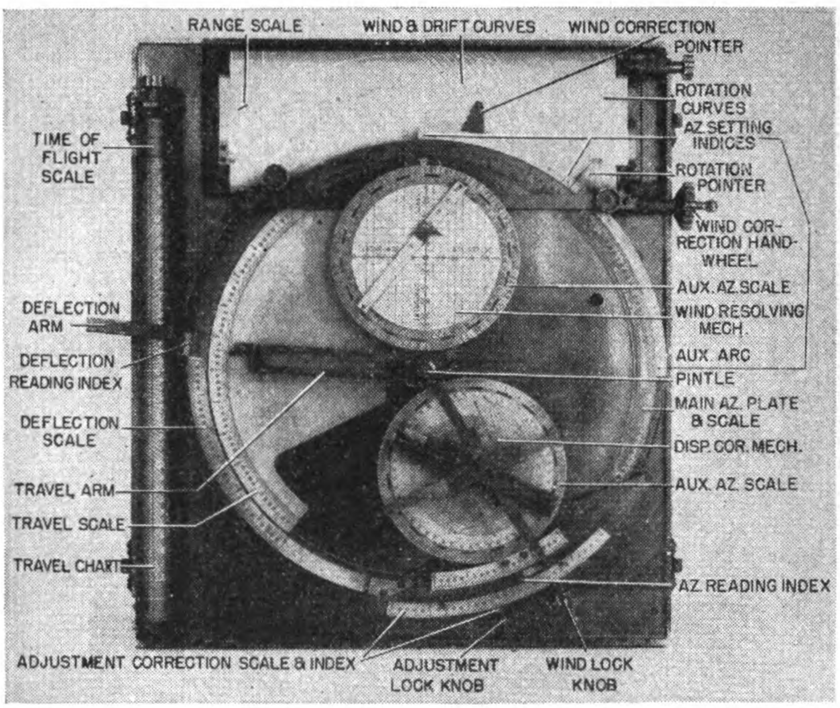


FIGURE 44.—Deflection board M1.

through the origin of each set of curves). If no correction is to be made for rotation of the earth, run the rotation pointer back against its stop and fasten it so that there will be no danger of it being accidentally displaced during operation of the board.

(2) Set the wind correction pointer on the zero deflection line of the set of wind and drift curves which are to be used. (Some charts furnished contain more than one set of wind and drift curves.)

(3) Set the lateral adjustment correction pointer to normal.

(4) Release the wind lock knob, set opposite the azimuth reading index the same azimuth as that found opposite the azimuth setting index, and tighten the wind lock knob.

Q. Explain how to adjust the board for case II pointing. *A.*

(1) Run the rotation pointer back against its stop and fasten it so that there will be no chances of it being accidentally displaced during operation of the board.

(2) Set the wind correction pointer on the zero deflection line of the set of wind and drift curves which are to be used.

(3) Set the lateral adjustment correction pointer to normal.

(4) Set the deflection arm to the normal of the travel chart.

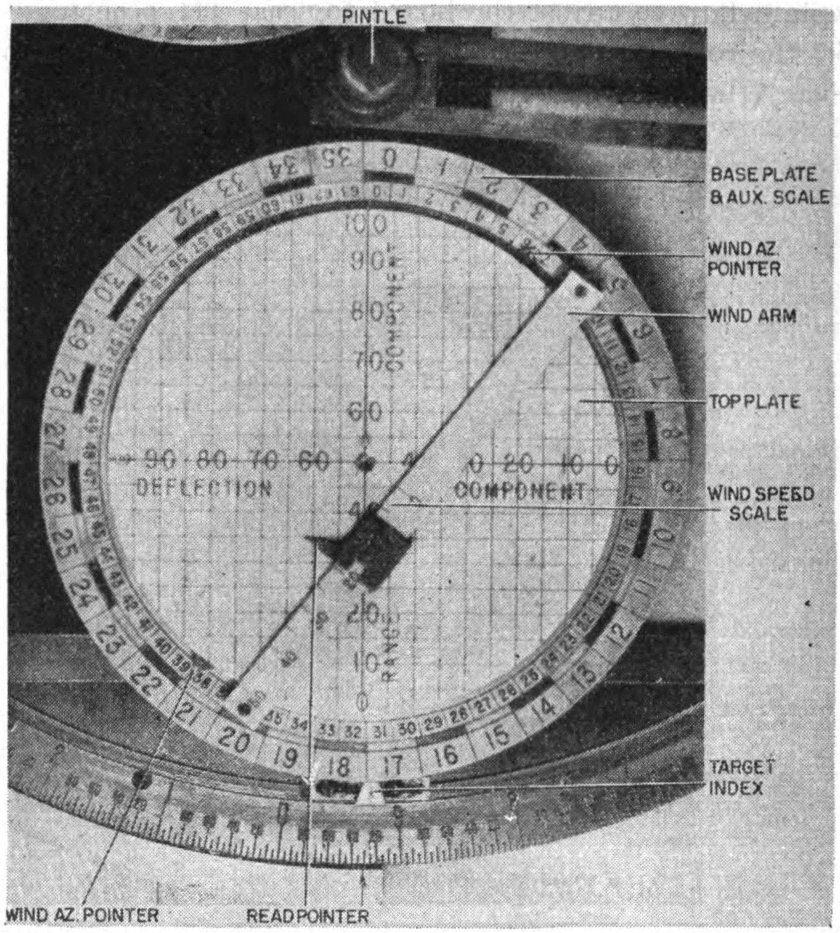


FIGURE 45.—Wind-resolving mechanism, deflection board M1.

(5) Release the wind lock knob, move the deflection scale until the deflection opposite the deflection reading index is normal, and tighten the wind lock knob.

Q. Is one adjustment good for all ballistic charts? *A*. No. If the ballistic chart is changed after the adjustment is made, a new adjustment must be made.

Q. If, after the case III adjustment has been made, the method of pointing is changed to case II, must the board be readjusted? *A*. Yes. When using case II pointing, the adjustment must include the travel chart.

Q. How do you set in a correction for wind and drift? *A.* Corrections for wind and drift are combined into one set of curves on the ballistic correction chart.

(1) Set the chart at the range to the set-forward point.

(2) By means of the wind correction handwheel, bring the wind correction pointer to the wind curve indicated on the wind-resolving mechanism. This displaces the azimuth reading index by the amount of the correction.

Q. How is a correction for rotation of the earth set into the instrument? *A.* Set the ballistic correction chart at the range to the set-forward point. Bring the rotation pointer to the proper azimuth curve on the chart. This pointer is fastened to the auxiliary arc bearing the setting index, so that in setting a rotation correction, the setting index is displaced by the amount of the correction, and the main azimuth plate must be reset to the proper azimuth.

Q. Explain how to set in a lateral adjustment correction. *A.*

(1) Loosen the adjustment lock knob.

(2) Shift the reading index and the adjustment scale so that the desired correction is indicated opposite the adjustment correction index and tighten the lock knob. The adjustment correction index remains locked to the wind correction pointer.

Q. Explain the purpose of the displacement corrector. *A.* The displacement corrector is for the purpose of correcting the firing data for parallax due to displacement; that is, if the guns are at a distance from the directing point sufficient to require the data, as computed for the directing point, to be corrected for use on the guns, the displacement corrector applies the necessary lateral correction. Also, if the two guns of a battery are separated sufficiently to require different firing data, and one gun is designated the directing gun, the displacement corrector will apply a lateral correction to the firing azimuth for the other gun.

Q. Explain how to set in a correction for displacement. *A.*

(1) Set the gun arm to the azimuth of the displaced gun from the directing point.

(2) Revolve the curve disk until the distance to the displaced gun, in yards, is set under the displacement pointer.

(3) Set the range pointer over the proper range curve on the curve disk.

(4) Read the corrected azimuth opposite the index on the parallax arm.

Q. What is the purpose of the angular-travel computing mechanism? *A.* The angular-travel computing mechanism is used in case II pointing for the purpose of correcting the deflection for the angular travel of the target during the time of flight.

Q. Explain its operation. *A*. After the main azimuth plate is set to the uncorrected azimuth to the set-forward point, set the travel arm to the normal (6.00) of the travel scale. When the next uncorrected azimuth is set, the travel arm, which is attached to the main azimuth plate by a slip friction device, will move with the main azimuth plate and indicate, on the travel scale, the angular travel of the target during the observing interval. The travel chart is rotated until the time

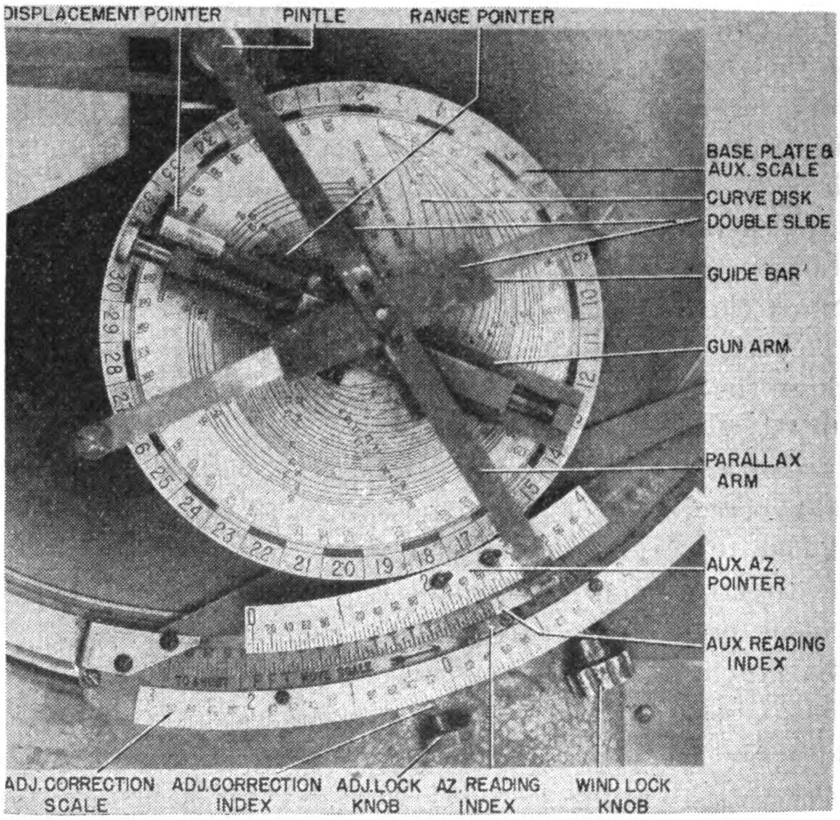


FIGURE 46.—Displacement corrector, deflection board M1.

of flight to the set-forward point is indicated opposite its index, and the deflection arm is set over the proper travel curve. The deflection is then read opposite the deflection reading index.

Q. How are ballistic and adjustment corrections applied for case II pointing? *A*. In the same manner as for case III pointing. The deflection is attached to the arm carrying the azimuth reading index, so that when that index is displaced, either by the wind correction pointer or by the application of an adjustment correction, the deflection scale is displaced by the same amount.

Q. How many men are required to operate this board? *A*. Two men are required for either case II or case III pointing. Operator A operates the wind-resolving mechanism and the ballistic correction chart and pointers, and sets the uncorrected azimuths. Operator B wears a telephone headset connecting him with the azimuth setters or gun pointers at the guns. He operates the lateral adjustment correction mechanism and angular travel device and transmits the corrected azimuths or deflections to the guns. He operates the displacement corrector when that mechanism is used.

36. Gun deflection board M1905.—*Q*. Point out the following parts of the gun deflection board M1905:

Drift scale.	Platen.
Platen scale.	Travel arm.
Range-time scale.	Wind scale.

A. See figure 47.

Q. Which edge of the wind arm or of the travel arm is read in setting off the readings? *A*. The one which would pass through the center of the pivot of the arm if prolonged.

Q. What information is necessary for the operation of this deflection board? *A*. The wind reference number, obtained from the wind component indicator; the corrected range to the set-forward point, obtained from the range percentage corrector; and the angular travel of the target, obtained from the angular-travel computer or from the plotting board.

Q. Explain the operation of the board to obtain the deflection for sight. *A*.

(1) Set the wind arm to the proper reference number, as indicated by the wind component indicator.

(2) Set the travel arm (reading edge) for the travel reference number obtained from the plotting board.

(3) Set the platen so that the point of the drift scale corresponding to the corrected range, obtained from the range percentage corrector, will be accurately over the right-hand edge of the wind arm.

(4) Set the range-time scale so that the point of its scale corresponding to the corrected range obtained from the range percentage corrector will be accurately over the reading edge of the travel arm.

(5) Set the lateral adjustment correction, obtained from the range officer, on the azimuth correction scale at the normal of the deflection scale.

(6) The beveled edge of the range-time scale then indicates on the azimuth correction scale the corrected deflection to be used on the sight with case I or II.

Q. May this deflection board be used in case III pointing? *A*. Yes, but such use is not very satisfactory and the board should not be used in case III pointing except in case of emergency.

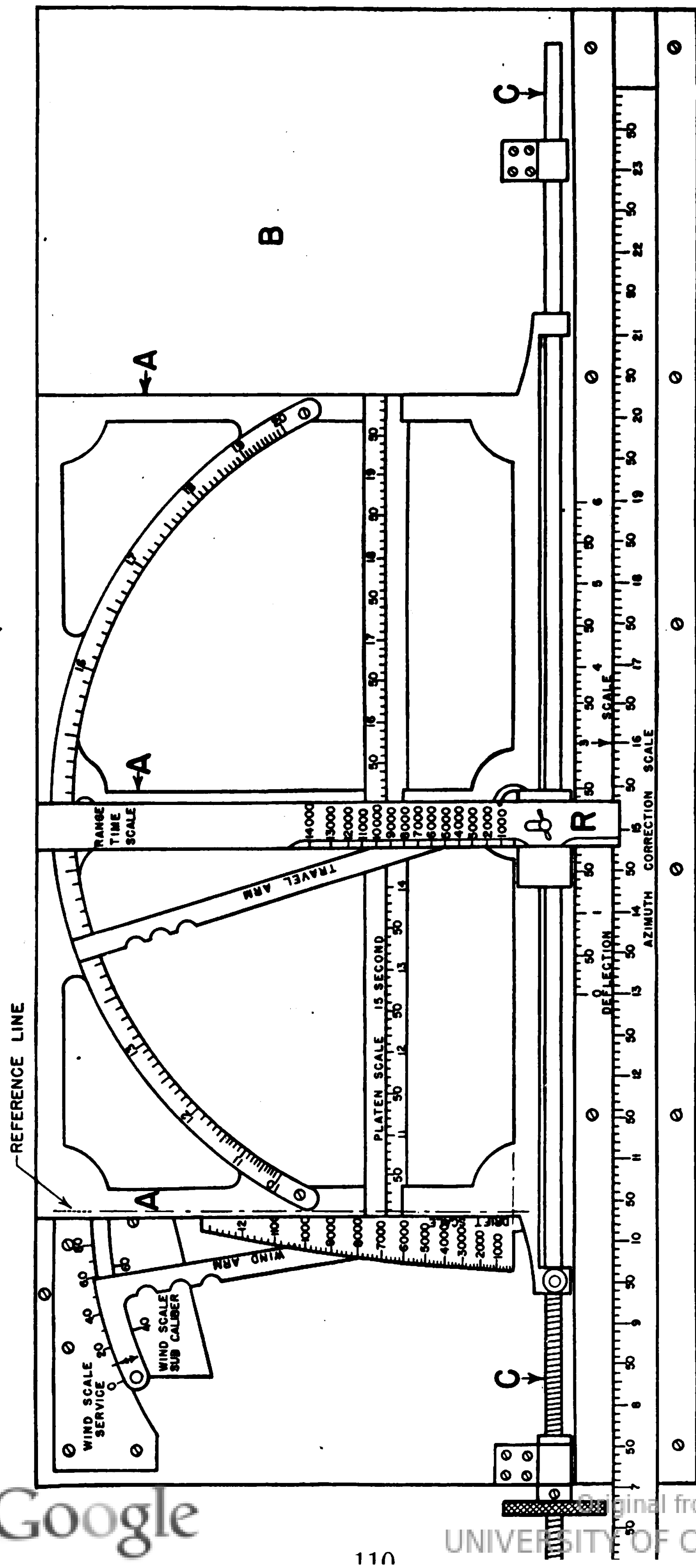


FIGURE 47.—Gun deflection board M1905.

Q. How is this board adapted for subcaliber firing? *A.* The range-time scale and the drift scale for service use are removed and replaced by corresponding subcaliber scales. The subcaliber wind scale is used instead of the service wind scale. The operation of the board is then the same as for service use.

37. Mortar deflection board M1906.—*Q.* Point out and state the purpose of each of the parts shown in figure 48. *A.* (See fig. 48.)

Q. What corrections does this board apply? *A.* It applies to the uncorrected azimuth corrections for wind, drift, and adjustment. It does not apply corrections for the rotation of the earth.

Q. How is the deflection chart oriented on the mortar deflection board? *A.*

(1) Bring the "read" and "set" pointers of the board to the same azimuth reading.

(2) Bring adjusting and lateral wind correction scales to normal of 3.00.

(3) Fasten the deflection chart to rollers so that the zero deflection line falls immediately beneath the normal of the adjusting scale.

Q. Explain the operation of the Board. *A.*

(1) Unless otherwise ordered, set the lower index of the adjusting scale to the normal of the lateral wind correction scale. Turn the handle and ratchet ring until the proper degree on the cylinder is brought into view and set the uncorrected azimuth pointer marked "set" to the uncorrected azimuth of the set-forward point as called out by the plotter. Turn the rear rod knob until the horizontal line representing the corrected elevation, obtained from the percentage corrector, coincides with the fiducial edge of the adjusting scale. Turn the slide knob until the arrow of the adjusting scale points to the proper curve representing the cross-wind component reference number, as obtained from the wind component indicator. Read the corrected azimuth of the set-forward point under the "read" pointer. As changes occur, move the chart to the new corrected elevation and the arrow to the new cross-wind reference number.

(2) If the wind measurements are not available, the pointer (normal) of the adjusting scale may be set on the wind curve representing a deflection wind reference number of 50 (normal, or zero, wind correction), thus correcting for drift alone.

(3) Corrections resulting from observation of fire are applied on lateral wind correction scale. Move the adjusting scale right or left until the lower arrow of the scale coincides with the proper graduation on the lateral wind correction scale, as indicated by the correction ordered. This correction is in reference numbers with normal of 3.00.

(4) This deflection board applies adjustment corrections as flat

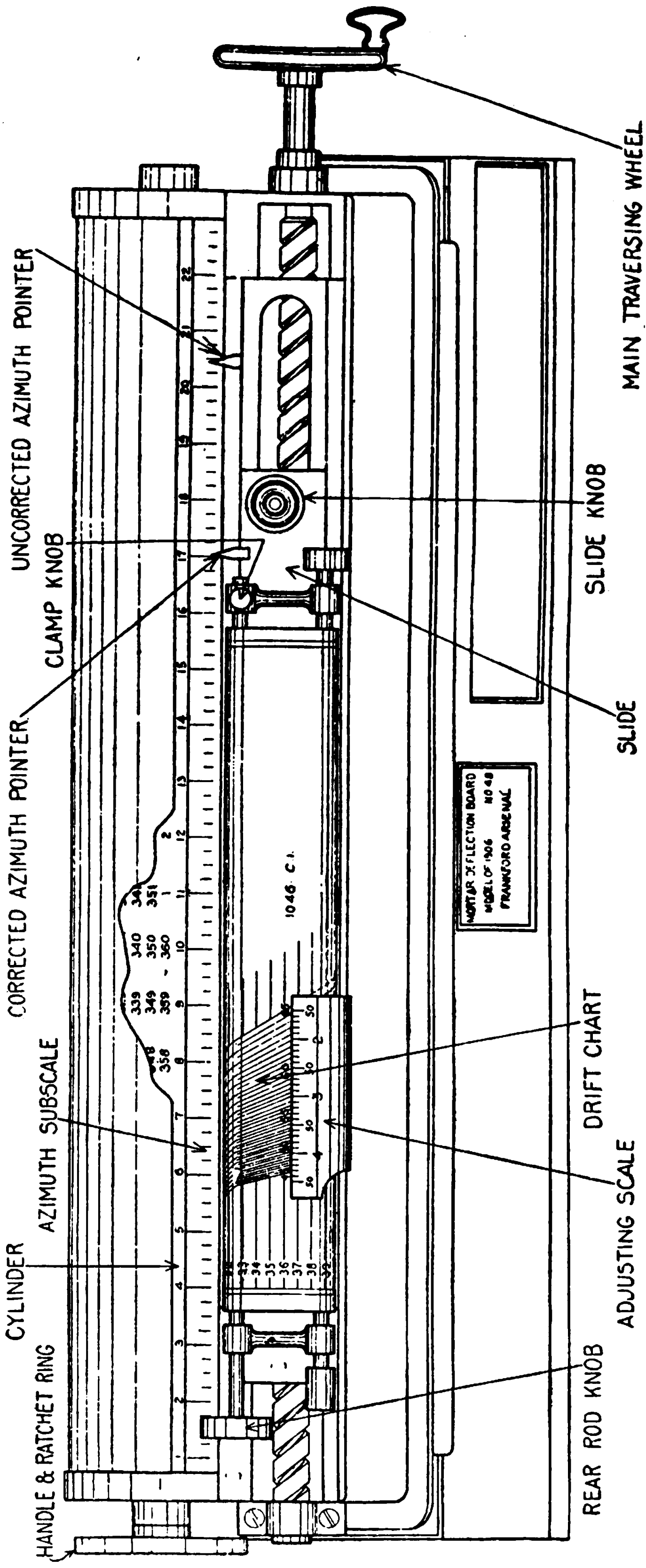


FIGURE 48.—Mortar deflection board M1906.

angular corrections. This is satisfactory for low-angle fire. When used for mortars, the azimuth adjustment slide rule should be used also to give the appropriate correction for changes in elevation.

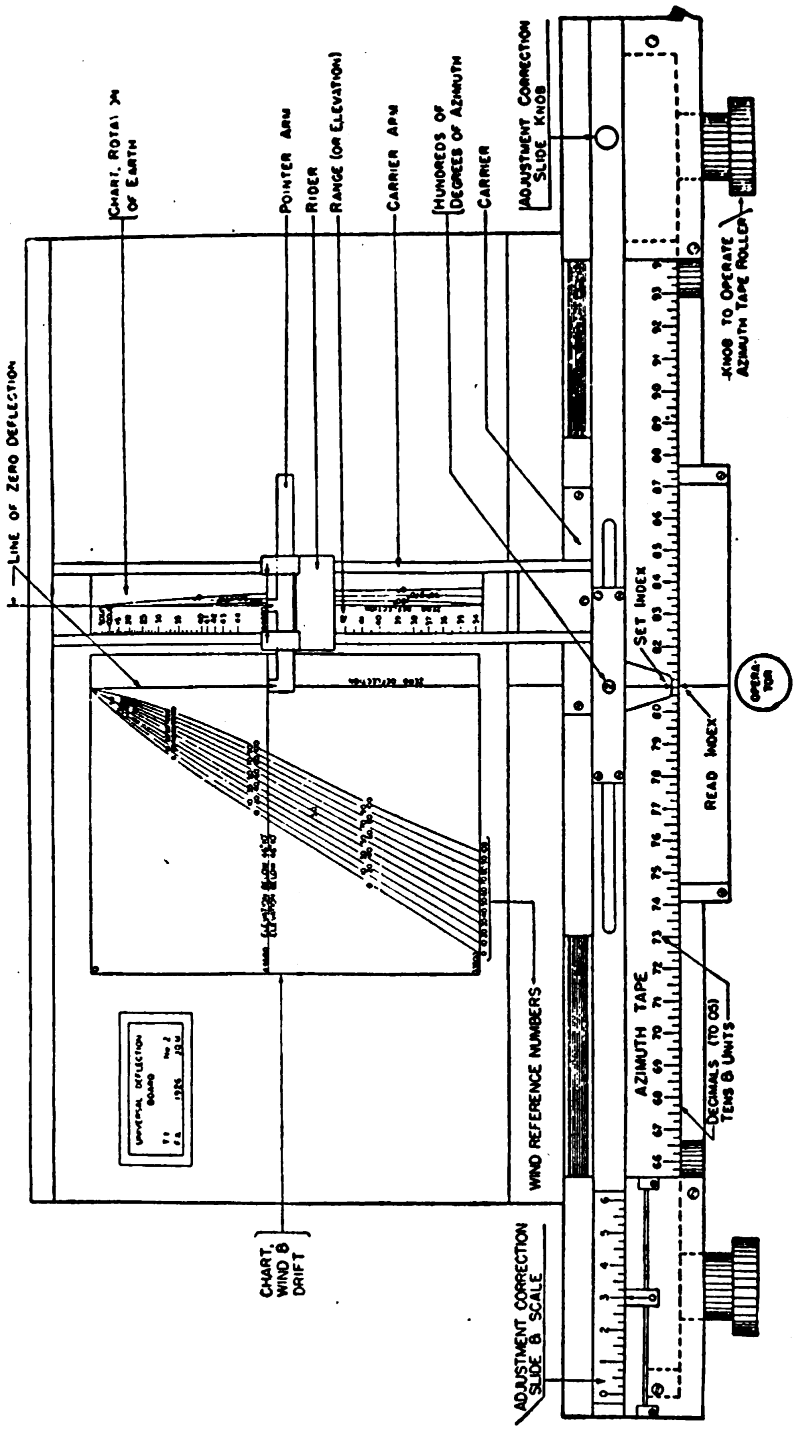


FIGURE 49.—Universal deflection board.

38. Universal deflection board.—*Q.* Point out and state the purpose of each of the parts shown in figure 49. *A.* (See fig. 49.)

Q. What corrections are applied on the universal deflection board? *A.* For drift, wind, rotation of the earth, and adjustment resulting from observation of fire.

Q. How is the board adjusted for case III pointing? Case II pointing? *A*.

(1) Case III pointing: The adjustment of the board consists in placing all pointers and indices at their normal or "zero" positions as follows:

(*a*) Reading index opposite the origin line of the wind and drift curves.

(*b*) Setting index directly over the reading index.

(*c*) Wind pointer opposite origin line of wind and drift curves.

(*d*) Rotation pointer opposite the origin line of the rotation curves.

(*e*) Adjustment correction pointer opposite normal (3.00) of the adjustment correction scale.

(2) Case II pointing: The same as for case III pointing.

Q. What data are necessary for the operation of the board for case III? *A*. Uncorrected azimuth of the set-forward point, wind-component reference number, corrected elevation, and the adjustment correction to be applied as a result of observation of fire.

Q. Explain the operation of the universal deflection board in case III. *A*. Set the pointer arm at the range to the set-forward point. The rider is set (for the rotational correction) at the curve corresponding to the approximate azimuth of the set-forward point. The wind-and-drift curve to be used is determined by the deflection wind component obtained from the wind component indicator. With the adjustment correction scale at zero, move the carrier, with arm, until the wind-and-drift correction pointer is brought to the proper wind-and-drift curve. Thereafter, keep the pointer arm set at the proper elevation, the rider on the proper rotation curve, and the pointer on the proper wind-and-drift curve. Set the slide to indicate the hundreds of degrees azimuth of the set-forward point. Move the tape so that the azimuth of the set-forward point called out by the plotter is set opposite the "set" index. Read the corrected azimuth on the tape opposite the "read" index.

Q. Explain the operation of the universal deflection board in case II. *A*. For use in case II firing, azimuth tapes for the universal board carry at one end scales graduated to correspond to the graduations of the deflection scales of telescopic sights, except that the azimuth tape scale is numbered from left to right. See that the adjustment correction slide is set at normal or at the adjustment correction ordered. Move the tape by rolling it up on the left roller until the normal of the scale of the sight being used comes under the "set" index. If the normal of the telescopic sight is 3, as in the usual case, the 3 of the deflection scale on the tape is set under the same index. The angular travel of the target during the time of flight is computed and added to or subtracted from (depending upon the direction of travel of the target) the normal of the proper sight scale (depending upon the sight being used) by the operator of the angular-travel computer, who transmits to the operator of the universal deflection board the angular-travel reference number so determined. The deflection board operator moves the azimuth tape until the angular-travel reference number is under the "set" index. Move the pointer arm until its index is set at the range to the set-forward point. Move the rotational correction rider until it coincides with the proper curve corresponding to the azimuth of the set-forward point. Move the wind-and-drift correction pointer by moving the carrier to the right or left until the index of the pointer is over the proper wind-and-drift curve. The corrected deflection is read on the tape under the "read" index.

Q. How are adjustment corrections applied to the universal deflection board? *A*. Through the adjustment correction slide which is graduated in 0.05° spaces to the right and left of normal (zero correction). The direction in which the slide is to be moved to make the correction is indicated by an arrow on the slide. Set the movable slide coincident with the fixed index of the adjustment correction slide and opposite its normal. Move the adjustment correction slide in the proper direction until the amount of the correction is read opposite the fixed index and the marker. The "set" index has been displaced by the amount of the correction, and readings made on the azimuth tape opposite the "read" index will give the corrected azimuth, which includes the adjustment correction. Move the reference pointer so that it will again be opposite the normal of the adjustment correction slide. Apply additional adjustment corrections with reference to the index of the marker, and after the corrections have been accomplished always move the marker until it is again opposite the normal of the adjustment correction slide.

39. Angular-travel computer.—*Q*. What is the purpose of the angular-travel computer? *A*. To determine the deflection due to angular travel (called the "angular-travel reference number"), for case II pointing.

Q. Point out the following parts: azimuth, scale, range-time scale, median line, deflection scale, and travel arm. *A*. (See fig. 50.)

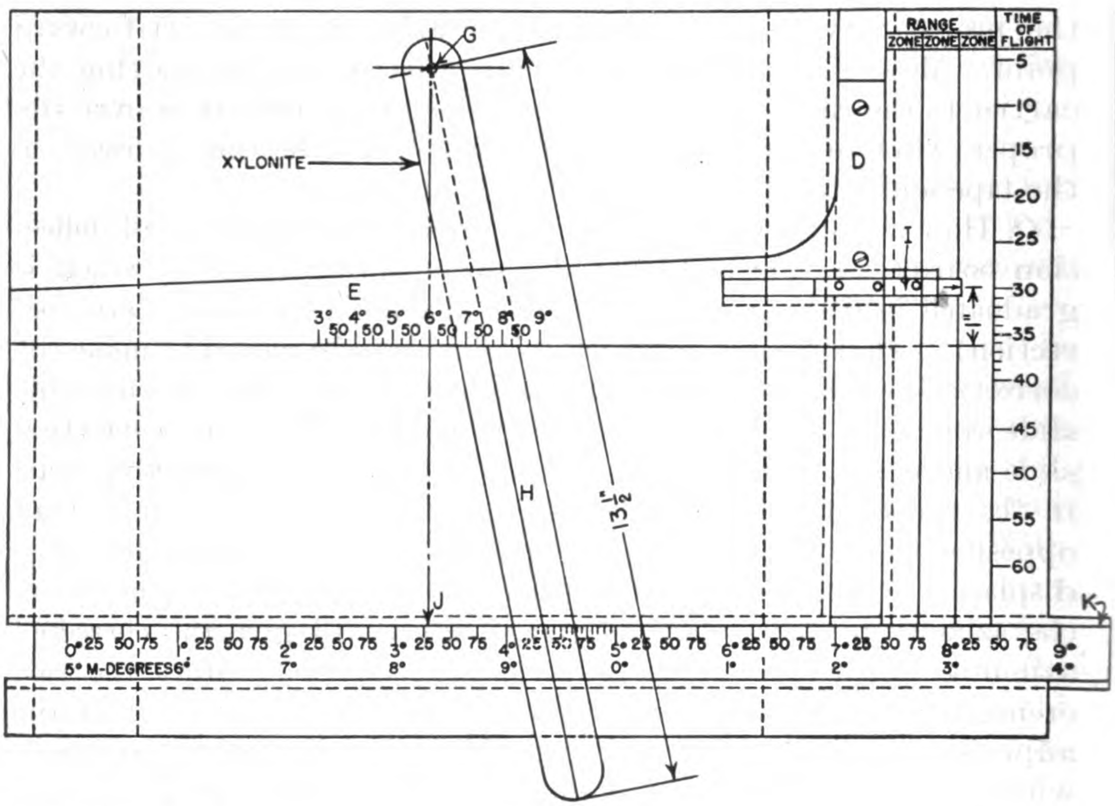
Q. How is the board adjusted for operation? *A*. By mounting the proper range-time scale and deflection scale in place. The range-time scale depends on the gun and ammunition being used, and the deflection scale depends on the gun sight being used.

Q. What data are necessary for the operation of the board? *A*. The corrected range to the current set-forward point and the uncorrected azimuths to the current set-forward point and the next preceding one.

Q. Explain the operation of the angular-travel computer. *A*.

(1) Set the azimuth scale so that the uncorrected azimuth (last three numbers) of the next preceding set-forward point is opposite the index J (the median line of the board).

(2) Set the range index opposite the range to the current set-forward point.



G–J. Median line.
E. Deflection scale.
M. Azimuth scale.
D. Slide.
I. Range index.
H. Travel arm.
K. Platen scale.

FIGURE 50.—Angular travel computer.

(3) Set the travel arm to the uncorrected azimuth of the current set-forward point.

(4) Read the angular-travel reference number indicated by the travel arm on the deflection scale.

Q. How is the board adjusted for subcaliber firing? *A*. By substituting the proper range-time scale.

Q. Can the same deflection scale be used if the observing interval is changed? *A*. No, because it is constructed for a particular observing interval.

40. Azimuth adjustment slide rule.—*Q.* What is the purpose of the azimuth adjustment slide rule? *A.* To provide a means for varying an angular adjustment correction according to the elevation in high-angle fire.

Q. When should it be used? *A.* For mortar and howitzer fire.

Q. Explain the operation of the rule. *A.* The rule may be operated by the deflection board operator or his assistant. He notes the adjust-

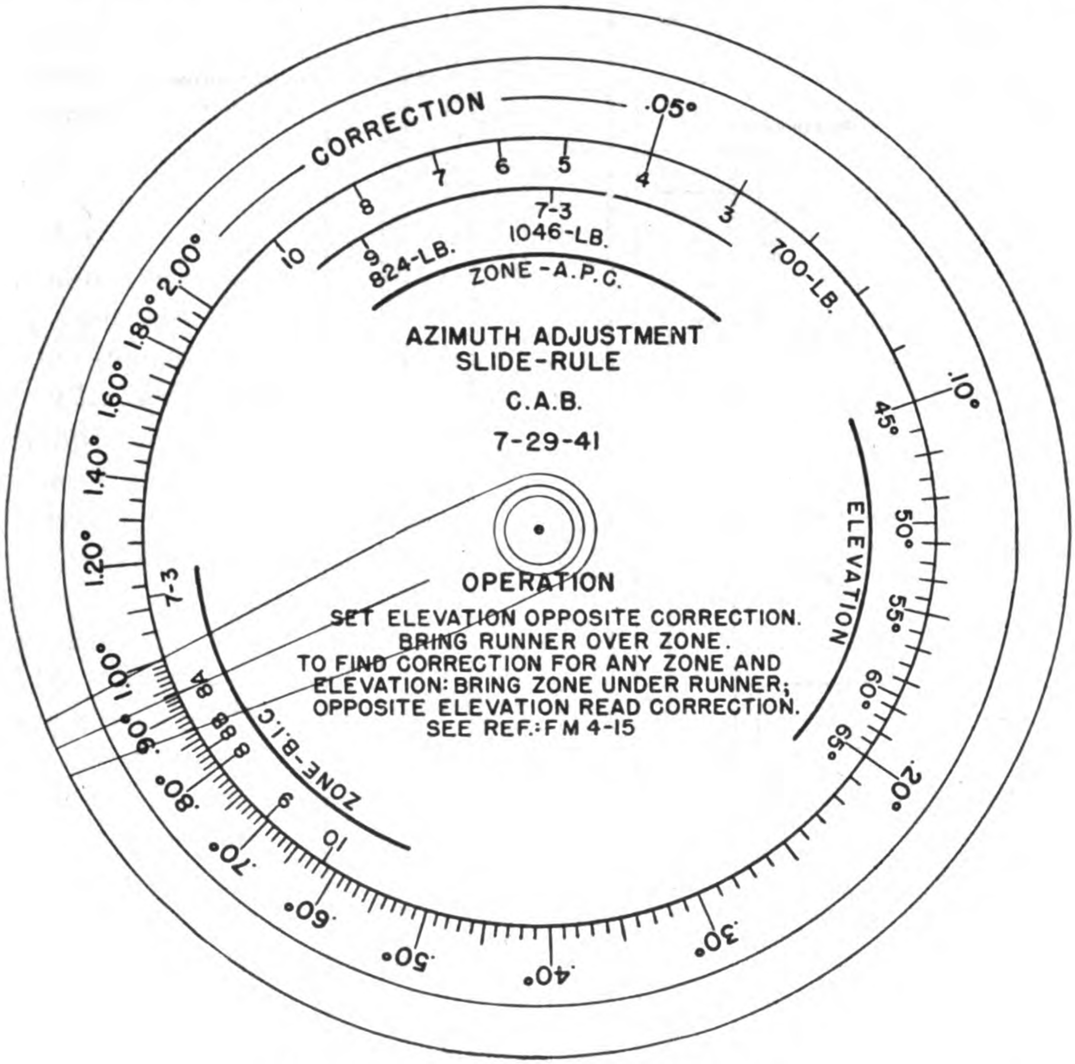


FIGURE 51.—Azimuth adjustment slide rule.

ment correction ordered and the zone and elevation being used. For example, assume that an adjustment correction of "left 0.15°" has been ordered when firing in zone 8–A using base increment charges, at an elevation of 55°. The operator applies the correction to his deflection board. He next sets the 55° elevation mark on the inner scale of the rule opposite the 0.15° correction mark on the outer scale, as shown in figure 51, and sets the center line of the runner over the mark representing zone 8–A on the B. I. C. scale. He then observes the change in the correction indicated by new elevations ordered and keeps the correction set to the nearest 0.05° on his deflection board. When the zone changes, he moves the smaller disk until the new

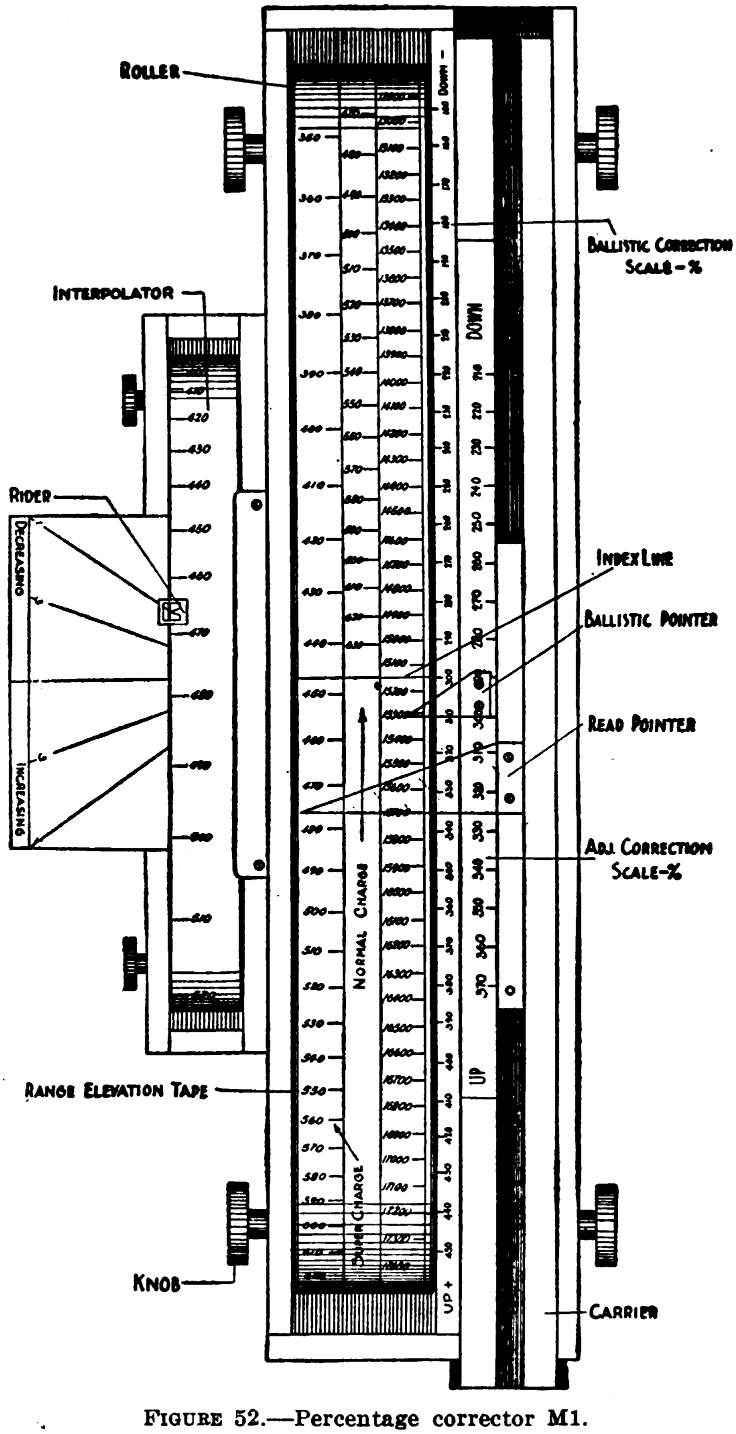


FIGURE 52.—Percentage corrector M1.

zone mark is under the runner. He then reads the new correction opposite the new elevation and applies it on the deflection board.

41. Percentage corrector.—*Q.* What is the purpose of the percentage corrector M1? *A.* The percentage corrector M1 is a device for applying the ballistic and adjustment corrections to the uncorrected range to the set-forward point, and for transforming the corrected range, when necessary, into the corresponding elevation or the corresponding range in those units with which the pointing device on the gun is marked.

Q. Explain its operation. *A*. The percentage corrector operator keeps the ballistic pointer set on the ballistic correction scale at the ballistic correction called out by the operator on the range correction board. If an adjustment correction has been ordered, he sets the "read" pointer at that correction on the adjustment correction scale; otherwise that pointer coincides with the ballistic pointer. As soon as the uncorrected range to the set-forward point is called out from the plotting board, he sets that range on the range scale under the index line on the xylonite. He wears a telephone headset connecting him to the range or elevation setters at the guns, and calls out to them the corrected range or elevation indicated by the "read" pointer on the range scale.

42. Wind component indicator.—*Q*. What is the purpose of the wind component indicator? *A*. To determine the range and deflection components of the ballistic wind for use in making wind corrections.

Q. What data are needed to operate the instrument? *A*. The azimuth and speed of the ballistic wind and the azimuth of the set-forward point.

Q. Where are they obtained? *A*. The wind azimuth and speed are obtained from the meteorological message. The azimuth of the set-forward point is obtained from the plotting board.

Q. How is the azimuth of the ballistic wind given in the meteorological message? *A*. It is always given in hundreds of mils from zero north.

Q. Explain the operation of the instrument when the target azimuths are measured in degrees from south. *A*.

(1) Set the pointer on the target arm to the wind speed.

(2) Turn the azimuth circle until the wind azimuth is indicated on the inner scale opposite the pointer K at the lower end of the deflection component normal line.

(3) Keep the target arm set to the approximate azimuth of the set-forward point by setting the index on the end of the arm opposite the azimuth of the set-forward point on the outer scale, changing the setting whenever the azimuth of the set-forward point. differs by as much as 2½°.

(4) Read the range component reference number from the vertical scale on the grid where the horizontal line that runs under the

pointer crosses the scale; and read the deflection component reference number from the horizontal scale where the vertical line that runs under the pointer crosses that scale.

Q. If there are no lines exactly under the pointer, what does one do? *A.* Take imaginary lines and estimate the nearest unit between the readings on the scales.

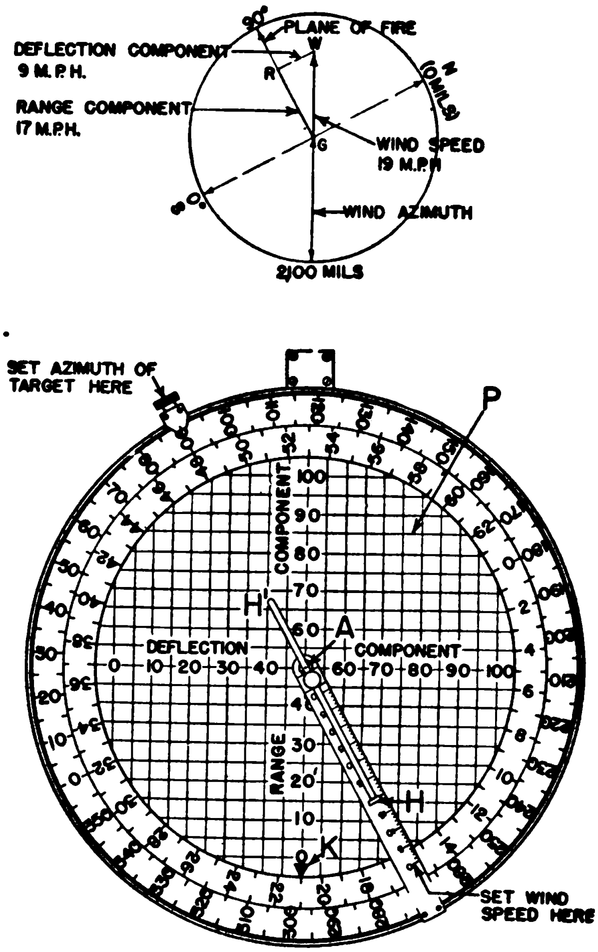


FIGURE 53.—Wind component indicator.

Q. What is the normal of the wind component reference scales? *A.* Fifty.

Q. If the target azimuth is measured in degrees from north, how is the instrument used? *A.* The only change in operation is to set the wind azimuth opposite the upper end of the deflection component normal line instead of the lower end.

Q. If the target azimuth is measured in mils from north, how is the instrument used? *A.* Set the wind azimuth at the lower end of the normal line, as in the first case, and set the target azimuths opposite the marks on the inner azimuth scale.

Q. Where is the range component reference number used? *A*. On the range correction board.

Q. Where is the deflection component reference number used? *A*. On the deflection board.

Q. Is the instrument used when the deflection board M1 is used? *A*. No. A wind component indicator is built into the deflection board.

SECTION II

OBSERVATION INSTRUMENTS, INCLUDING RANGE FINDERS

NOTE.—Instruction and tests or examinations should be as practical as possible. Therefore, they should be conducted in the stations where the instruments are to be found. If a man cannot give the exact names of the less prominent parts, he should be considered qualified if he can point to the part under discussion and if he can tell what it is for, how it operates, and give other pertinent information as to care and adjustment.

43. Orientation and adjustment of instruments.—*Q*. What is meant by orienting an observation instrument? *A*. So adjusting the instrument that it will read correct azimuths.

Q. Name the necessary adjustments, in the order in which they are usually made, to an observation instrument for reading azimuths.

(1) Exact location of the instrument over the point representing the base-end station.

(2) Leveling of the instrument.

(3) Focusing the eyepiece.

(4) Removal of parallax.

(5) Orientation to read correct azimuths.

Q. How is an instrument with tripod mount placed exactly over a point representing a base-end station? *A*. Set up and adjust the height of tripod as desired, mount the instrument on the tripod head, and hang a plumb bob from the base. With the aid of the plumb bob, place the tripod approximately over the point representing the base-end station, making the tripod head as nearly level as possible by eye. Traverse the instrument until it reads the azimuth of a known datum point visible from the station. Adjust the telescope so that it is in its normal position on the base. (For example, the telescope of an azimuth instrument should be adjusted so that the eyepiece extends over the rear of the base.) Lift up the instrument and tripod together and set them down so that the telescope points in the general direction of the datum point. Center the plumb bob over the point representing the base-end station by shifting the tripod legs, keeping the tripod head as level as possible and the telescope pointed toward the datum point. Make sure that the legs when finally adjusted are firmly fixed into the ground.

Q. Explain how to level an instrument that has four leveling screws. *A*. See that all four leveling screws have a uniform and moderately firm bearing on the leveling plate. Traverse the instrument until one of the levels on the base is parallel to two diagonally opposite leveling screws. Turn those screws simultaneously, one clockwise and the other counterclockwise, until the level bubble is centered. The bubble will follow the direction of motion of the left thumb. Without traversing the instrument, center the bubble of the other level by means of the other two leveling screws, readjusting each bubble for any error caused in centering the other. Traverse the instrument 180° and check the level; if a bubble leaves the center, correct one-half of the error by the adjusting screws on the level box and the other half by the proper pair of leveling screws. Repeat the operation until the level bubbles remain centered for any position of the telescope in azimuth.

Q. Explain how to level an instrument with only three leveling screws. *A*. The procedure is the same except that one of the levels is set parallel to any two leveling screws, the other being perpendicular to them. The first level is then centered by means of the two parallel screws and the second by means of the third screw used with each of the others alternately.

Q. What precautions should be taken in leveling? *A*. Have each leveling screw bear firmly but not too tightly on the leveling plate; do not force a screw if it binds but slack off on the opposite screw. Binding of the screws will bend the spindle and make correct leveling of the instrument impossible in the future.

Q. Explain how to focus the eyepiece and remove parallax. *A*.

(1) *Focusing eyepiece.*—Screw the eyepiece in or out until the roughness of the cross wires can be seen most distinctly. This should be done with the telescope pointed at the sky if possible.

(2) *Removal of parallax.*—Parallax is the apparent motion of the cross wire across the image of an object as the eye is moved from side to side across the eyepiece. It is caused by improper focusing of the objective lens. To remove parallax, point the telescope at a distant object and move the objective lens in or out until the cross wire remains on the same point of the image as the eye is moved.

NOTE.—This operation is unnecessary on some types of instrument because they have a fixed focus.

44. Azimuth instruments.—*Q*. For what is an azimuth instrument used? *A*. To measure the azimuth to any point, such as a target, and to measure the angular deviation of a splash from a target.

Q. In what units are these angles measured? *A*. In degrees or in mils, depending on the instrument.

Q. How many degrees are there in a circle? How many mils? *A*. 360°; 6,400 mils.

Q. Name the three main parts of an azimuth instrument and state their uses. *A*.

(1) The telescope, which contains the lenses that enable the observer to see distant objects.

(2) The base, which supports the telescope and provides gears for transversing and scales for reading the azimuths.

(3) The tripod, which supports the base.

Q. How are azimuths of a moving target measured? *A*. The observer tracks the target, keeping the vertical cross wire on the target, until a signal is sounded indicating the end of an observing interval. At that instant he stops traversing the instrument, and the reader reads the azimuth indicated. This process is repeated throughout the course.

Q. How is the azimuth of a fixed target measured? *A*. The observer traverses the instrument until the vertical cross wire is on the target and stops the instrument. The reader than reads the azimuth indicated.

Q. Where are azimuth instruments generally used? *A*. In base-end stations and spotting stations.

Q. How many men are necessary to operate the instrument? *A*. When determining azimuths, two are required, an observer and a reader; when measuring deviations (spotting), one man does both jobs.

Q. How are deviations measured? *A*. The observer keeps the cross wire on the target until the splash occurs. The instrument is then held stationary and the angular deviation of the splash is read directly (without using the splash pointer) by means of the deflection scale etched on the reticle. If it is desired to read the deviation of the center of impact of a salvo, the splash pointer is moved to the estimated position of the center of impact and the deviation is read on the deflection scale.

Q. Assuming that the preliminary adjustments have been made, explain how to orient an instrument to read correct azimuths. *A*. With the instrument set at the azimuth of the datum point, loosen the azimuth clamp screw and bring the vertical cross wire on or very nearly on the datum point. Tighten the azimuth clamp screw and bring the vertical cross wire exactly on the datum point by means of the azimuth slow-motion screw. Clamp the azimuth slow-motion screw. Check the adjustment by traversing the instrument away from and back to the datum point several times, checking the readings of the azimuth scale. The orientation should be checked on at least one other known datum point if possible.

Q. What two standard types of azimuth instruments are issued? *A*. The azimuth instruments M1910A1 and M1918.

Q. What is the main difference between them? *A*. The M1910A1 instrument measures angles in degrees and hundredths and cannot be used to measure vertical angles; the M1918 instrument measures angles in mils and can be used to measure vertical angles from minus 300 to plus 500 mils.

Q. What is the value of one space on the graduated circle of each? *A*. On the M1910A1 instrument, 1°; on the M1918, 10 mils.

Q. What are the smallest graduations on the index disks? *A*. On the M1910A1 instrument, one one-hundredth of a degree; on the M1918, one-tenth of a mil.

Q. Where are the instruments used? *A*. The M1910A1 instrument is used for all seacoast artillery except the 155-mm guns. The M1918 instrument is used for 155-mm guns.

Q. How is backlash eliminated? *A*. Adjust the worm-box adjusting screw so that there is no play between the worm and the worm gear; adjust the worm adjusting screw until there is no longitudinal play of the worm in its box. The disk crank should turn freely but not too loosely, and there should be some movement of the graduated circle when the graduated disk is turned.

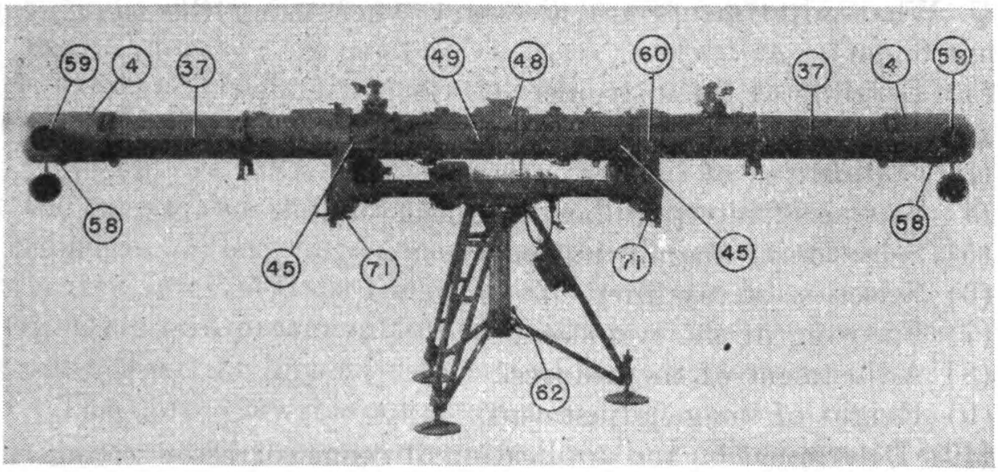
Q. What care should be given the instrument? *A*. It should be kept free from dust and dirt. Both dust and moisture will in time injure the glasses. It should be kept in the case provided for it when not in use. It should be kept properly oiled. Do not touch the lenses with the fingers. Clean the lenses with soft linen or special paper supplied for the purpose. Do not jar the instrument. Keep one eyepiece assembled in the telescope to prevent dust or moisture from collecting on the reticle. Do not turn the leveling screws so that they bear too hard against the leveling plate; too much pressure may bend the spindle. If the screws bind, loosen one screw until they all have a uniform and moderately firm bearing.

Q. Where can detailed descriptions of the azimuth instruments be found? *A*. In the ordnance pamphlets issued with the instruments.

45. Self-contained horizontal base range finders.—*Q*. What different types of range finders are in use? *A*.

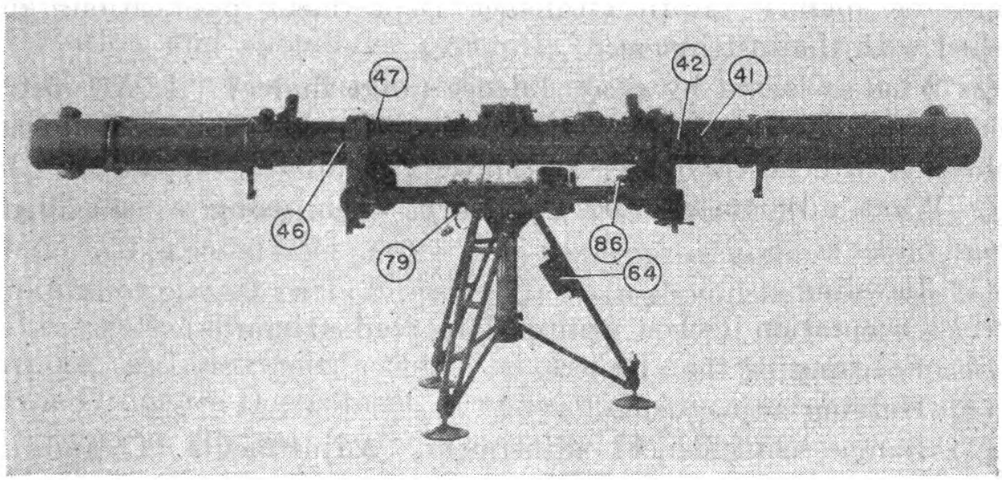
(1) Stereoscopic type.

(2) Coincidence type.



4. End box.
37. Porter bars.
45. Internal adjuster cover plates.
48. Wiring box.
49. Centering plate cover plug.
58. Air valve.
59. Sunshade.
60. Worm gear plate.
62. Sleeve clamp screws.
71. Locking knob.

FIGURE 54.—Stereoscopic height (range) finder M1, front view.



41. Compensator unit support.
42. Bevel gear cover cap.
46. Elevation index.
47. Main tube level.
64. Eyepiece cover in stand-by position.
79. Tube lighting socket.
86. Orientation clutch.

FIGURE 55.—Stereoscopic height (range) finder M1, rear view.

Q. What is the adopted standard for seacoast artillery? *A*. The stereoscopic height (range) finder M1, originally designed for antiaircraft artillery.

Q. Where can a detailed description of this instrument be found? *A*. In TM 4–250.

Q. What is meant by a stereoscopic range finder? *A*. An instrument which gives correct ranges when the object sighted appears at the same distance, or depth, as an image or reticle marked on a lens of the optical system.

Q. What adjustments are necessary when using the stereoscopic range finder? *A*.

(1) Leveling of the instrument.
(2) Orientation of the instrument.
(3) Collimation of trackers' telescopes.
(4) Setting of interpupillary distance.
(5) Selection of magnifying power.
(6) Selection of ray filter.
(7) Focusing of the eyepieces.
(8) Adjustment of the headrest.
(9) Height of image adjustment.
(10) Determination and application of range corrector setting.
(11) Setting of range height lever.

Q. How many operators are required for the range finder M1, and what are they? *A*. Four. Elevation tracker, azimuth tracker, observer, and reader.

Q. Where can a detailed description of the coincidence range finder be found? *A*. In Ordnance Department publications furnished with the instrument.

Q. What is meant by a coincidence range finder? *A*. An instrument which gives correct ranges when the object sighted appears unbroken in both the upper and lower part of the eyepiece.

Q. What adjustments are necessary when using a coincidence range finder? *A*.

(1) Leveling.
(2) Orientation (when equipped to read azimuths).
(3) Focusing of the eyepiece.
(4) Halving adjustment.
(5) Range (coincidence) adjustment. Adjustments (1) and (2) are the same as for any other observation instruments.

Q. Describe the halving adjustment. *A*. Sight on an object such as a flagpole or spire; move the telescope in elevation until the object is seen only in the lower field; then gradually change the elevation until the image rises to the separating line. If halving is correct, the top of the object will appear above the dividing line at the instant it disappears from the lower field. If the image appears too soon, rotate the halving adjusting knob upward. If the image appears too late, rotate the halving adjustment knob downward.

Q. Describe the range (coincidence) adjustment. *A*. Turn the measuring knob until the scale reads the range to a known object. If the partial images do not coincide, move the correction wedge dial until the partial images coincide (come together). Check at two or more known ranges, and then leave adjustment alone.

Q. When is the astigmatizer used? *A*. At night when observing on small lights.

Q. Describe briefly the operation of the instrument. *A*. The observer and trainer bring the instrument approximately on the target by sighting over it. Thereafter the trainer keeps the instrument on the target and the observer brings the two partial images into coincidence. When coincidence is obtained (not necessarily at any given time interval), the range is read from the range scale.

46. Care and preservation of instruments.—*Q*. May telescopes be taken apart or any adjustment made by battery personnel? *A*. No. The only allowable adjustment is to focus the telescope.

Q. How should telescopes be cared for? *A*. They should be protected from moisture and dust. To obtain satisfactory vision the glasses should be kept perfectly clean and dry. Only such material as is issued by the Ordnance Department specifically for the purpose of cleaning lenses should be used, taking care that the cleaning material does not contain any dirt or grit. Chamois skins must not be used to clean lenses. Finger marks and lint will cause trouble in observation and should be promptly removed from lenses. Care should be taken that no oil comes in contact with lenses or prisms. Care must be taken to avoid shock to the telescopes.

Q. How are position-finding instruments cared for? *A*. These are all delicate instruments and should be handled carefully, avoiding any shock. All exposed steel parts should be protected against rusting by a thin film of oil; all parts subject to friction should be oiled regularly and carefully. Except as otherwise noted, neutral oil is used for the purpose. All instruments should be checked and adjusted frequently by the Ordnance Department, if necessary. No *abrasive* is permitted to be used on any part of the instrument by battery personnel.

Q. What special care is to be given the azimuth instrument M1910A1? *A*. An oilhole, closed by an oiler in the base of the yoke, provides a means for lubricating the internal bearings. Vaseline is used for lubricating worms and worm gearings. The opening covered by the spring cover in the rear surface of the body should be kept closed.

Q. How is the depression position finder M1907 cared for? *A*. This instrument should be oiled twice a year, paying particular attention to the table center and circular rack bearing surfaces, the unit-degree azimuth dial center, and the compensating screw. Vaseline, slightly thinned with paraffin oil, should be used on the compensating screw.

Q. How are self-contained range finders cared for? *A*. They should be kept in a dry place and covered when not in use. The optical parts of these instruments should be given the same care as telescopes of azimuth instruments and depression position finders.

CHAPTER 10

USE OF TRANSIT

47. General.—*Q*. What is the most practical method of locating gun positions? *A*. By means of a traverse from some point whose location is known. By traversing is meant the determination of the lengths and azimuths of a series of straight lines usually extending from a known point to the point desired.

Q. What instruments are used in making a traverse? *A*. A plane table with telescopic alidade or a transit.

Q. What are the uses of a transit? *A*. The transit is the most useful and universal of all surveying instruments. Besides measuring horizontal and vertical angles, it may be used to determine bearings by means of the compass and for leveling by means of the long bubble under the telescope. Distances may also be measured by means of stadia wires in the telescope.

48. Operation of transit.—*Q*. What are the steps in setting up a transit? *A*.

(1) Adjust the plumb bob over the stake.

(2) Level the instrument.

(3) Focus and eliminate parallax.

Q. Describe in general terms the method of leveling a transit or similar instrument. *A*.

(1) Turn the plates so that each plate level is parallel to a pair of opposite leveling screws. Each level is then controlled by the pair of leveling screws which lie parallel to it.

(2) Always move the two screws either toward each other or away from each other, not in the same direction. The bubble will follow the motion of the *left* thumb.

(3) If leveling screws are too tight, unscrew either but not both.

Q. What are some of the precautions to be used in the care of a transit? *A*.

(1) Never lift or hold the transit by the telescope or telescope supports. Grasp it beneath the horizontal limb or by the leveling head.

(2) Never force a screw.

(3) Do not set clamp screws as tight as possible.

(4) Never attempt to rotate the telescope, plate, or limb without seeing that the clamp is loosened.

(5) Do not rub off the object glass with a cloth. Blow it off or brush it off gently.

Q. What should be done before moving a transit from one position to another? *A.*

(1) Loosen the lower motion clamp.

(2) Point the telescope straight up and clamp very lightly.

(3) Lift the needle from the pivot if it has been used.

Q. How is a deflection angle measured? *A.*

(1) With the transit pointing at the station in rear (backsight), read and record the readings of both the A and B verniers.

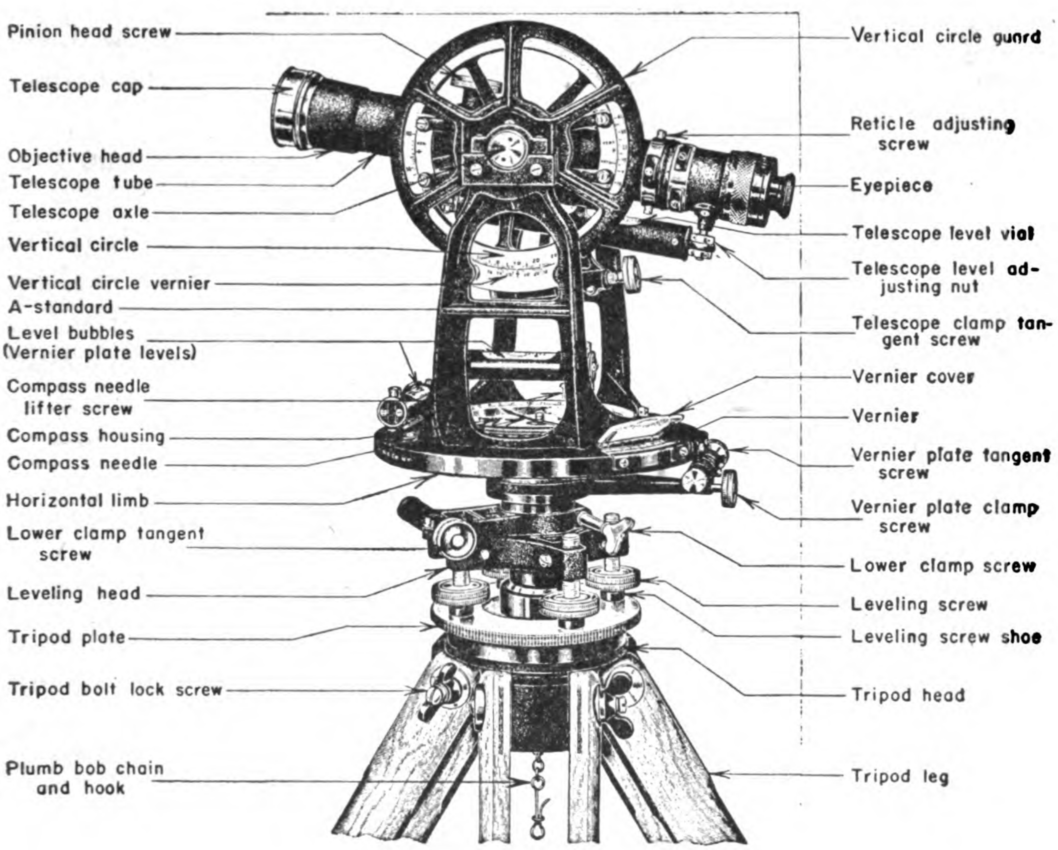


FIGURE 56.—Engineer's transit.

(2) Reverse the telescope by turning it 180° on its horizontal axis or trunnions, and note whether the forward station is to the right or left of the line of sighting. If the forward station appears on the right of the line of sighting with the telescope reversed, the deflection angle will be plus, and if on the left, minus.

(3) With the telescope still reversed, unclamp the upper motion, direct the line of sighting upon the next station, clamp the upper motion, and record the readings of verniers A and B.

(4) With the telescope still reversed, unclamp the lower motion and sight on the rear station.

(5) Reverse the telescope on its horizontal axis (turn it right side up), unclamp the upper motion, sight again on the forward station, and record the readings of both verniers.

(6) Compute the deflection angle by finding the differences of the vernier readings. If the transit is in adjustment, two values of the deflection angle should differ by not more than 1 minute. The value of the deflection angle should be taken as the mean of at least two readings.

49. Transit traverse.—*Q*. Describe the procedure of making a transit traverse. *A*.

(1) Set up the transit with its plumb bob over a station whose coordinates are known and which is at one end of the line whose azimuth is known and along which a point can be sighted. Call the transit position station 1.

(2) Measure the deflection angle between the orienting line and the next point at which the transit is to be set up (station 2).

(3) Measure with a tape or chain the distance from station 1 to station 2. Check the distance as thus measured with a stadia reading when possible.

(4) Set up the transit at station 2. Using station 1 as a backsight on which to orient, measure the deflection angle formed by the lines station 2=station 1 and station 2=station 3.

(5) Measure the distance station 2-station 3 and check by stadia.

(6) Set up at station 3 and continue the procedure until the gun position is reached.

(7) Whenever possible, close the traverse; that is, using the gun position as a station, continue by another route back to station 1.

Q. What are the personnel of a traverse party? *A*. Instrument man in charge, a recorder, two chainmen, and two rodmen. In case of necessity the rear chainman may also be front rodman and the instrument man can keep his own notes.

Q. How are the readings recorded? *A*.

(1) Rule up seven columns in a notebook.

(2) Column 1 contains names of stations and distances to the next succeeding station.

(3) Columns 2 and 3 contain readings of verniers A and B, respectively.

(4) Column 4 contains the mean or average readings.

(5) Column 5 contains the computed deflection angle.

(6) Column 6 contains the computed azimuth.

(7) Column 7 contains remarks and compass bearings which should be taken from time to time.

(8) Columns 1 to 4, inclusive, and 7 are filled in as the readings are taken. The others may be filled in after the traverse is completed. The following is a sample of record sheet:

TRAVERSE FROM BM 7 (x=726939.2) (y=1582611.0) TO GUN POSITION

(1) Station and distance (in feet)	(2) Vernier A	(3) Vernier B	(4) Mean	(5) Deflection angle	(6) Azimuth
	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″
Azimuth BM to station 1.[1]					115 24 30
Station 1 1,200	316 53 30	136 53 30	316 53 30		
	275 07 00	95 07 30	275 07 15	41 46 15	73 38 45
	233 22 00	53 22 00	233 22 00	41 45 15	73 39 45
				−41 45 45	
Station 2 1,900[2]	233 22 00	53 22 00	233 22 00		
	279 05 00	99 05 00	279 05 00	45 43 00	119 21 45
	324 48 00	144 48 00	324 48 00	45 43 00	119 23 45
				+45 43 00	
Station 3 2,250	324 48 00	144 48 00	324 48 00		
	342 08 00	162 08 00	342 08 00	17 20 00	136 41 52
	359 28 00	179 28 30	359 28 15	17 20 15	136 44 52
				+17 20 07	
Station 4 1,500	359 28 00	179 28 30	179 28 15		
	11 03 30	191 03 30	191 03 30	11 35 15	
	22 39 00	202 39 00	202 39 00	11 35 30	148 17 14
				+11 35 22	
Azimuth station					148 21 15
4 to station 5[3]	22 39 00	202 39 00	22 39 00		
station 5.[4]	17 38 00	197 38 00	17 38 00	5 01 00	
	12 38 00	192 38 00	12 38 00	5 00 00	143 20 45
				−5 00 30	

[1] BM No. 7 is back sight for station 1. Distance BM No. 7 to station 1 is 870 feet. The azimuth, BM to station 1, is computed from astronomical observations.

[2] Magnetic bearing S 54°45′ E.

[3] Azimuth, station 4 to station 5, is computed from astronomical observations.

[4] Foresight at station 5 was taken on the gun. Distance station 5 to gun is 23 feet.

Chapter 11

INSTRUCTION OF RANGE SECTION

50. Instruction of members of range section.—The candidate should be required to demonstrate practically his ability to instruct one or more members of the range section. General duties of members of the range section are outlined in TM 4-315. Modifications are made in assignments depending upon the plotting room equipment actually in use.

CHAPTER 12

OBSERVATION

SECTION I

OBSERVATION OF FIRE AND APPLICATION OF CORRECTIONS

51. Observation of fire.—*Q*. What is spotting? *A*. The process of determining deviations or sensings for use in adjustment of fire.

Q. What is spotting by sensing? *A*. Locating the position of a splash from the target, in sense only, as over or short, right or left. This method of spotting is used with the bracketing method of adjustment.

Q. What is spotting by sense and magnitude? *A*. Finding the direction and distance of a splash from the target, as so many yards over or short, so many mils (or hundredths of a degree) right or left. This method of spotting is used with the magnitude method of adjustment.

Q. What are the two general methods of spotting? *A*.

(1) Terrestrial.

(2) Aerial.

Q. What are the two classes of terrestrial spotting systems? *A*.

(1) Where two instruments some distance apart are used (two-station or bilateral).

(2) Where one instrument or station is used (single-station).

Q. Classify the spotting systems using only one spotting station. *A*. The systems are called—

(1) Axial, if the angle battery-target-station is less than 5°.

(2) Unilateral, if this angle is between 5° and 75°.

(3) Flank, if this angle is more than 75°.

Q. In axial spotting what effect does height of site have on the accuracy of range sensings? *A*. Increasing the height of site should increase the accuracy of range sensings by making the relative positions of target and splash more easily seen.

Q. What deviations can be determined by axial spotting? Flank spotting? *A*.

(1) Axial spotting can be used to determine the magnitude of lateral deviations and the sense of range deviations. If the height of site is great enough, the magnitude of the range deviation can be determined by using a depression position finder.

(2) Flank spotting can be used to determine the sense of the range deviations.

Q. Can the stereoscopic range finder be used as a spotting instrument? *A*. Yes. Its use will greatly facilitate axial spotting.

Q. Explain briefly bilateral spotting. *A*. Two instruments are used, one at each end of a base line. The angular deviation of the impact (or center of impact) from the target as seen from each station is read by the observer. These deviations are set into a graphical spotting board and the range and lateral deviations with respect to the battery are read from it.

Q. On what part of the splash should a spotting observer read? *A*. On the side of the splash toward the guns.

Q. If two or more batteries are firing at the same time, how may a spotting observer be helped in identifying splashes? *A*. By the chief spotter telling him when a shot is fired and calling "splash" at the end of the time of flight.

Q. Why should fire be observed whenever possible? *A*. The presence of systematic errors may result in the center of impact being off the target. In observed fire this can be corrected for by introducing adjustment corrections to obtain the maximum probability of hitting.

52. Application of corrections.—*Q*. What is the purpose of adjustment of fire? *A*. To place the center of dispersion on the target and keep it there.

Q. What is a probable error? *A*. The error which is as likely as not to be exceeded. A value which will, in the long run, be exceeded half the time and not be exceeded half the time.

Q. What is a fork? *A*. Four probable errors. For example, if the probable error is 50 yards, then a fork would be 200 yards.

Q. What is trial fire? *A*. Usually four shots fired with the object of obtaining a correction which will cause the target to be within three probable errors of the center of dispersion.

Q. What is fire for effect? *A*. Fire for the purpose of obtaining destructive effect on the target by placing the center of dispersion on the target and keeping it there. It should follow the trial fire with as little delay as possible.

Q. What methods of trial fire may be used. *A.*

(1) Ranging salvos at the target with corrections applied after the last salvo based on the center of impact of all salvos. (A correction may be applied after the first salvo if its center of impact is more than two gun probable errors from the target.)

(2) Single ranging shots at the target with corrections based on the center of impact of all shots, applied after the last shot.

(3) Single ranging shots at the target, with a correction applied after the last shot if the deviation of that shot is more than three probable errors of the target; and a final correction based on the average of all deviations, taking into consideration any correction applied during the firing of the trial shots.

(4) Four shots fired with the same data at a fixed point in the water with corrections based on the center of impact of all shots, applied after the last shot.

(5) Bracketing method. Fire by salvos or single shots until a bracket of one fork has been obtained.

Q. Explain the method used in your battery for adjusting fire in direction. *A.* ———.

Q. What are the two methods of adjustment of fire for range. *A.*

(1) Magnitude method (when the amount and sense of the deviation are known).

(2) Bracketing method (when the sense only of the deviation is known).

Q. What is meant by stripped deviation? *A.* The deviation which would have occurred had no adjustment correction been applied, and had there been no personnel errors.

Q. What is meant by stripped center of impact? *A.* The algebraic mean of the stripped deviations.

Q. What is the standard fire adjustment board? *A.* Fire adjustment board M1. (See fig. 57.)

Q. What does this board accomplish? *A.* It provides means of plotting stripped deviations, of determining quickly this stripped center of impact, and of determining the proper adjustment. It provides also a permanent record of the adjustment.

Q. What instrument is used to apply the adjustment correction determined on the fire adjustment board? *A.* The percentage corrector.

Q. Explain the operation of the fire adjustment board M1. *A.*

(1) A piece of cross-section paper (10 divisions to the inch) is fastened to the board so that the horizontal lines are parallel to the edge of the T-square. Every tenth vertical line—that is, each whole percent line—is numbered each way from the center, 300, 290, 280, etc.,

to the left and 310, 320, etc., to the right. Numbers should be placed at the top and should be repeated on horizontal lines about every 2 inches below the top. Time is plotted vertically to any convenient scale, or shots or salvos may be plotted vertically at equal intervals.

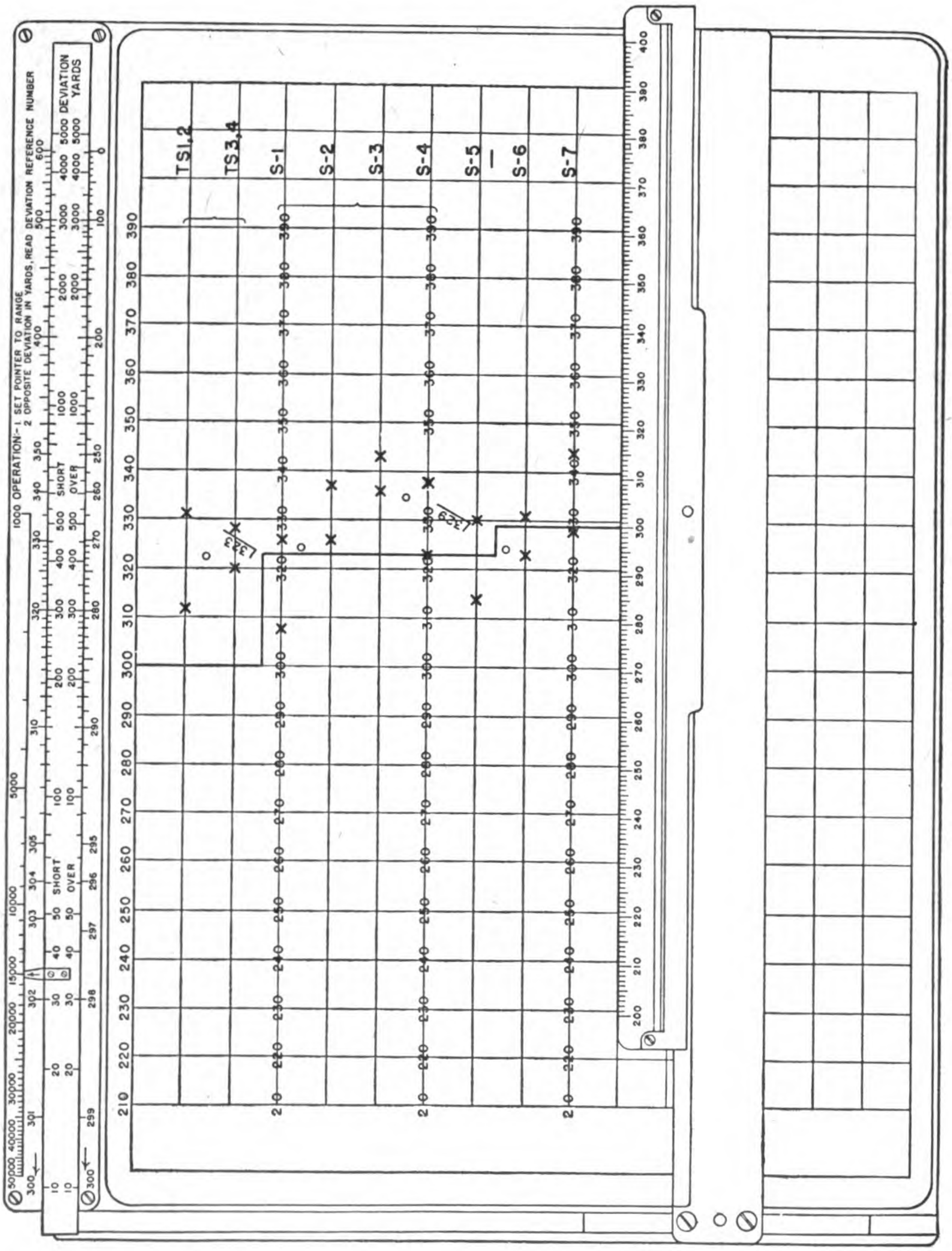


FIGURE 57.—Fire-adjustment board M1.

Except where fired with different adjustment corrections, all trial shots are usually plotted on the same horizontal line.

(2) To begin the adjustment, bring the reading edge of the scale on the T-square just below the horizontal line on which the trial shots are to be plotted, with the normal of the scale (300) on the

300 line of the chart. (Until an adjustment correction is made, the 300 line of the chart is the "line of targets" and the scale is not absolutely necessary.) Each correction of the trial shots (or trial salvo) received in reference numbers from the spotting board is plotted with a cross (×). A center of impact of four shots is indicated by a small circle (O). A check mark is made to indicate the center of impact of the trial shots and the adjustment correction is read from the chart at the top of the chart or at the nearest set of numbers above the check mark. It is sent to the percentage corrector where it is applied on the adjustment correction scale. The amount of the correction ordered is written above the check mark. A new line of targets is drawn downward below this check mark at the proper place and the 300 mark on the scale is then brought to this new line. A horizontal line may be drawn to connect the old line of targets with the new line.

(3) When fire for effect begins, the operator checks off with an (S) each salvo as fired. With the normal of the scale on the line of targets, he plots with a cross (×) on the proper horizontal line each correction received. (A center of impact of four shots is indicated by a small circle.) If a new correction is made after the impacts of the first shots (or the salvos comprising them) have been plotted, the normal of the scale is brought to the center of impact of both trial fire and fire for effect, and the new correction is read from the nearest scale on chart. (Under certain conditions trial fire is not considered.) If some crosses indicate single impacts and others indicate salvos, this fact must be considered in giving them weight in determining the position of the center of impact. Crosses for impacts of salvos are marked with an exponent equal to the number of shots in the salvo. As soon as the correction is ordered, a check mark (√) is made at the proper position and the amount of the correction ordered is written above it. As soon as an elevation or range carrying this correction is transmitted to the guns, the percentage corrector operator reports, "Correction applied." The group of impacts on which a correction is based is indicated by a bracket. From a consideration of the salvos fired a horizontal mark on the side of the chart is made, indicating the salvo on which the correction is applied. A new line of targets is then drawn downward beneath the check mark and the normal (300) of the scale is brought to this line for plotting of the next shots.

(4) This procedure is continued throughout the firing, additional corrections being made to keep the line of targets on the center of impact of the preceding shots.

(5) If deviations are received in yards, as in aerial spotting, the slide rule at the top of the board is used to convert these deviations into reference numbers. The slide is moved until the arrow is at the range to the set-forward point for that particular shot or salvo. Opposite the deviation in yards is read the proper reference number for use in plotting that shot or salvo.

Q. What indicates the corrections applied? *A*. The line of targets indicates the magnitude of the correction and the salvos on which each is applied. The correction is positive (greater than 300) if it is to the right of the axis of correction, and negative if to the left.

Q. What indicates the actual deviations? *A*. The distance from any cross (×) to the line of targets indicates the magnitude of the

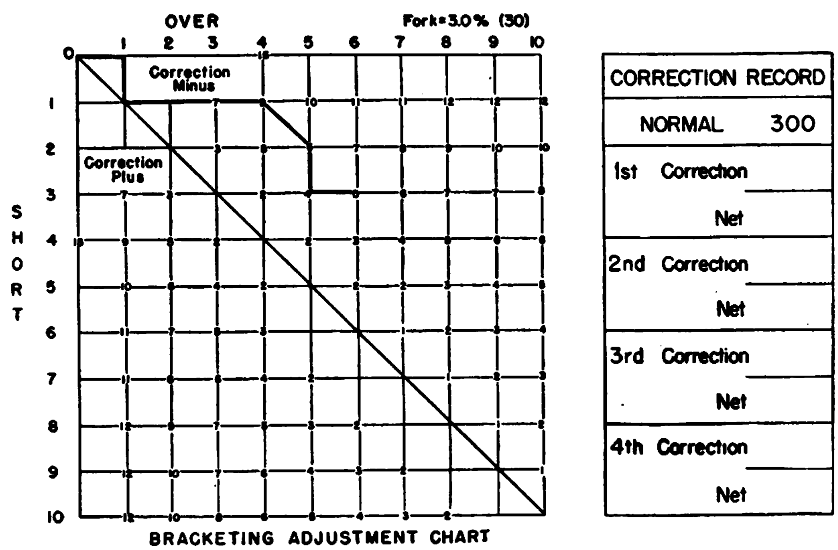


FIGURE 58.—Bracketing adjustment chart, grid type.

deviation, short if the cross is to the right of this line, and over if to the left.

Q. What indicates the stripped deviations? *A*. The distance from any plotted deviation (×) to the 300 line of the chart measures the stripped deviation of the impact, short if the cross is to the right of this line, and over if to the left.

Q. What is the over-short adjustment rule? *A*. It is the rule followed in adjusting fire by the bracketing method. The correction applied is found by taking the difference between the "overs" and "shorts" divided by twice the number of shots, times one fork.

$$\frac{S-0}{2\,(S+0)} \times \text{fork} = \text{correction}$$

Q. How can this rule be applied rapidly and accurately? *A*. By using a bracketing adjustment chart.

Q. Explain the use of the bracketing adjustment chart, grid type.
A. The operator using the chart starts with a heavy or colored pencil at the upper left-hand corner. The first sensing being an "over," he draws the line horizontally one square. The next being a "short," he continues downward one division. The next three being sensed as "over," the line is continued three divisions to the right. The next shot was a "hit" and the line is drawn diagonally across the next square because a hit is counted as both an "over" and a "short." A "short" and an "over" bring the line to the intersection of "over" 6

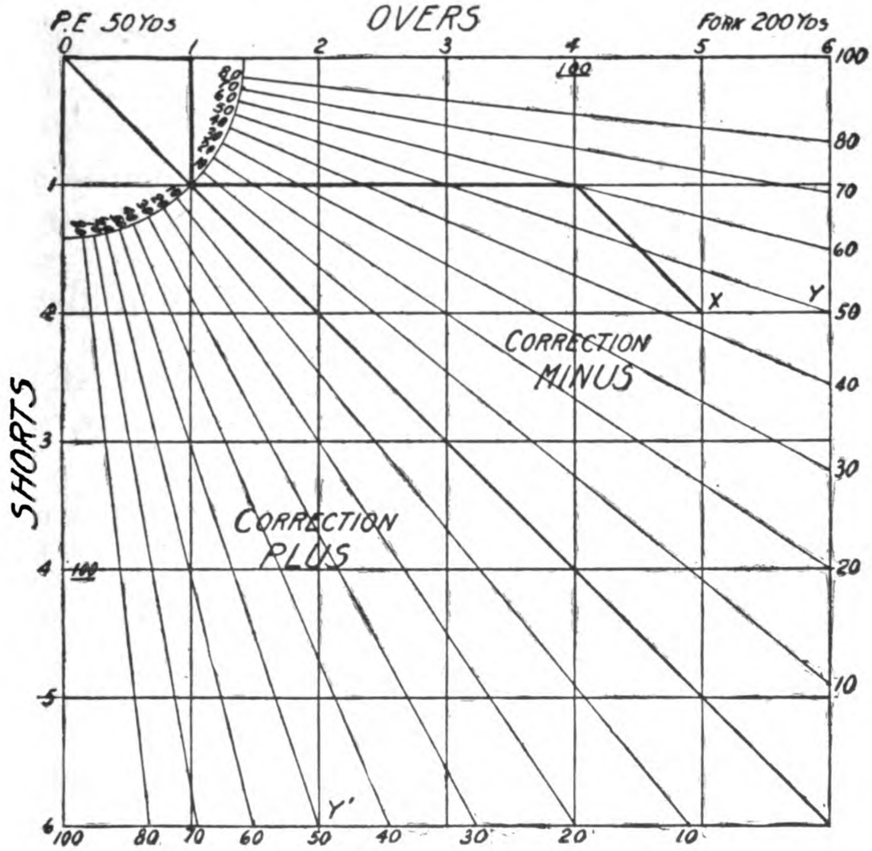


FIGURE 59.—Bracketing adjustment chart, ray type.

and "short" 3, and the correction "minus" 5 (5 percent) is indicated. If this correction is to be sent to the percentage corrector, it must be converted to reference numbers by adding algebraically to 300. This computation is made and the record of corrections is kept conveniently on the correction record at the right of the chart. The correction would thus be $300-5=295$, which would be set on the adjustment correction scale of the percentage corrector. The operator waits until he is certain that shots are falling carrying the ordered correction and then starts a new graph with a new chart or with a pencil of another color. The next correction indicated would be added algebraically to 295, the previous correction.

Q. Explain the use of the ray type of bracketing adjustment chart. *A.* This chart is operated in a similar manner to that used to operate the grid type chart. Instead of numbered intersections (as in the grid type), rays are used to indicate the corrections in yards in the desired amounts. The value of the correction corresponding to a particular intersection is determined by noting the ray that passes closest to the intersection (or by interpolating between the two closest rays).

Section II

SPOTTING BOARDS

53. Spotting boards, general.—Q. What is the purpose of a spotting board? *A.* To determine the amount the splash is over or short and right or left of the target.

Q. What use is made of the data determined on a spotting board? *A.* It is used as a basis for adjustment of fire.

Q. What spotting boards may be found in service? *A.* M2, M3 (recently adopted but not yet extensively issued), Gray, and Cole spotting boards.

Note.—In addition to the general questions contained in this paragraph, the candidate will be instructed in the use of the particular spotting board in use in the battery. If the board used is the M2 board described in paragraph 54, that paragraph will be used; if not, questions of a similar scope will be used to cover the particular board in use.

54. Spotting board M2.—*Q.* Describe the orientation of the spotting board M2. *A.*

(1) See that the proper scales are inserted in the target range scale (C) and the spotting platens (J).

(2) See that the proper sides of the deviation grid (B) and deviation disks (L) are up. (The proper side of the deviation grid is the one marked "range deviation percent." The proper side of each deviation disk is the side marked "degrees." The other side of the grid and the other sides of the two disks are no longer used, they having been graduated for use with a method of fire adjustment now obsolete.)

(3) See that the scales on the deviation grid are properly graduated. The numbers on the longitudinal scale should increase from the normal toward the lower end (orienting disk end) of the board and decrease from the normal toward the upper end. The numbers on the lateral scale should increase to the left (as seen by a person facing the board at the lower end) and decrease to the right of the normal. If the

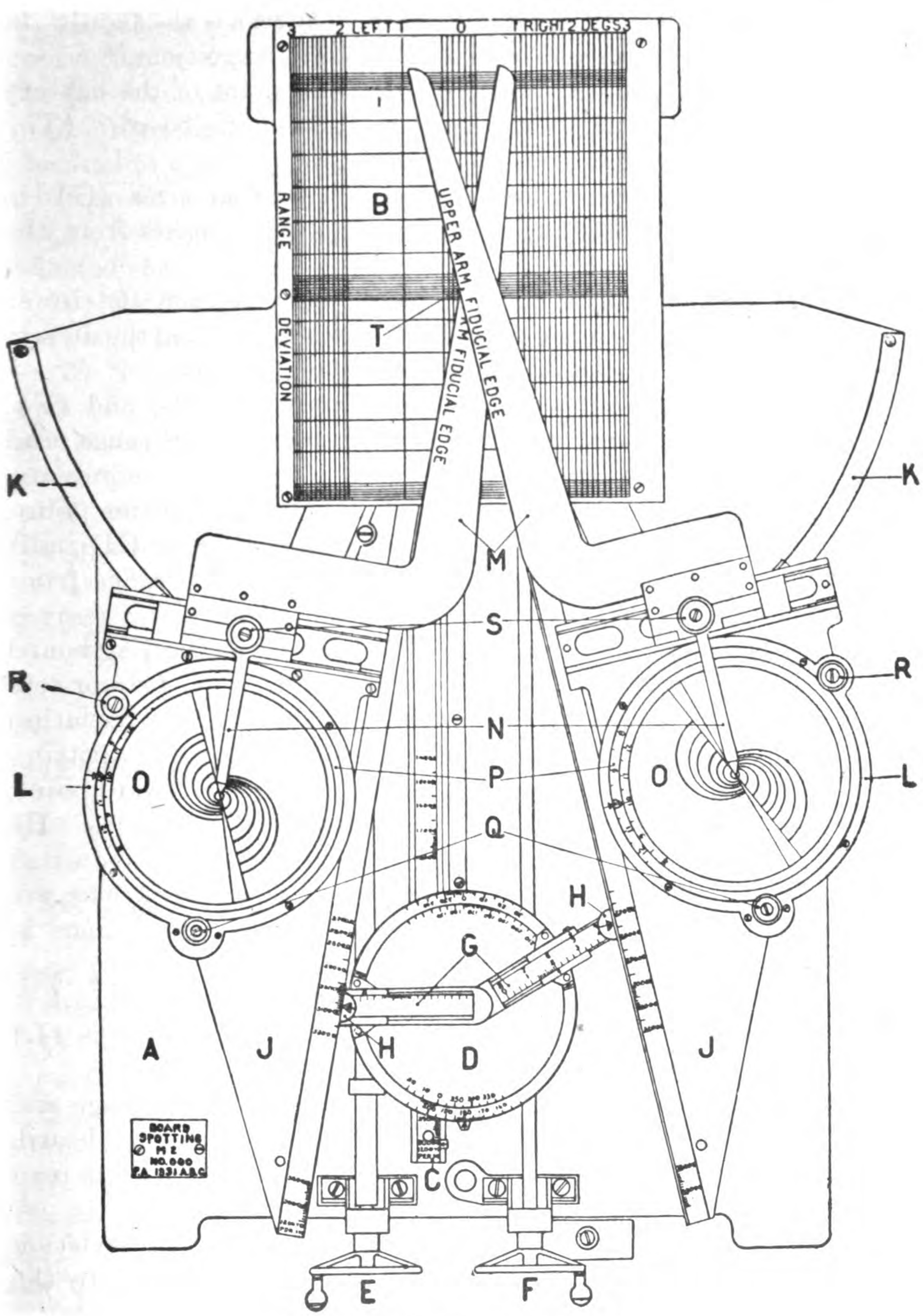


FIGURE 60.—Spotting board M2.

numbers engraved on the grid are contrary to this, they should be covered with adhesive tape or paper and the scales should be remarked. Further, the words "range deviation" appearing on the longitudinal scale of the grid should be changed to "range correction"; and the words "left" and "right" appearing on the lateral scale should be covered and that scale should be marked "lateral corrections."

(4) Convert the distances from the directing point of the battery to each spotting station into inches at the scale of the board. (The graduations on the station arms are in inches.)

(5) Loosen the clamp screws holding the station arms (G) in position and set each station to its proper distance in inches from the directing point.

(6) Turn each station arm until its index reads (on the inner azimuth circle of the orienting disk (D)) the azimuth from the directing point to that spotting station. Tighten clamp screws.

(7) By turning the range and azimuth handwheels (E) and (F), the indices of the orienting disk are made to read the range and azimuth of any target in the field of fire. The board then represents, to scale in their proper relative position, the target, the directing point, and each spotting station. The index on each station targ (H) indicates on the range scale of each spotting platen (J) the range from that station to the target.

Q. How many operators are required to operate the spotting board M2? What are their duties? *A.* Two operators. One operator sets the range to the set-forward point and operates the left-hand deviation disk. He is connected by telephone to the corresponding spotting station. The other operator sets the azimuth to the set-forward point, operates the right-hand deviation disk, and reads the corrections. He is connected to the other spotting station by telephone.

Q. In what units are readings made? *A.* Range corrections are read in percent (by reference numbers) and direction corrections in degrees and hundredths (by reference numbers).

Q. Explain in detail the operation of the spotting board M2. *A.*

(1) See that the deviation grid (B) and the deviation disks (L) are set with the proper faces up.

(2) Keep the orienting disk (D) set to the uncorrected range and azimuth to the set-forward point as determined on the plotting board.

(3) Set the gun range ring (P) on each deviation disk (L) to read the range from the directing point to the target.

(4) Set the range scale on the inner plate (O) of each deviation disk (L) to the range from that station to the target as shown by the reading of each station targ (H) on the spotting platen range scales.

(5) Set each deviation pointer (N) to the curve corresponding to the splash reading reported by the spotting observer at that station.

(6) On the grid (B) read the range and lateral correction indicated by the intersection of the deviation arms (M).

Q. How may the "zero" of the deviation pointers (N) be checked?

A. Set the deviation arms (M) to indicate the zero range and lateral correction on the grid (B). The deviation pointers (N) should be at the center, or zero, of the curves on the inner plate (O).

Q. When the spotting board M2 has been oriented, how may it be checked to assure that it is functioning properly? *A*. Make a check with previously computed data as follows:

(1) Set the orienting disk (D) to the range and azimuth of the selected check point.

(2) Set the gun range ring (P) on each deviation disk (L) to read the range from the directing point to the check point.

(3) Set the range scale on the inner plate (O) of each deviation disk (L) to the range from the station to the check point as shown by the reading of each station targ (H) on the spotting platen range scales.

(4) Set each deviation pointer (N) to the curve corresponding to the splash readings selected.

(5) The deviation arms (M) should indicate on the grid (B) the correct range and lateral corrections for the selected conditions as computed arithmetically.

Section III

GENERAL DUTIES OF OBSERVERS IN OBSERVATION POSTS

55. Duties of observers.—*Q*. What is the purpose of an observer? *A*. To observe and report all enemy activity.

Q. When is a report made concerning enemy activity? *A*. As soon as observed.

Q. What record is kept in an observation post? *A*. Observer's report.

Q. What is done with this report? *A*. It is sent to the unit commander at times specified.

Q. What are the general duties of an observer in a seacoast artillery observation post? *A*.

(1) To obtain definite information as to the location of the observation post, and at least one reference point, in order to orient the instruments.

(2) To take charge of the observation post, all apparatus therein, readers and all other personnel assigned, and be responsible for the condition of all apparatus, and that the readers are proficient in their duties.

(3) To report promptly any enemy activity observed.

(4) During drill or action, to observe the location of any target indicated to him and see that information as to the azimuth and movements of the target is promptly transmitted to the plotting room, and when necessary, to the battery commander's station.

(5) When it is necessary to maintain a continuous watch for the enemy, to see that the man on watch is properly instructed as to his duties, that reliefs are made at stated intervals, and that suitable provision is made for meals and rest.

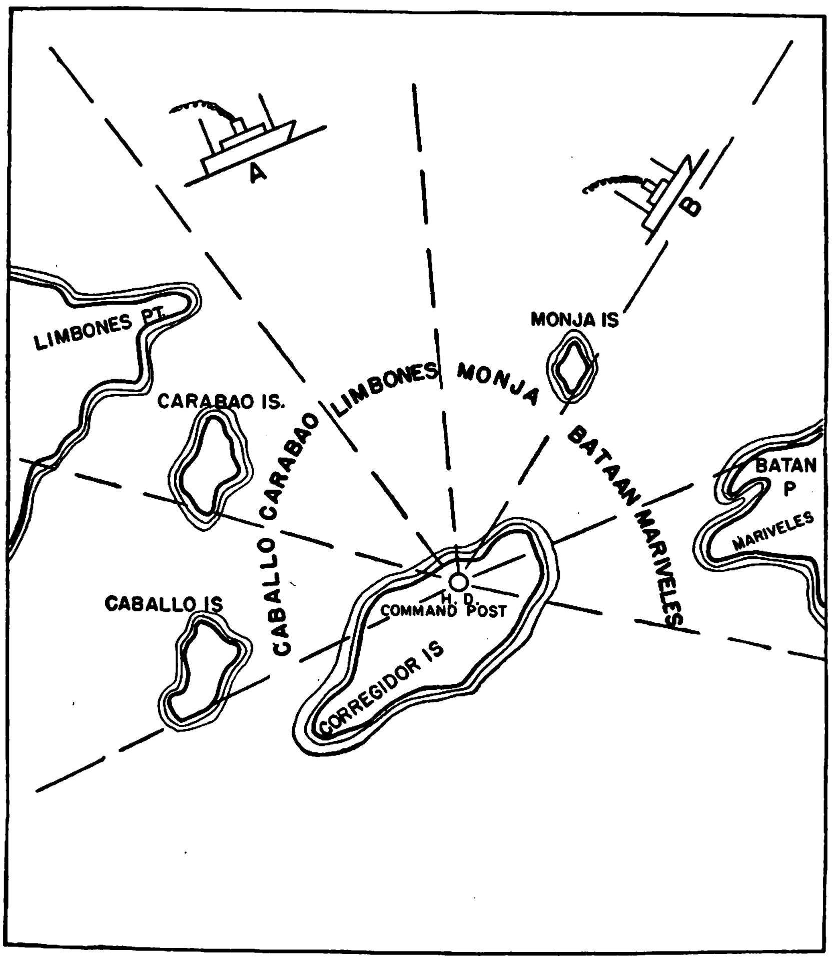


FIGURE 61.—Subdivision of harbor defense water area.

Q. What should the man on watch at an observation post report? *A.* Any indication of enemy activity, whether sounds, lights, a smoke screen, or movements of vessels. Any vessel seen should be reported, with its location, its apparent course and speed, any description which will aid in identifying it, and the time of the observation. As far as possible, the same information will be given as to aircraft over the area of observation from that post.

Q. Why is it necessary to identify approaching aircraft? *A.* So that friendly troops will not be needlessly disturbed if the aircraft is friendly, and so that if hostile aircraft is approaching, warning can be given by means of a flash message.

Q. How may the general position of a naval or aerial target be indicated? *A*. In the case of a naval target, the water area adjacent to a harbor defense is organized into subdivisions and each subdivision given a name. In the case of an aerial target, the entire area (360°) is divided into sectors.

Q. How does an observer indicate the location of a target? *A*. He may locate it according to the water area or sector as seen from his post, giving direction of movement, and in the case of an aerial target, the altitude (high, medium, or low); by giving the azimuth and range to the target; or when a grid system is used, by designating the grid square in which the target is operating.

Q. Where does the observer get the information as to the division of the areas which he is required to observe? *A*. Each observation station should be furnished with a map or chart showing the subdivisions of the area. The chart should be kept oriented.

Chapter 13

TARGETS, LOCAL SHIPPING, AND WATER AREAS

Section I

NAVAL TARGETS

56. Indication.—*Q*. How are naval targets indicated? *A*. By stating the subarea and the name (or type and class) of a single ship; or subarea, type, formation, direction of movement, ship number, and class, when target is one of a group of ships.

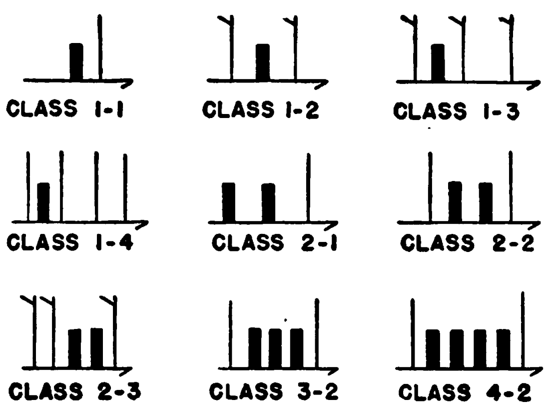


Figure 62.—Classification of ships.

Q. How would the leading destroyer of a column in water subarea Rudy be assigned as a target? *A*. 1. Target. 2. Rudy. 3. Destroyer division in column. 4. Leading ship. (Observers, spotters, and gun pointers report on target.) 5. Track.

Q. How may ships be classified by the number of funnels and masts? *A*. By stating the number of funnels followed by the number of masts. Thus a ship with three funnels and two masts would be designated as "class 3–2."

57. Identification and characteristic features.—*Q*. How may warships be classified? *A*. Warships are classified broadly as follows:

(1) Capital ships, mounting guns of a caliber exceeding 8 inches, including battleships and battle cruisers.

(2) Noncapital ships, mounting guns 8 inches and smaller, including cruisers, destroyers, aircraft carriers, and submarines.

Q. What are the purpose and characteristic features of each type?

A.

(1) *Capital ships.*—(*a*) Battleships (BB) form the first line of battle. They are the most formidable type of war vessel and combine powerful weapons with the greatest protection possible. To carry the heavy guns and armor required to give maximum offensive and defensive power, speed has to be sacrificed to a certain extent. Characteristic features of battleships are great size, moderate speed, heavy armor, large guns in turrets, massive appearance, low to medium freeboard, and broad beam. Their main batteries are of a caliber exceeding 8 inches and may include 16-inch guns with an effective range of 35,000 yards.

(*b*) Battle cruisers (CC) are similar in appearance to the battleships although their lines are finer. They carry the maximum caliber guns practicable, though fewer in number, and their armor protection is less than that of a battleship. This saving in weight is used to gain greater speed, permitting them to leave the battle line to gather information and yet be able to return in time to join the main action.

(*c*) Pocket battleships are small armored ships mounting guns of large caliber. They are capable of greater speed than are the battleships.

(*d*) Other capital ships include those provided for coast defense, carrying large-caliber guns but having a very limited speed and cruising radius. Monitors are an example of this type.

(2) *Noncapital ships.*—(*a*) Airplane carriers (CV) are large ships of considerable displacement, moderate to high speed, some of them armored, armed with moderate-sized guns, and carrying a large number of planes which are launched from and landed on specially constructed decks. The landing deck and the peculiar arrangement of the funnels and superstructure render these ships unmistakable. They are vulnerable to gunfire on account of their size and limited protection.

(*b*) Cruisers vary from fairly fast, heavily armed, moderately armored, large ships, to fast, lightly armed, unarmed ships of moderate displacement. First-line cruisers are from 7,500 to 10,000 tons displacement mount guns up to 8 inches in caliber, have up to 5 inches in side armor, and are capable of speeds in excess of 32 knots. They are intended for scouting, screening fleet movements, raiding, and similar purposes. Cruisers may be further classified as—

1. Heavy (CA), armed with 8-inch or near 8-inch guns.

2. Light (CL), armed with guns usually 6 inches or less.

3. Antiaircraft (AA), whose total armament may be used against aircraft.

(*c*) Destroyers (DD) are high-speed, unarmored naval vessels of approximately 1,500 tons displacement armed principally with torpedoes. In addition to making torpedo attacks, they may employ depth charges against submarines and may be used as mine layers. They mount guns of less than 6-inch caliber for their own defense and to attack unarmored enemy vessels.

(*d*) Submarines (SS) operate either under water or awash (on the surface). They are armed with the torpedo; the larger ones with mines and guns in addition. Aside from raiding operations, reconnaissance, and attempts against vessels within a fortified harbor, submarines have little use against coast defenses.

(*e*) Torpedo boats (PT) are similar to, but generally inferior to, destroyers.

(*f*) Minor war vessels consist of gunboats, mine layers (CM), escort vessels, and patrol vessels.

(*g*) Auxiliary vessels consist of such ships as transports (AP), hospital ships, tenders, mine sweepers (AM), and tugs. Transports and mine sweepers are usually commercial vessels with no armor and with but a few guns of 6-inch or smaller caliber. All vessels of this type are exceedingly vulnerable to the fire of all types of seacoast armament.

(*h*) Small craft consist of small auxiliary vessels and the modern motor torpedo boat, a small vessel of great speed armed with torpedoes, mines, and automatic weapons.

(*i*) Landing boats may vary from small, fast surf boats with a capacity of one squad, to large self-propelled lighters capable of landing light tanks. All may be armed with automatic weapons.

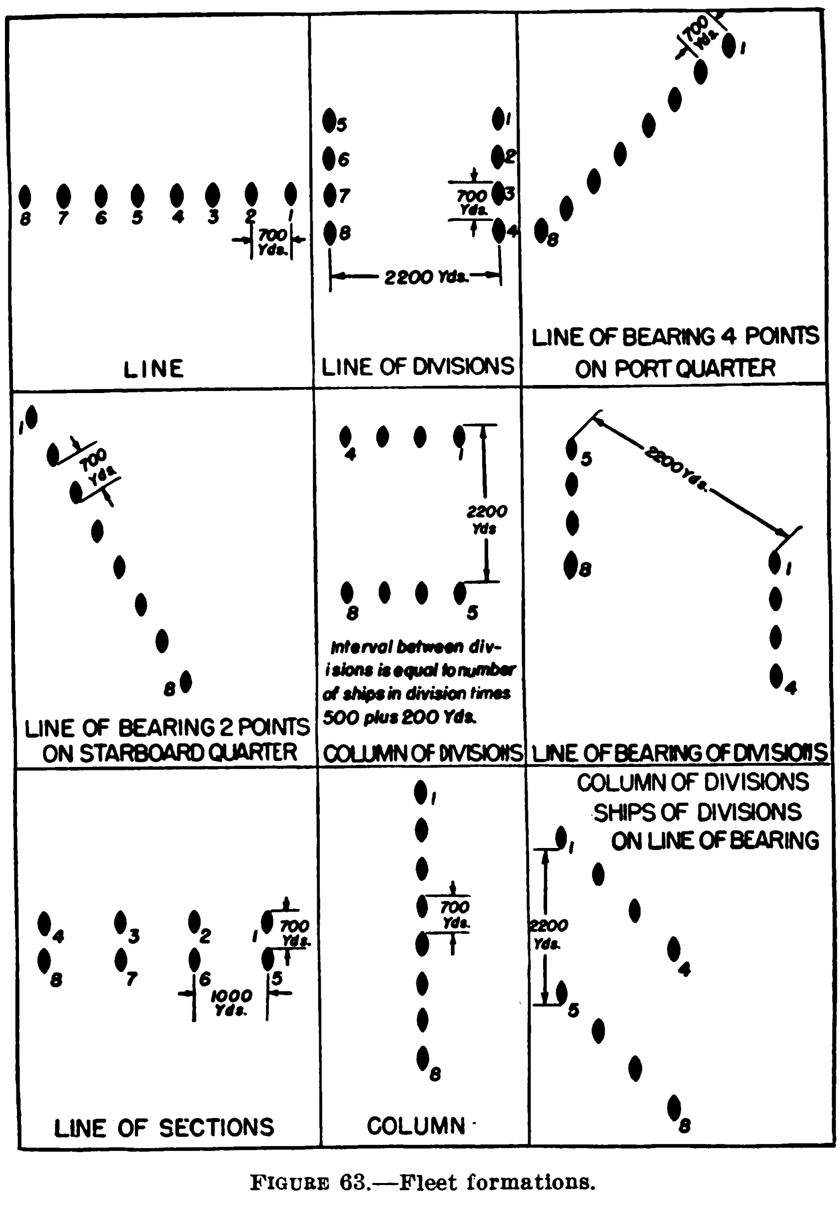
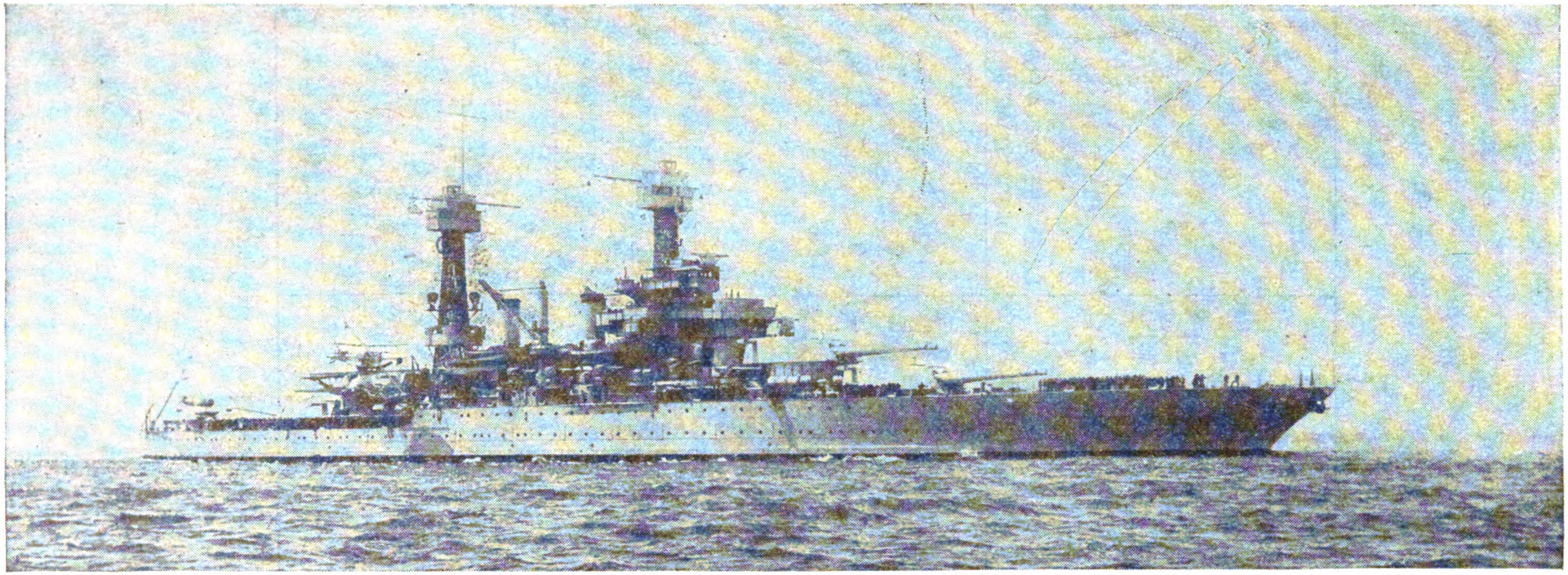


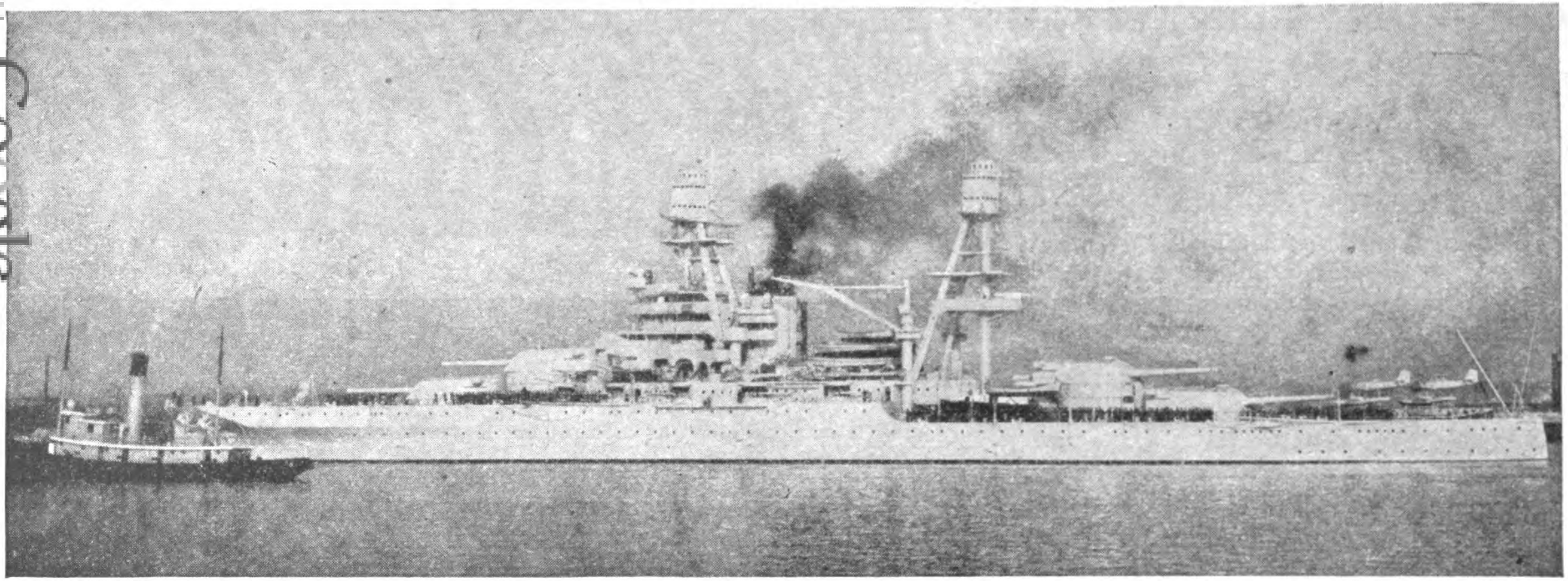
FIGURE 63.—Fleet formations.



Displacement : 32,000 tons.
Length : 624 feet.
Beam : 97 feet.
Draft : 31¼ feet.
Guns : eight 16-inch, twelve 5-inch, eight 5-inch (AA).

Armor : belt 16- to 14-inch, deck 3-inch, turrets 18- to 9-inch, conning tower 16-inch.
Torpedo tubes : two 21-inch submerged.
Speed : 21 knots.
Sister ships : *Colorado* and *Maryland*. The *California* and *Tennessee* are similar.

FIGURE 64.—United States battleship *West Virginia*.

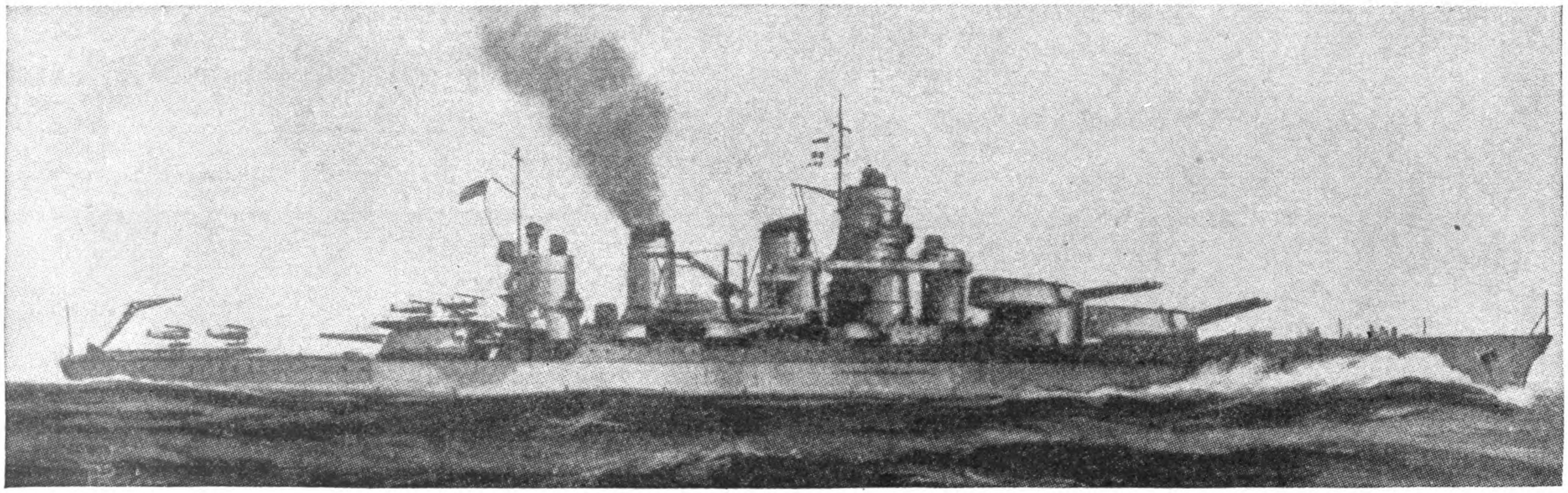


Displacement : 32,100 tons.
Length : 608 feet.
Beam : 97 feet.
Draft : 29⅝ feet.
Guns : twelve 14-inch, fourteen 5-inch, eight 5-inch (AA).

Armor : belt 13½-inch, deck 3-inch, turrets 18- to 9-inch, conning tower 16-inch.
Torpedo tubes : two 21-inch submerged (probably removed now).
Speed : 21 knots.
Sister ship *Pennsylvania*.

FIGURE 65.—United States battleship *Arizona*.

NOTE.—Ships of the class shown in figure 65, as well as those of the *Nevada* and *New Mexico* classes, either have been or are being remodeled. The alterations consist of the substitution of tripod for cage masts, 5-inch cal. 25 AA guns for 3-inch AA, increased underwater protection, additional protective deck armor, and a certain amount of rearrangement of the torpedo defense and AA batteries. Because of these modifications the data given above may not be exactly correct. New engines have been installed to compensate for any increased weight in order to maintain the designed speed.



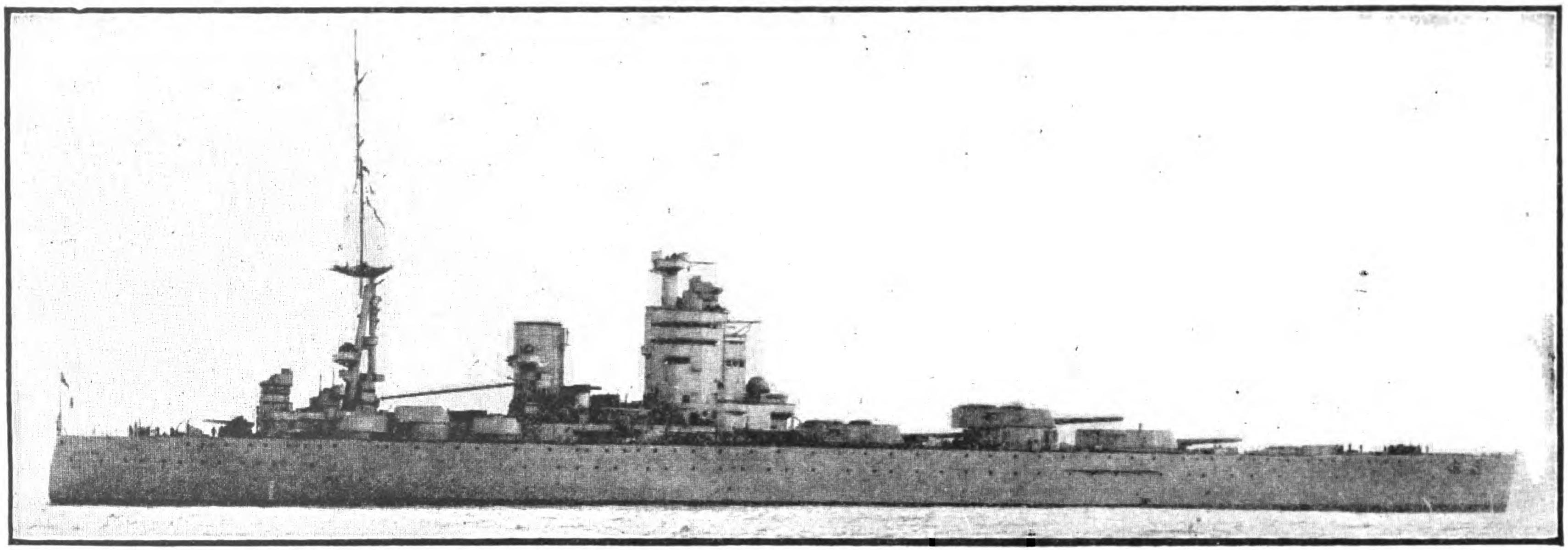
Displacement : 35,000 tons.
Speed : 30 knots.
Guns : nine 16-inch, twenty 5-inch dual purpose.

Aircraft : 4.
Armor : belt 16-inch, upper deck 6-inch, lower deck 4-inch.
Length : 750 feet.

FIGURE 66.—United States battleship *Washington*.

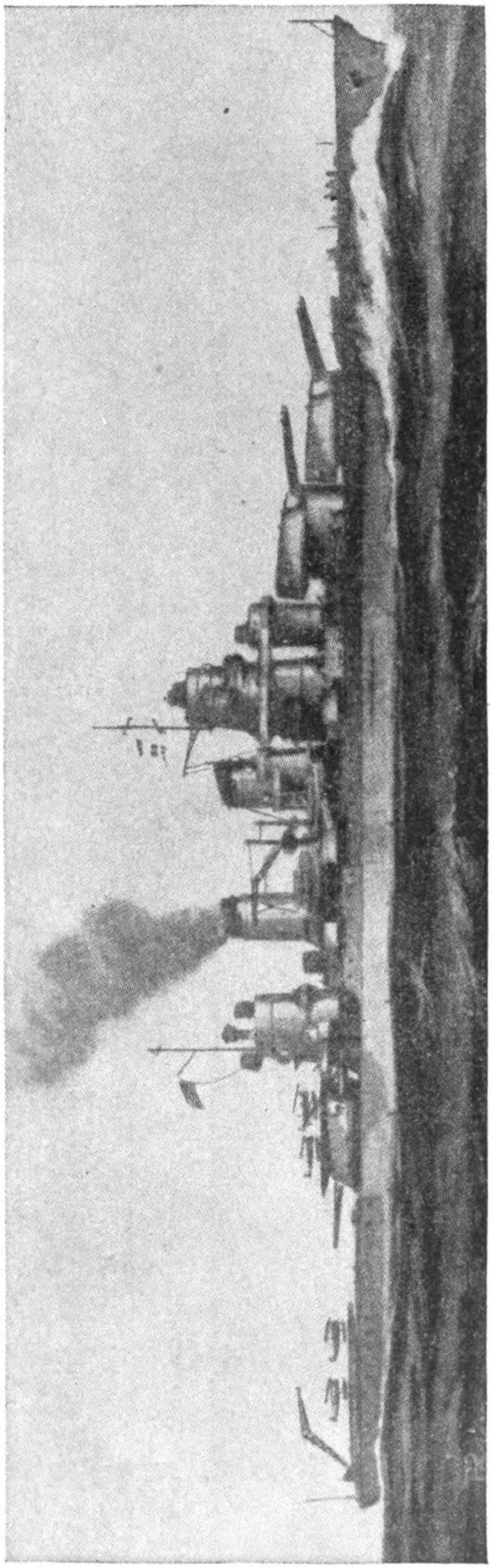
①

Displacement : 35,000 tons.
Length : 710 feet.
Beam : 106 feet.
Draft : 32 feet.
Torpedo tubes : two submerged.
Speed : 23 knots.
Guns : nine 16-inch, twelve 6-inch, six 4.7-inch (AA).
Armor : belt 14-inch, turrets 16- to 9-inch, deck 6¼-inch.



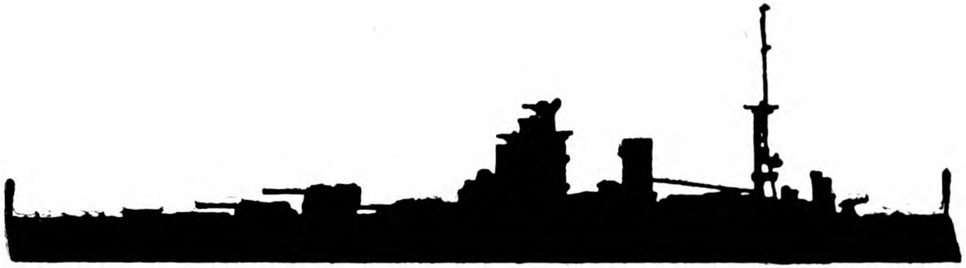
②

FIGURE 67.—British battleship *Nelson* (sister ship *Rodney*).



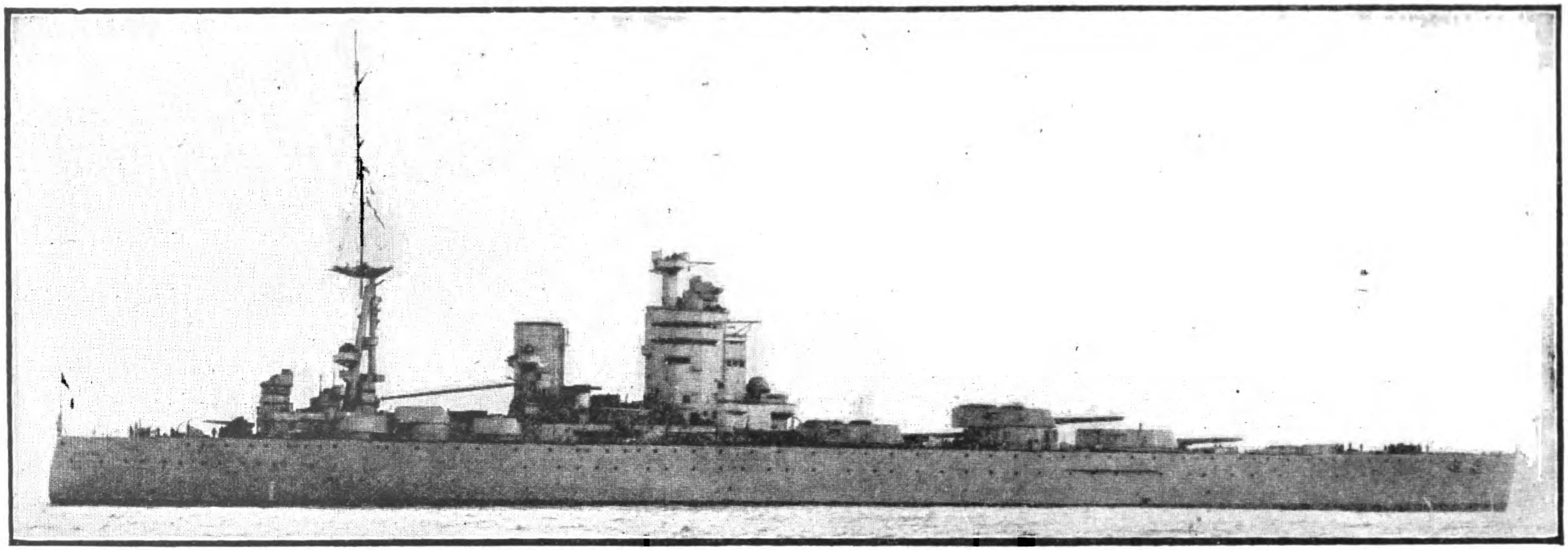
Displacement : 35,000 tons.
Speed : 30 knots.
Guns : nine 16-inch, twenty 5-inch dual purpose.
Aircraft : 4.
Armor : belt 16-inch, upper deck 6-inch, lower deck 4-inch.
Length : 750 feet.

FIGURE 66.—United States battleship *Washington*.



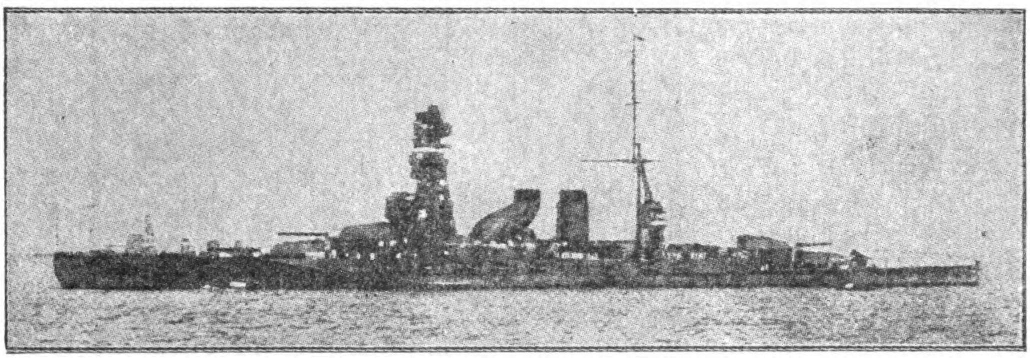
①

Displacement : 35,000 tons.
Length : 710 feet.
Beam : 106 feet.
Draft : 32 feet.
Torpedo tubes : two submerged.
Speed : 23 knots.
Guns : nine 16-inch, twelve 6-inch, six 4.7-inch (AA).
Armor : belt 14-inch, turrets 16- to 9-inch, deck 6¼-inch.



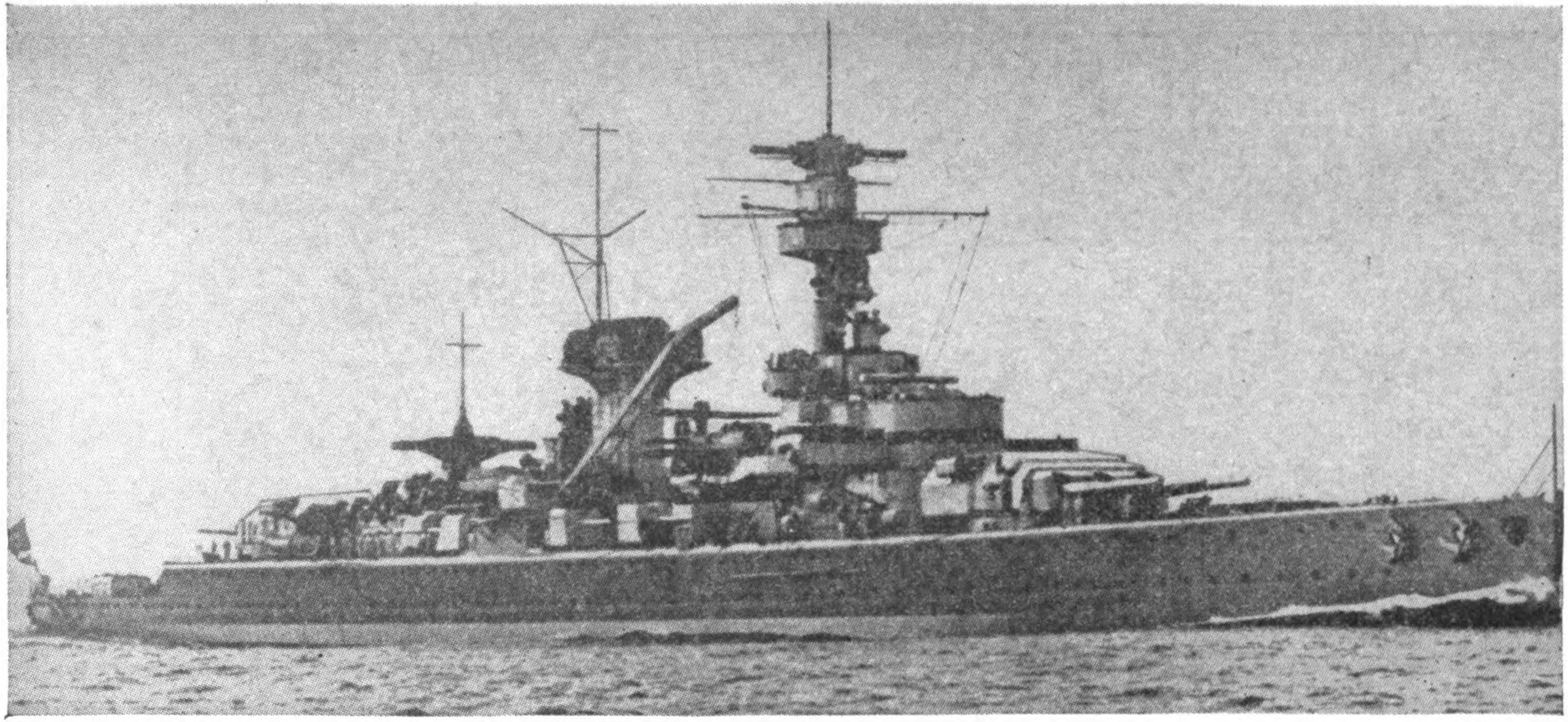
②

FIGURE 67.—British battleship *Nelson* (sister ship *Rodney*).



Displacement: 32,720 tons.
Length: 700 feet.
Beam: 95 feet.
Draft: 30 feet.
Guns: eight 16-inch, twenty 5.5-inch, four 3.3-inch (AA).
Armor: belt 13- or 12-inch, deck 3½-inch (7-inch above magazines, boilers, and engine room), turrets 14-inch, conning tower 12-inch.
Torpedo tubes: four 21-inch submerged, four above the water.
Speed: 23 knots.

FIGURE 68.—Japanese battleship *Mutsu*.

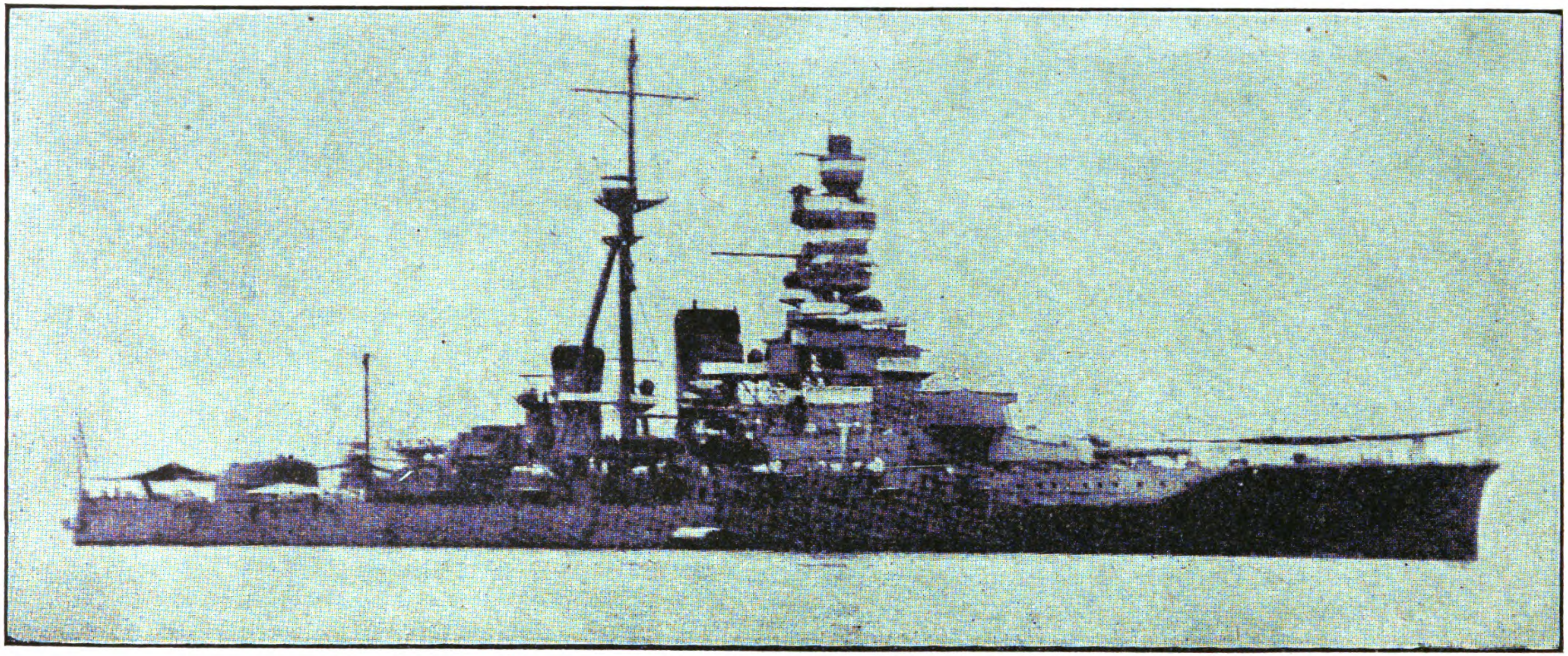


Displacement: 10,000 tons.
Length: 593 feet.
Beam: 67½ feet.
Draft: 21⅔ feet.
Speed: 26 knots.
Guns: six 11-inch, eight 5.9-inch, six 4.1-inch (AA), eight 3-pounder (AA), ten machine guns.
Torpedo tubes: eight 21-inch.
Aircraft: 2.
Armor: belt 4-inch with 1½-inch internally; turrets 4-inch bases, 7-inch faces, 2- to 3-inch sides; conning tower 5-inch, 2-inch roof; deck 1½- to 2¼-inch, 3-inch over magazine.

FIGURE 69.—German pocket battleship *Lutzow* (ex-*Deutschland*).

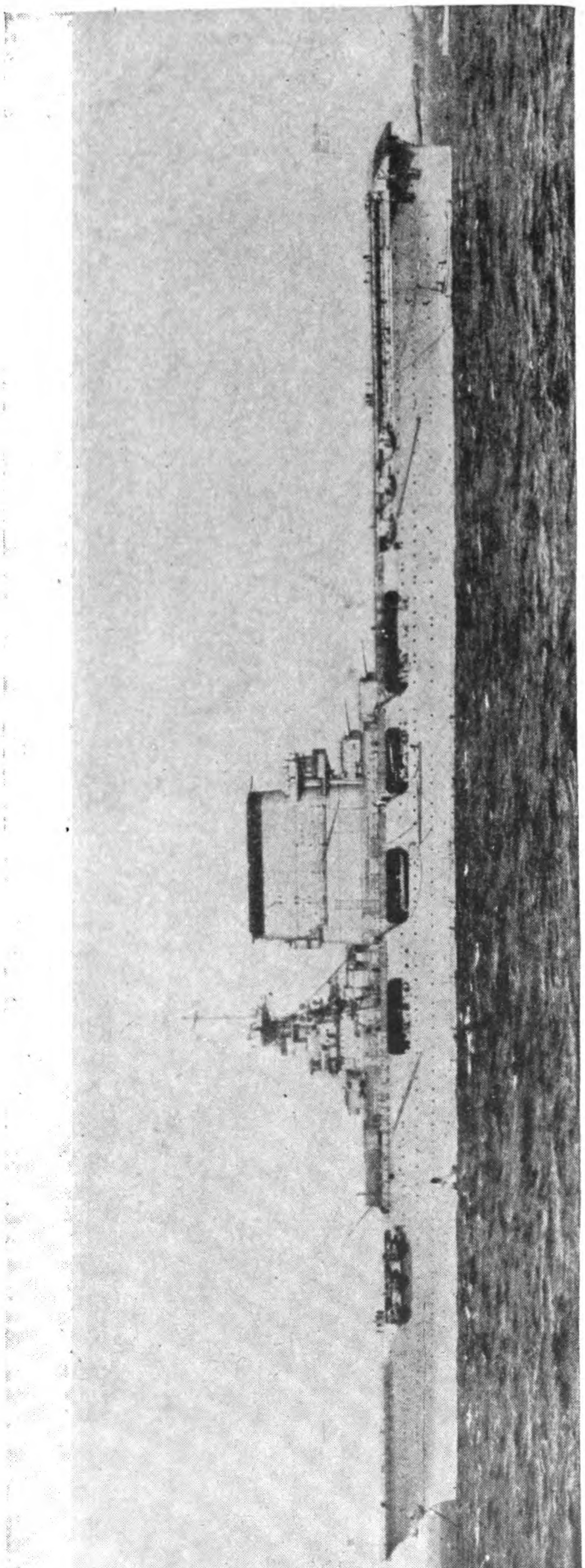
①

Displacement: 32,330 tons.
Length: 704 feet.
Beam: 95 feet.
Draft: 27½ feet.
Torpedo tubes: four 21-inch submerged.
Speed: 28 knots.
Guns: eight 14-inch, sixteen 6-inch, four 3-inch (AA).
Armor: belt 8-inch, turrets 10- to 9-inch, conning tower 10- to 9-inch, deck 6¾-inch.



②

FIGURE 70.—Japanese battle cruiser *Harauna*

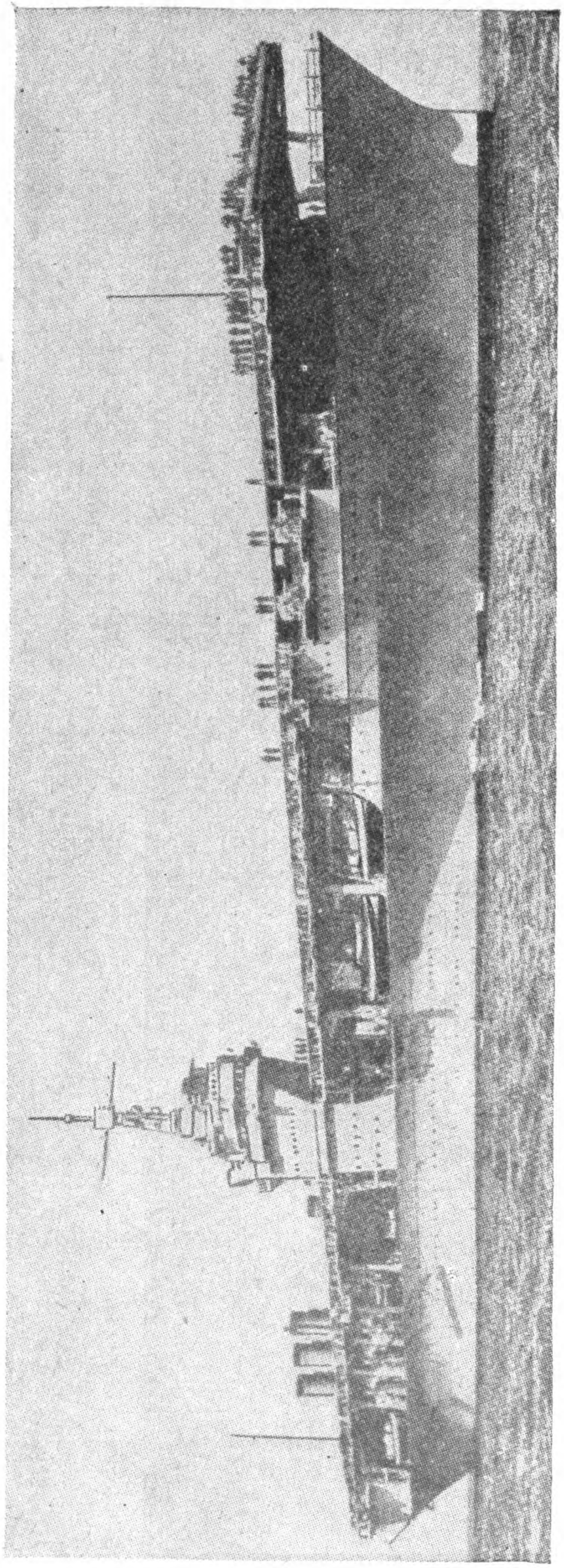


Displacement: 33,000 tons.
Length: 888 feet.
Beam, over flight deck: 90 feet.
Draft: 25½ feet.

Guns: eight 8-inch, twelve 5-inch (AA).
Armor: belt 6-inch, deck 3-inch; triple hull and bulge protection.
Airplanes: 120.

Speed: 33 knots.
Sister ship: *Saratoga*.

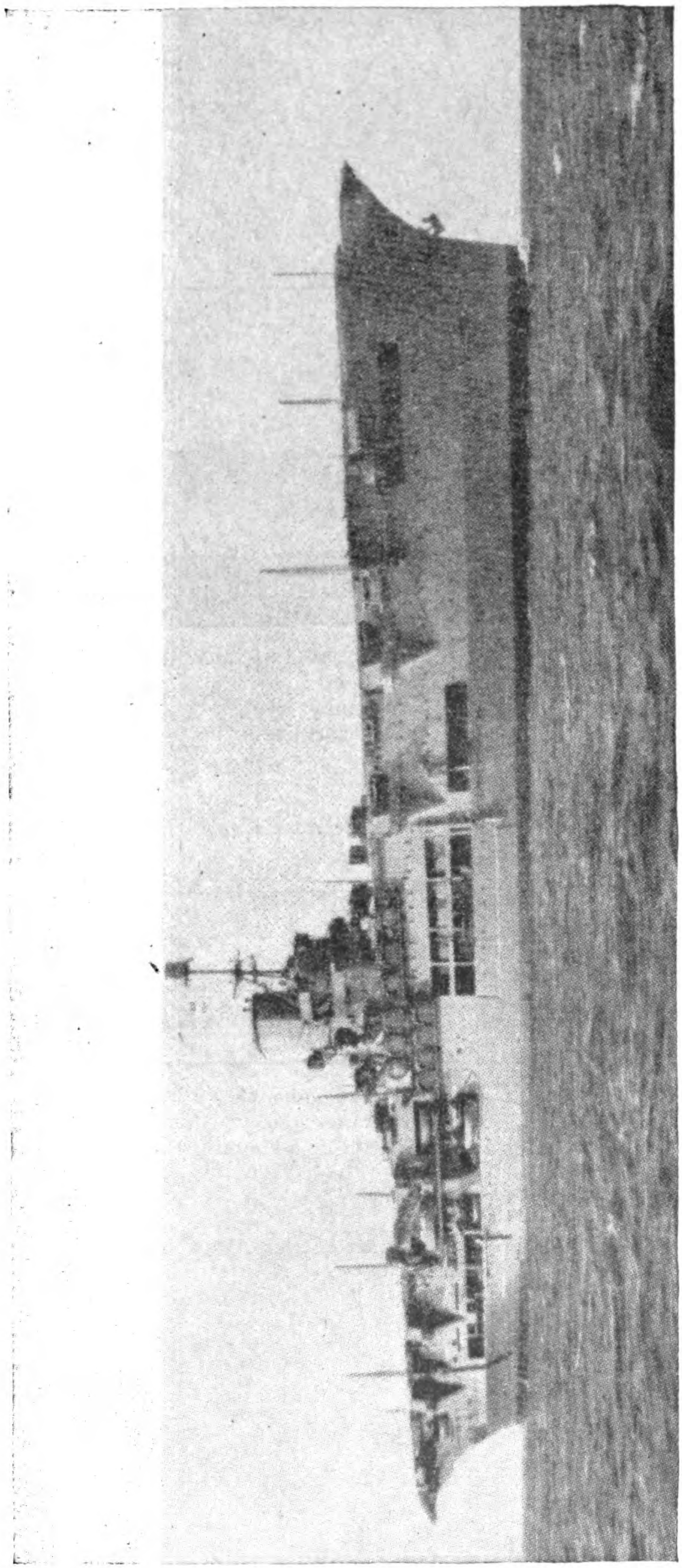
FIGURE 71.—United States aircraft carrier *Lexington*.



Displacement: 14,500 tons.
Length: 769 feet.
Beam: 80 feet 1 inch.
Draft: 19⅔ feet.

Speed: 30 to 35 knots.
Guns: eight 5-inch (AA).
Aircraft: 75.

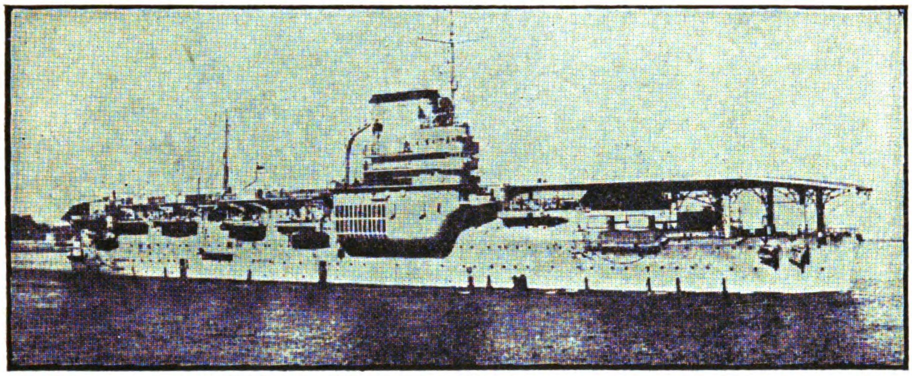
FIGURE 72.—United States aircraft carrier *Ranger*.



Displacement: 22,000 tons.
Length: 800 feet.
Beam, over flight deck: 94 feet.
Draft: 22⅝ feet.

Guns: sixteen 4.5-inch (dual purpose), four 3-pounders, six multiple pompoms.
Airplanes: 60.
Speed: 31 knots.

FIGURE 73.—British aircraft carrier *Ark Royal*.

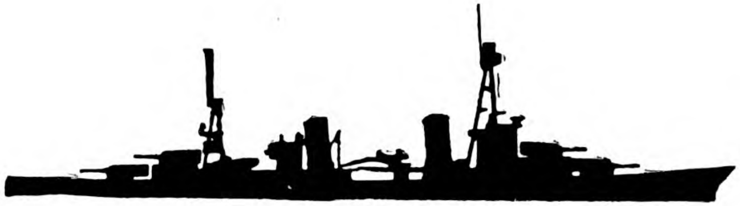


Displacement: 22,150 tons.
Length: 580 feet.
Beam, over flight deck: 89 feet.
Draft: 26 feet.
Guns: eight 6.1-inch, six 14-pounder (AA), eight 3-pounder (AA).
Armor: side 3¼-inch, deck (main and flight) 1-inch.
Airplanes: 40.
Speed: 21 knots.

FIGURE 74.—French aircraft carrier *Bearn*.

Displacement: 28,100 tons.
Length: 780 feet.
Beam: 92 feet.
Draft: 21¼ feet.
Guns: ten 8-inch, four 4.7-inch, twelve 4.7-inch (AA).
Armor: unknown.
Airplanes: 50.
Speed: 28.5 knots.

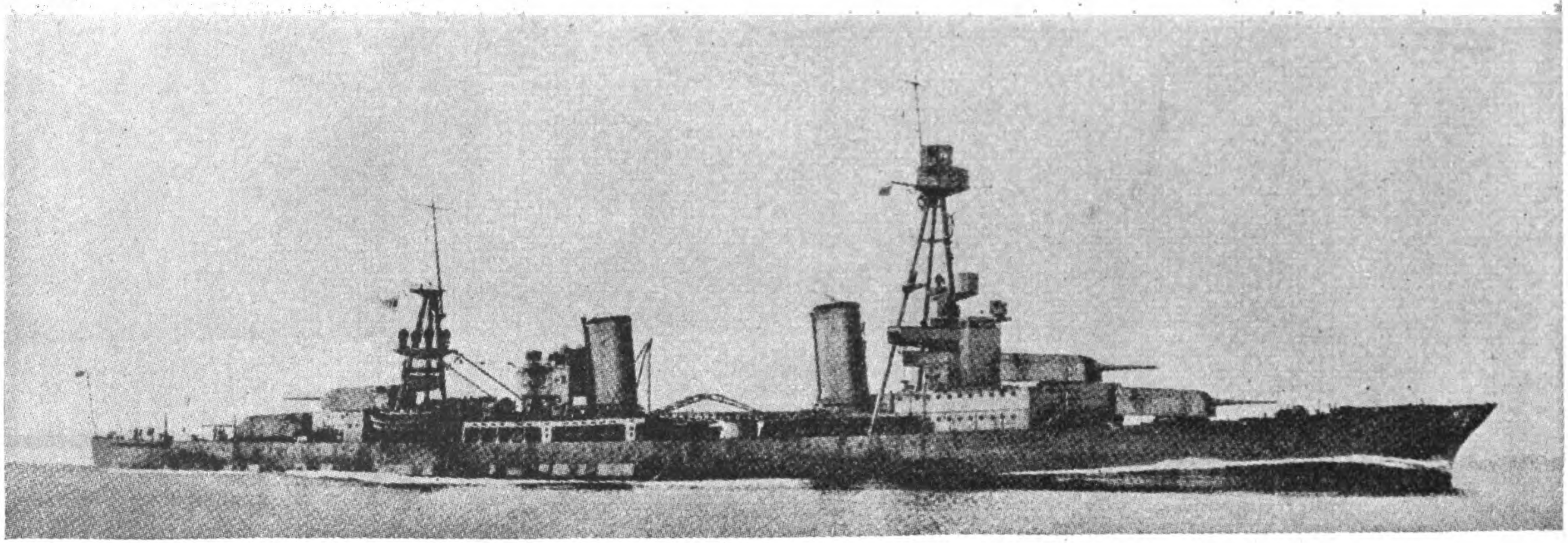
FIGURE 75.—Japanese aircraft carrier *Akagi*.



①

Displacement : 10,000 tons.
Length : 585 feet.
Beam : 64 feet.
Draft : 19 feet.
Torpedo tubes : six 21-inch.

Speed : 33 knots.
Guns : ten 8-inch, four 5-inch (AA).
Armor : side 1½-inch, gunhouse 1½-inch, deck 3-inch.

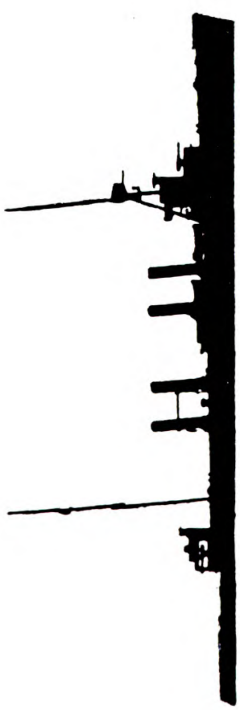


②

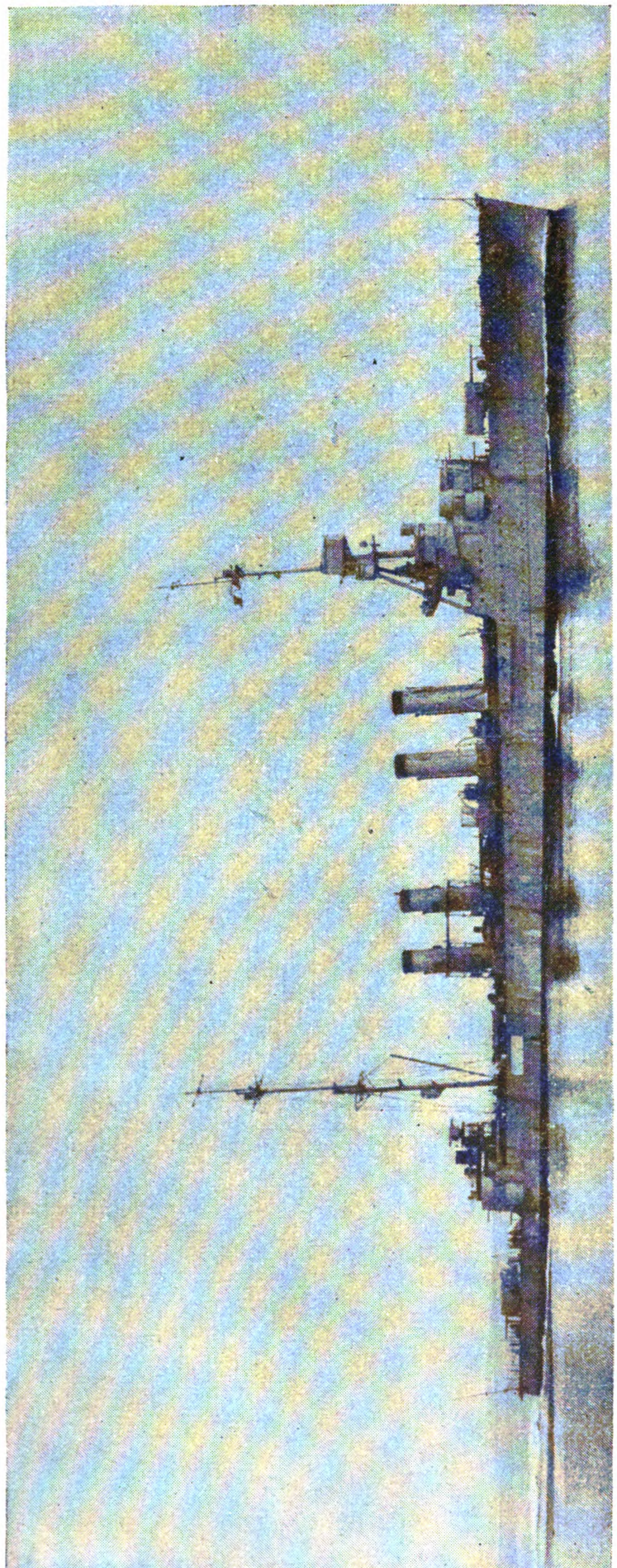
FIGURE 76.—United States cruiser *Salt Lake City*.

Displacement: 7,500 tons.
Length: 555 feet.
Beam: 55 feet.
Draft: 15½ feet.

Torpedo tubes: six 21-inch.
Speed: 34 knots.
Guns: twelve 6-inch, four 3-inch (AA).
Armor: side 3-inch, deck 1½-inch.

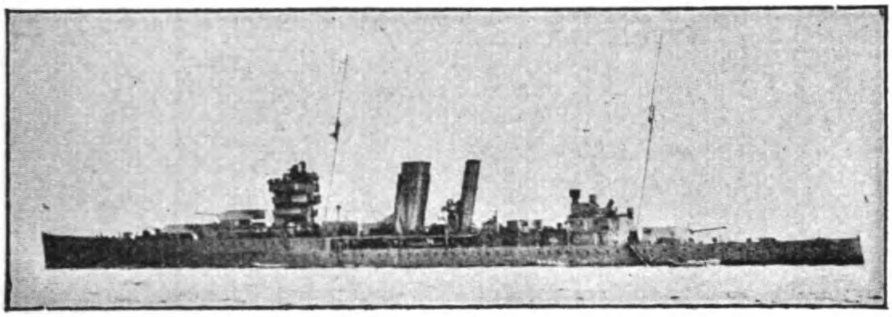


①



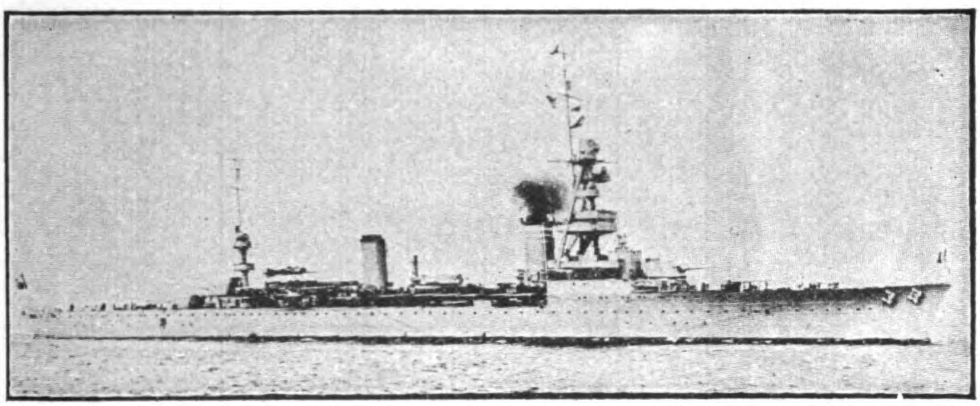
②

FIGURE 77.—United States cruiser *Marblehead*.



Displacement: 8,400 tons.
Length: 575 feet.
Beam: 57 feet.
Draft: 17 feet.
Guns: six 8-inch, four 4-inch (AA).
Armor: deck 2-inch, conning tower 3-inch.
Torpedo tubes: six 21-inch.
Speed: 32 knots.

FIGURE 78.—British cruiser *York*.



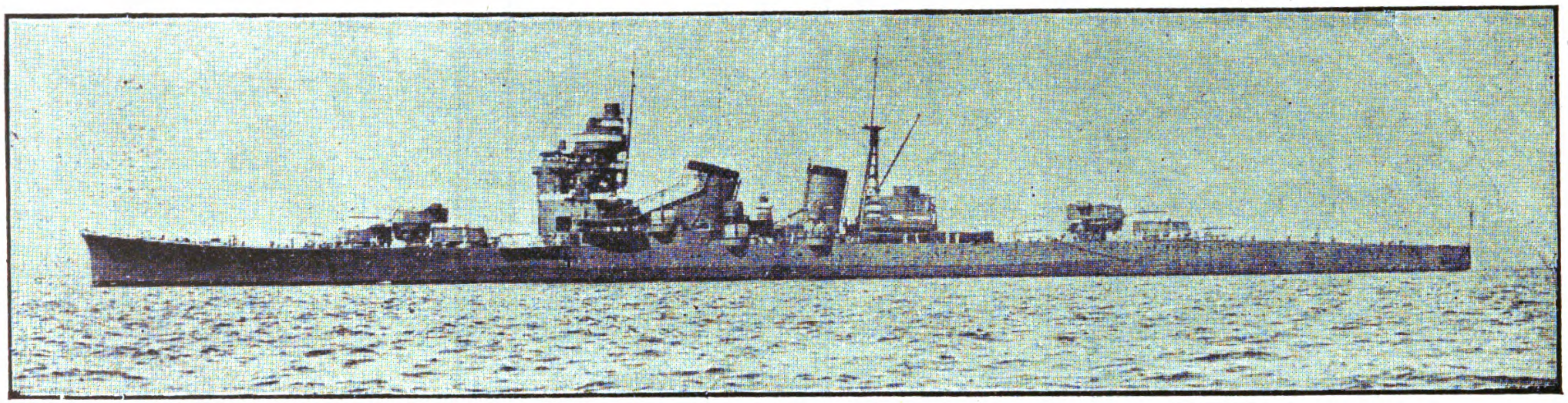
Displacement: 9,940 tons.
Length: 617 feet.
Beam: 65 feet.
Draft: 20 feet.
Guns: eight 8-inch, eight 3.5-inch (AA).
Armor: thin over engine and boiler spaces. Fitted with external bulges.
Torpedo tubes: six 21-inch.
Speed: 33 knots.

FIGURE 79.—French cruiser *Suffern*.

①

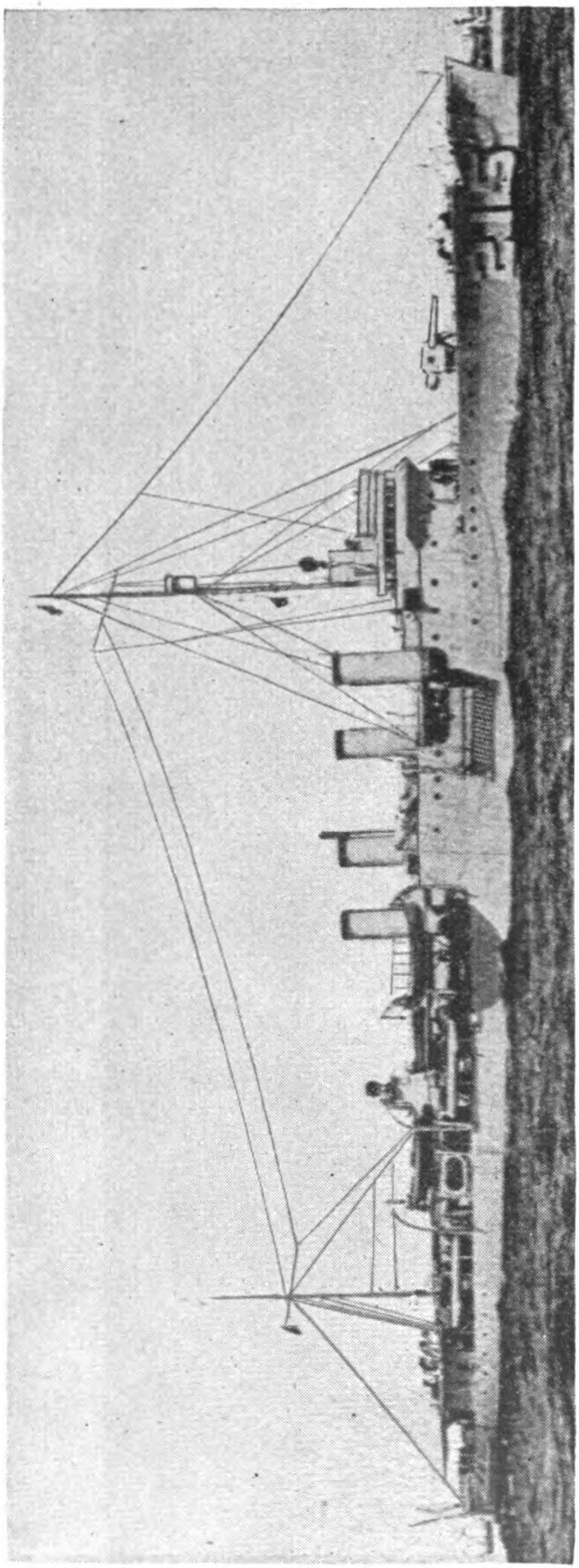
Displacement: 10,000 tons.
Length: 640 feet.
Beam: 57 feet.
Draft: 16½ feet.
Torpedo tubes: twelve 21-inch above water.

Speed: 33 knots.
Guns: ten 8-inch, six 4.7-inch (AA).
Armor: belt 3- to 4-inch, deck unknown, turrets unknown.



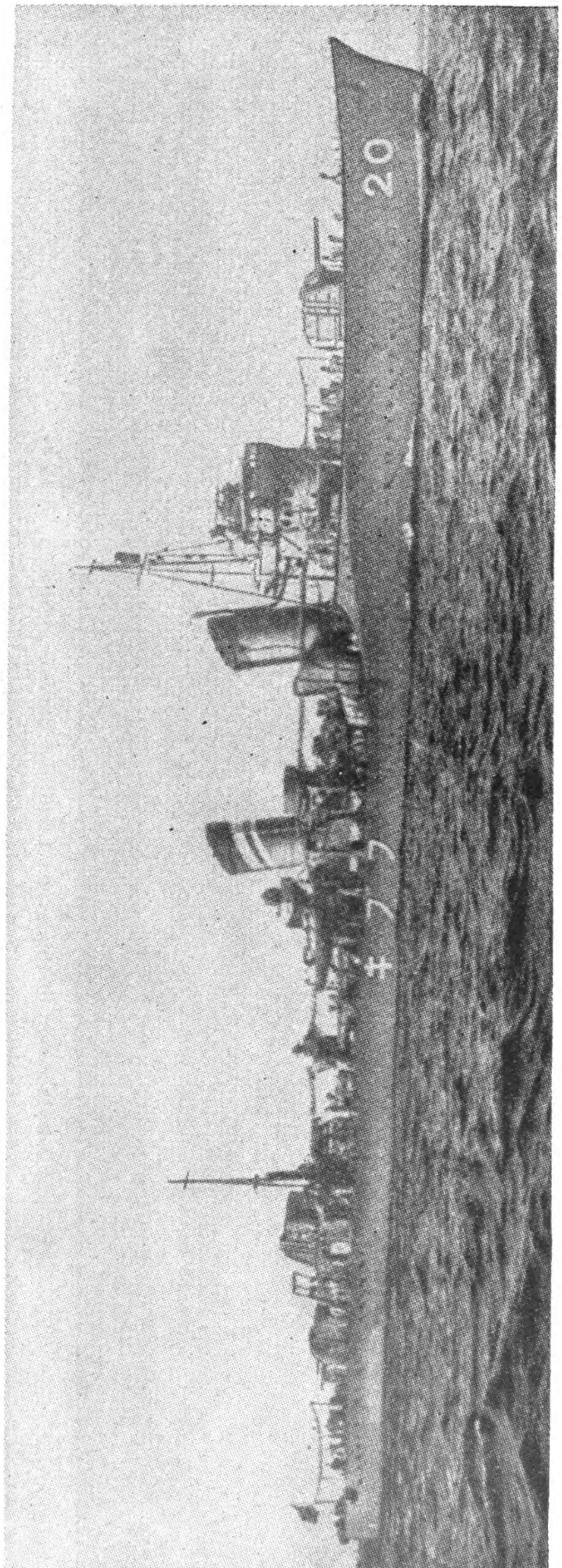
②

FIGURE 80.—Japanese cruiser *Nachi*.



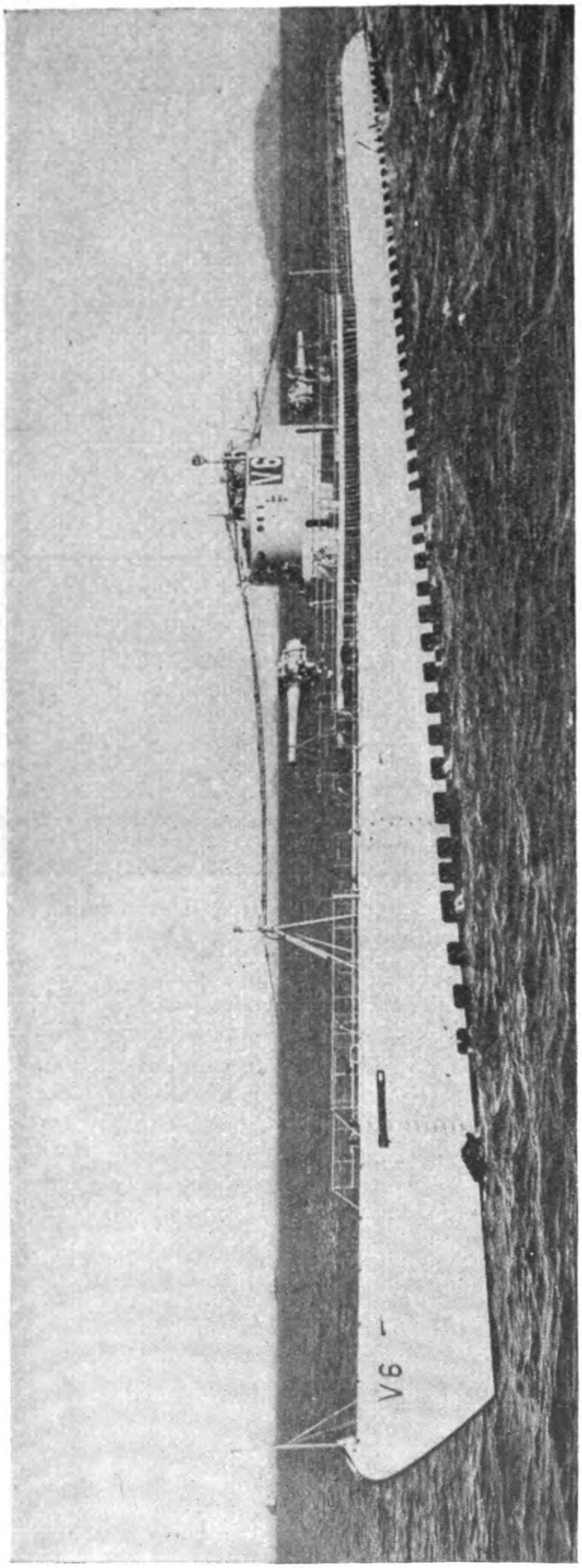
Displacement of this type: 1,020 to 1,190 tons. Speed: 35 knots.

FIGURE 81.—United States destroyer *Borie* (flush decker).



Displacement: 1,700 tons. Speed: 34 knots.

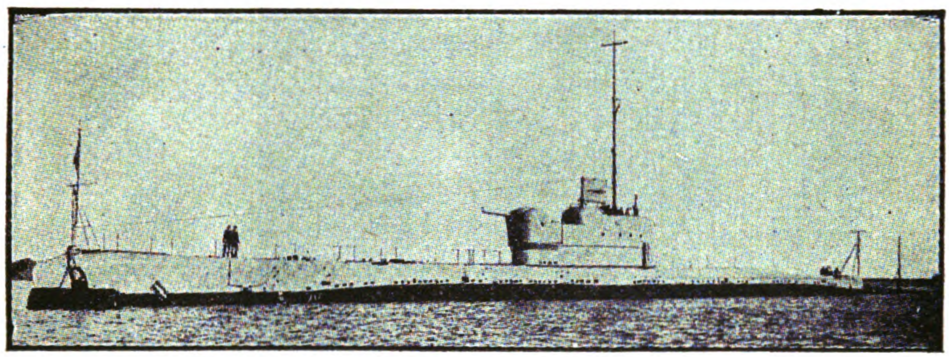
FIGURE 82.—Japanese destroyer *Hubuki*.



Displacement : 2,760 tons.
Length : 371 feet.
Guns : two 6-inch.
Torpedo tubes : six 21-inch.
Speed : 17/8.5 knots.

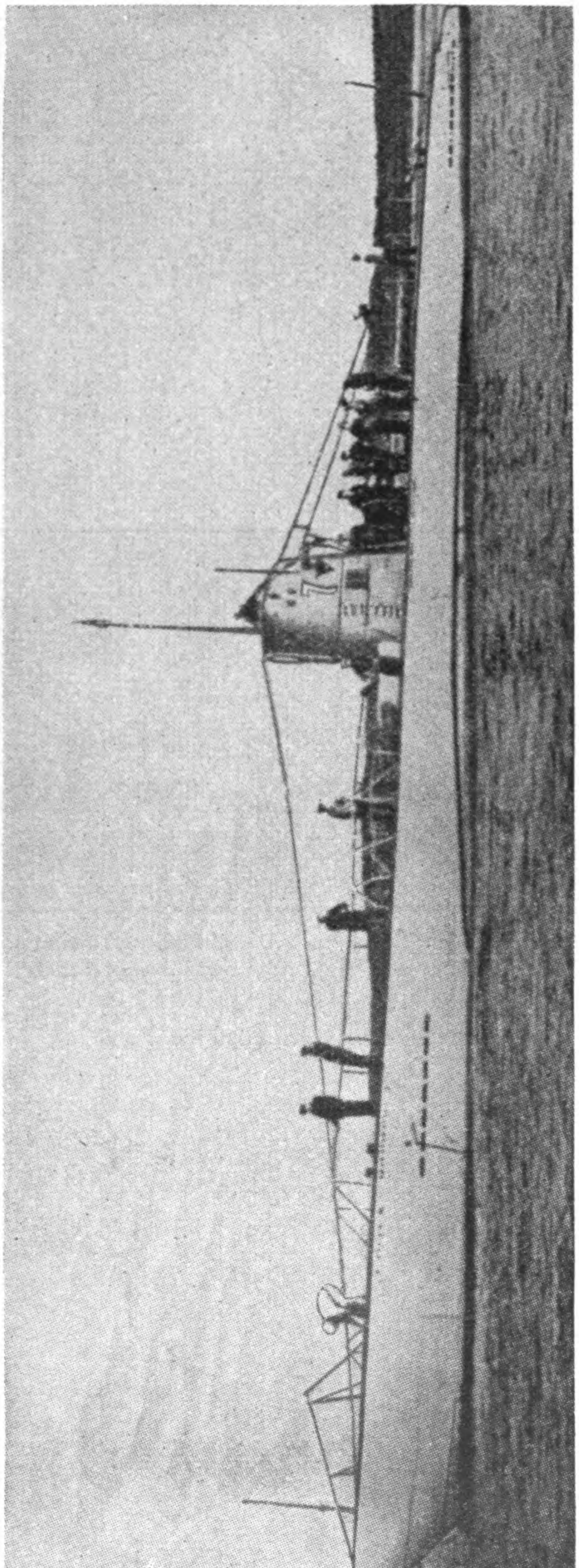
NOTE.—The speed given indicates the surface and submerged speeds in the order given.

FIGURE 83.—United States submarine *Nautilus* N–2 (ex–V–6).



Displacement: 1,475 tons.
Length: 260 feet.
Torpedo tubes: eight 21-inch.
Speed: 17.5/9 knots.
Guns: one 4.9-inch.

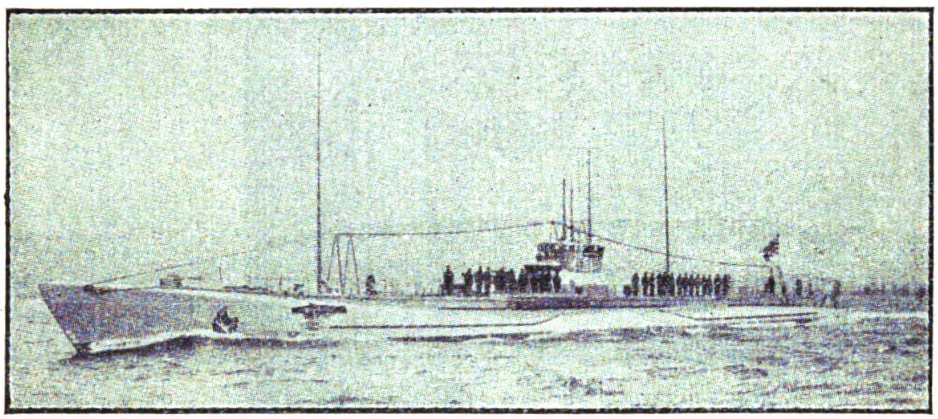
FIGURE 84.—British submarine *Perseus*.



Displacement : 250 to 330 tons.
Length ; 136½ feet.
Torpedo tubes : three 21-inch.

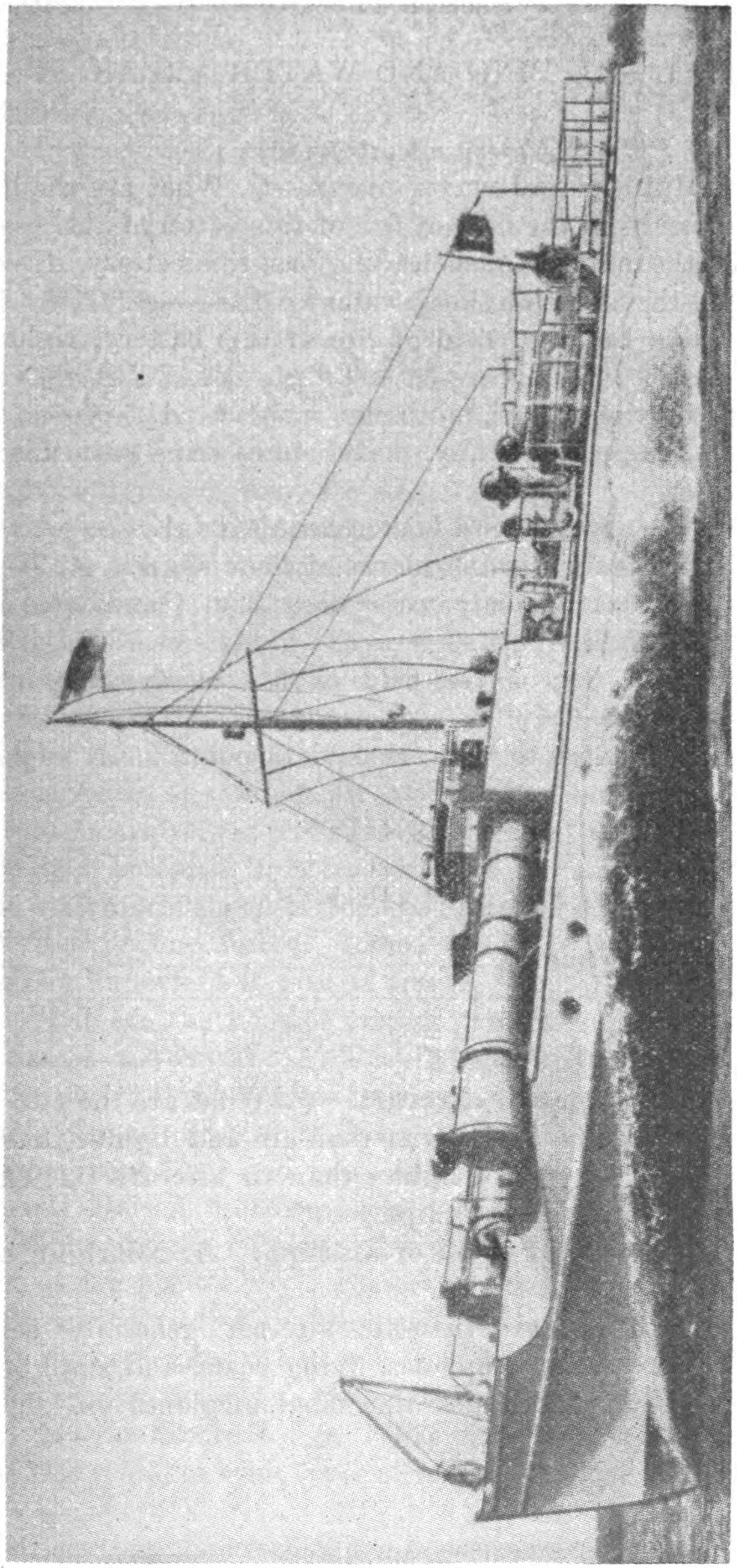
Speed : 13/7 knots.
Guns : one 1-pounder (AA).

FIGURE 85.—German submarine, U–7 coastal type, Nos. 1–24.



Displacement: 1,635 tons.
Length: 320 feet.
Torpedo tubes: six 21-inch.
Speed: 19/10 knots.
Guns: one 4.7-inch.

FIGURE 86.—Japanese submarine *Mitsu Bishi* type.



Displacement: 62 tons.
Length: 93 feet.
Speed: 30 to 36 knots.

Torpedo tubes: two 19.7-inch.
Guns: one 1-pounder (AA).

FIGURE 87.—German motor torpedo boat S6–25 (*Schnellboote*).

SECTION II

LOCAL SHIPPING AND WATER AREAS

58. Local shipping and water areas.—*Q*. What are the limits of the water subareas in the field of fire of this battery? *A*. ———.

Q. Where are the main channels leading past this battery. *A*. ———.

Q. Where are the areas of shoal water? *A*. ———.

Q. What are the limits of field of fire of this battery, right and left? *A*. ———.

Q. What are maximum and minimum ranges? *A*. ———.

Q. What local shipping, if any, makes daily trips past this battery? *A*. ———.

Q. What are the approximate boat schedules? *A*. ———.

Q. What are the distinguishing marks of these ships? *A*. ———.

Q. What other commercial boats does one (candidate) frequently see while at drill? *A*. ———.

Q. What time of day is the field of fire most nearly clear? *A*. ———.

Q. What are the ranges to the various data points? *A*. ———.

SECTION III

AERIAL TARGETS

59. Classes and types of aircraft.—*Q*. What are the two general classes of aircraft? *A*. Heavier-than-air and lighter-than-air.

Q. Name the general types of lighter-than-air aircraft. *A*. Observation balloons and dirigible airships.

Q. What are the general types of airships? *A*. Nonrigid, semirigid, and rigid.

Q. What are the heavier-than-air aircraft generally called? *A*. Airplanes or aeroplanes, seaplanes, flying boats, and amphibians.

Q. What are the general types of combat airplanes used by the United States Army? *A*.

(1) Pursuit.
(2) Bombardment.
(3) Reconnaissance, observation, and liaison.
(4) Transport.

Q. How are pursuit airplanes classified? *A*.
(1) Interceptor.
(2) Single-place fighter.
(3) Multiplace fighter.
Q. How are bombardment airplanes classified? *A*.
(1) Heavy.
(2) Medium.
(3) Light.

60. Missions of aircraft.—*Q*. What is the normal mission of pursuit airplanes? *A*. The interception, attack, and destruction of enemy aircraft in the air. The interceptor is usually a single seater with one or two powerful engines. The single-place fighter is used for escort and patrol in addition to normal pursuit missions. The multiplace fighter is used for escort and patrol duty near important objectives and against ground-troop formations.

Q. What are the normal missions of heavy and medium bombardment airplanes? *A*. To carry heavy bomb loads to great distances for attack of material objectives, and also to conduct long-range strategic reconnaissance over land and sea.

Q. What are the normal missions of light bombardment airplanes? *A*. Light bombardment airplanes (formerly designated as attack) are designed to attack objectives of light construction, routes of communication, airdromes, troop movements, and concentrations of troops in the open or under light shelter. The light bombardment airplane is the striking element of combat aviation which operates in direct support of ground forces. Identification of this type of airplane is especially important to ground troops.

Q. What are the normal missions of reconnaissance, observation, and liaison airplanes? *A*. They gather information of the enemy. The two latter types operate in conjunction with friendly forces, performing fire-adjustment missions for artillery, maintaining contact with the front lines and marching columns, and carrying on other command, liaison, and courier missions.

Q. What are the missions of transport airplanes? *A*. Transport airplanes are not strictly a combat type of airplane. They are used for the transportation of personnel and supplies. Their importance is rapidly increasing when one considers the transportation of air-landing troops, parachute troops, and important supplies.

61. Naval aircraft.—*Q*. What types of airplanes are employed by the Navy, and to what types of Army airplanes do they correspond? *A*.

(1) Scouting-observation airplanes corresponding to observation airplanes.

(2) Fighter airplanes corresponding to pursuit airplanes.

(3) Torpedo-bombardment airplanes corresponding to bombardment airplanes.

(4) Patrol airplanes which do not correspond to any special type of Army airplane. The Navy has no type of airplane corresponding to the Army light bombardment airplane.

Q. Does the Navy make more extensive use of the biplane type of airplane than the Army? *A*. Yes. They are used on carriers and on board other types of warships, being launched from catapults. They are used for this purpose because they are more stable in flight at low air speeds than monoplanes.

Q. What are seaplanes and flying boats? *A*. They are airplanes equipped with floats (pontons) or boat-shaped hulls instead of wheels, so that they may alight on water. Seaplanes have floats while flying boats have hulls.

Q. What is an amphibian airplane? *A*. It is an airplane having a boat-shaped hull, and also equipped with wheels (that can be pulled up when operating on water) so that it can alight or take off from either a land or water surface.

62. Identification and indication of aircraft.—*Q*. Why is it important that ground personnel be familiar with the appearance in flight, method of operation, and characteristic sounds of airplanes? *A*. These factors are the means by which airplanes are identified and indicated.

Q. What are the basic flight positions used for ready recognition of airplane types? *A*.

(1) Coming flight or front view.

(2) Passing flight or side view.

(3) Flight at lower altitude or top view.

(4) Overhead flight or bottom view.

(5) Maneuvering flight or perspective view.

Q. What is meant by coming flight or front view? *A*. All positions of flight in which only a general head-on view of the airplane may be had.

Q. What is meant by passing flight or side view? *A*. All positions of flight in which the side of the fuselage, vertical fin, and rudder are the major surfaces presented to view.

Q. What is meant by flight at lower altitude or top view? *A*. All positions of flight in which the upper sides of wings, fuselage, and horizontal tail surfaces are the major surfaces presented to view.

Q. What is meant by overhead flight or bottom view? *A*. All flight positions in which the under sides of wings, fuselage, and horizontal tail surfaces are presented to view.

Q. What is meant by maneuvering flight or perspective view? *A.* All flight positions which are different from straight and level flight. It includes banking, turning, climbing, diving, and combinations of such maneuvers. The airplane may present, momentarily at least, nearly all of the views presented under other conditions of flight.

Q. What characteristics of outline of the airplane are most readily seen in overhead flight? *A.*

(1) *Shape of wing.*—The general shape and proportion of wings, as long and narrow, short and stubby.

(2) *Type and shape of nose.*—Nose extends much or little in advance of leading edge of wings; that is, plane is long-nosed or short-nosed.

(3) *Length and shape of fuselage.*—Compare the relatively short fuselage of the small and medium-sized airplanes with the long, slender, streamlined appearance of the larger types.

(4) *Location and number of engines.*—In single-engined airplanes the engine is located in the nose and by its type determines the shape of the nose; that is, with radial engines the nose is blunt and stubby, while with in-line and V-type engines the nose is more slender and pointed. In multiple-engined airplanes the engines are usually housed in nacelles extending from the leading edge of the wings. In the unusual pusher types, the engines extend from the trailing edge of the wings. Even at great altitude when the number of engine nacelles cannot be exactly determined, their presence will give an unmistakable irregular outline to the wings warranting identification as multiple-engined.

Q. What characteristics of outline are most readily seen in passing flight? *A.*

(1) *Shape and outline of fuselage.*—It is short and chunky in smaller pursuit type; elongated and streamlined in larger types; and long and thick-bodied in larger bombardment types. Note outline being broken by such parts as cockpits, canopies over cockpits, and gun turrets.

(2) *Shape of nose.*—It may be slender and pointed, blunt and stubby, smoothly rounded, or shark-nosed.

(3) *Size of vertical fin and rudder.*—Note the relative size of the vertical fin and rudder compared to the fuselage.

Q. What characteristics of outline are most readily seen in coming or going flight? *A.*

(1) *Relationship of wings to fuselage.*—Has high-wing, midwing, low-wing, or parasol-wing types; dihedral angle, pronounced moderate, or practically zero.

(2) *Number of engines.*—The irregularity of outline of wings will indicate a multiple-engined type.

(3) *Features of vertical tail members.*—It is usually possible to identify single- and double-rudder types.

(4) *Undercarriages.*—Nonretractable landing gear is usually plainly visible.

Q. What characteristics of outline are most readily seen in maneuvering flight? *A*. All the features previously pointed out may be momentarily visible.

Q. What characteristic methods of operation of pursuit assist in its identification? *A*. Pursuit normally operates in formation with the squadron of 18 airplanes as the largest group operating as a unit. An observer noting one such formation should look below and to the front of it and above and to the rear of it for other units.

Q. What characteristic methods of operation of heavy and medium bombardment assist in their identification? *A*. They operate in column of three-plane elements (route column) with successive elements stepped up or down from front to rear. They usually fly straight courses at medium or high altitudes unless attacked from the air or by antiaircraft fire.

Q. What characteristic methods of operation assist in the identification of light bombardment? *A*. They operate in formation at minimum or medium altitudes. They use the three-plane element echeloned to the rear at approximately the same altitude. The normal operating unit is the squadron of nine airplanes with the largest formation the group of three squadrons. This type of aviation supports the operations of ground troops.

Q. What characteristics of operation of reconnaissance airplanes assist in their identification? *A*. They operate at any altitude from low to high; usually operate singly; and fly straight courses unless attacked. Bombardment airplanes may perform long-range reconnaissance.

Q. What characteristic methods of operation assist in identification of observation and liaison airplanes? *A*. They operate almost entirely within own lines; fly singly on various courses at low and medium altitudes; and will be seen circling over own troops and troop columns to drop messages and observe panels.

Q. What are some of the characteristic sounds of pursuit airplanes in flight? *A*. Pursuit airplanes in flight are characterized by sounds of fast rhythm, high pitch, moderate volume, and by extreme variations in pitch and tone while maneuvering.

Q. What are some of the characteristic sounds of heavy and medium bombardment airplanes while in flight? *A*. They have a fairly deep pitch, a moderately heavy volume, and a steady tone and rhythm.

Q. What are some of the characteristic sounds of light bombardment airplanes while in flight? *A*. They have a heavy volume of sound due to low altitude, and a fairly deep pitch, with tone and rhythm steady but varying considerably when maneuvering.

Q. State, in the order in which given, what information is given and the terms used in indicating aircraft during daylight. *A*.

(1) Designation of reporting station by name or number.

(2) Number of airplanes, when they can be counted. If they cannot be counted the word "several" or the word "many" may be used.

(3) Type of airplane, such as "observation," "pursuit," etc., when they can be identified. In other cases the word "airplane" is used.

(4) Altitude, in general terms as follows: "very low" (below 500 yards); "low" (500 to 2,000 yards); "medium" (2,000 to 5,000 yards); or "high" (over 5,000 yards).

(5) Location, by the sector in which or toward which the aircraft are flying.

(6) Direction of flight, by one of the eight points of the compass: North, NE, East, SE, South, SW, West, NW.

Q. State which of these elements of information are given in indicating aircraft at night. *A*. Designation of reporting station, number of airplanes (one, several, or many), altitude, and location.

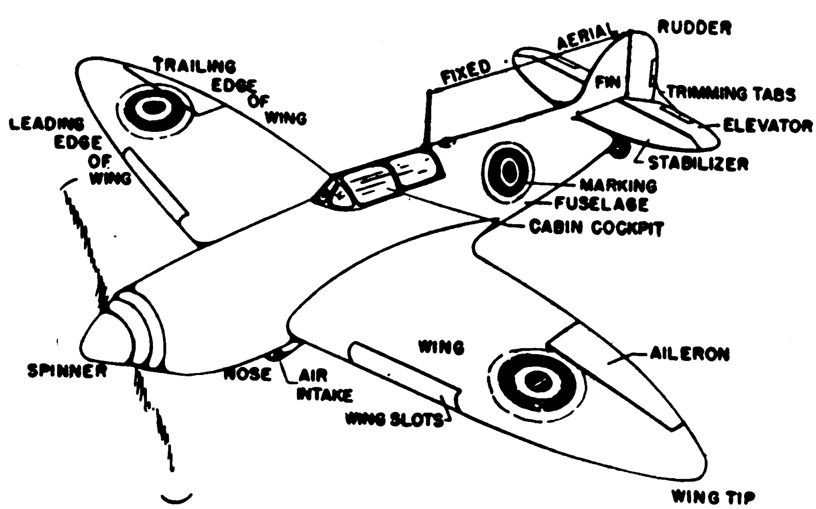
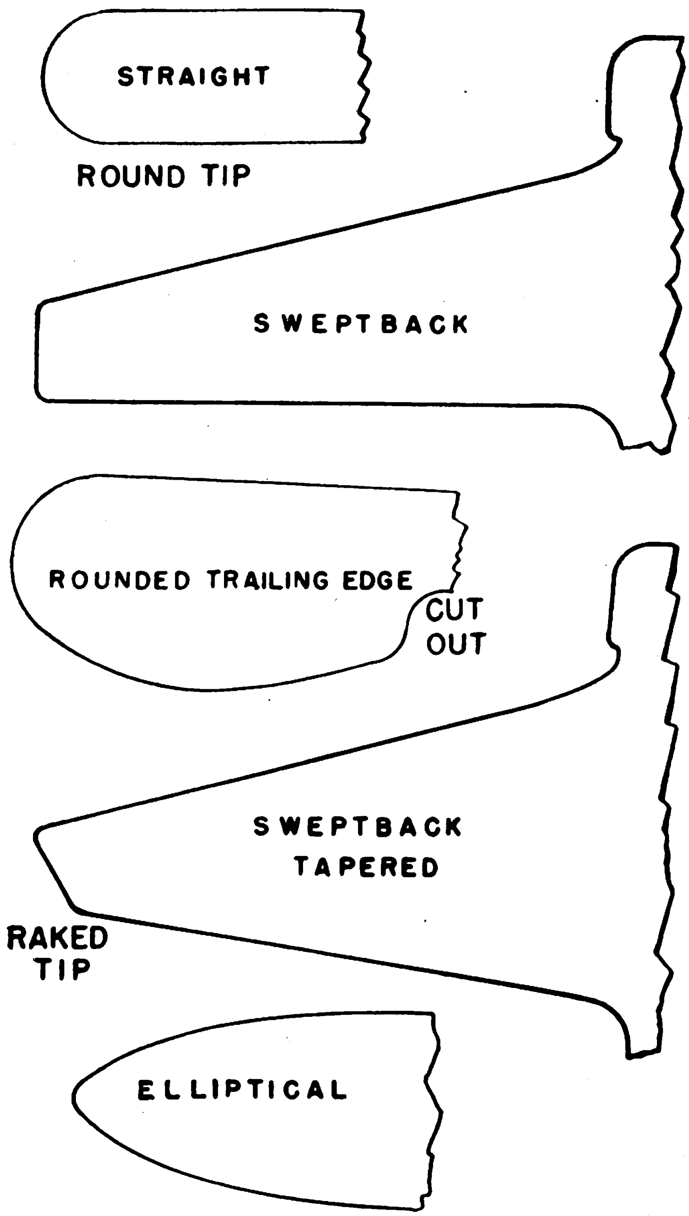
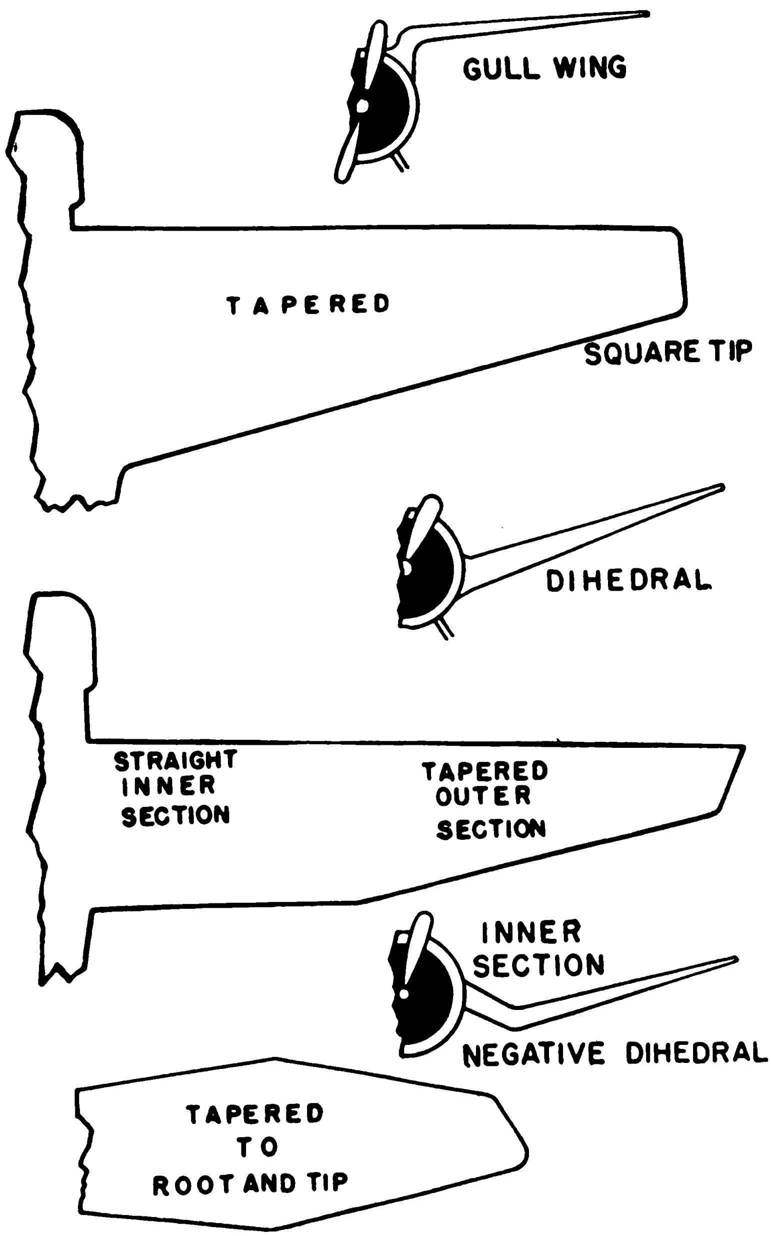


FIGURE 88.—Nomenclature of airplane parts.



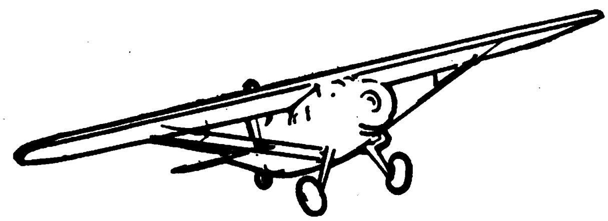
①

FIGURE 89.—Wing shapes.

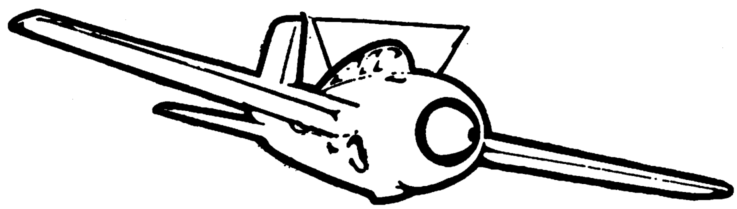


②

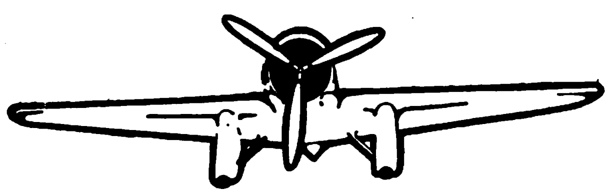
FIGURE 89.—Wing shapes—Continued.



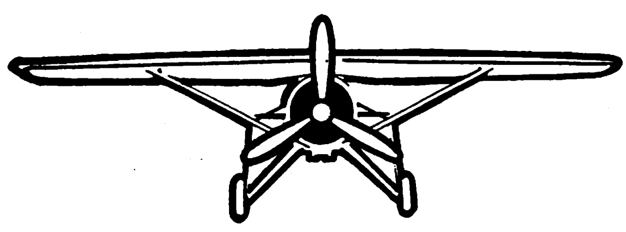
HIGH-WING



MIDWING



LOW-WING



PARASOL MONOPLANE

FIGURE 90.—Monoplanes.

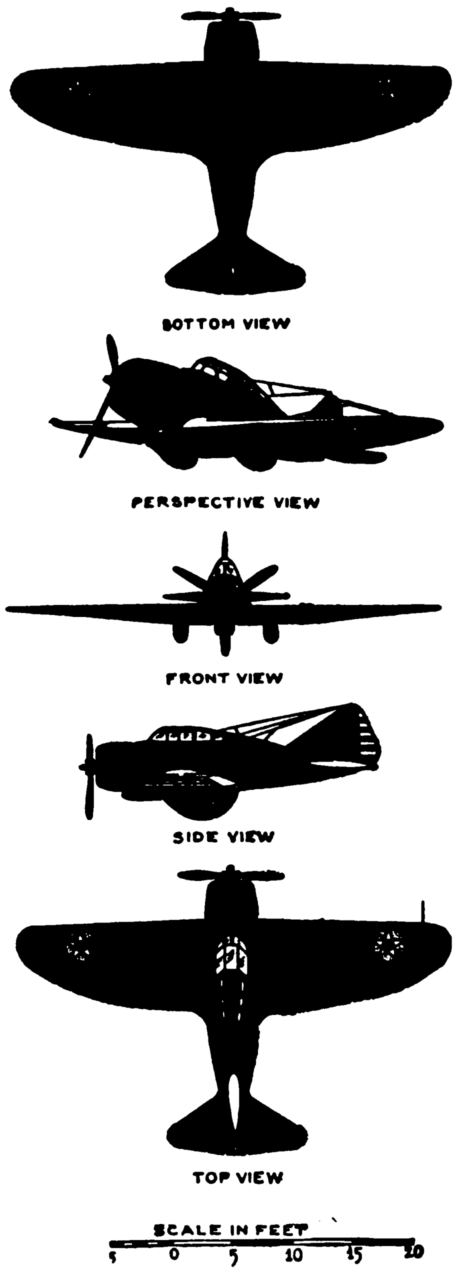


FIGURE 91.—Pursuit USA P-35.

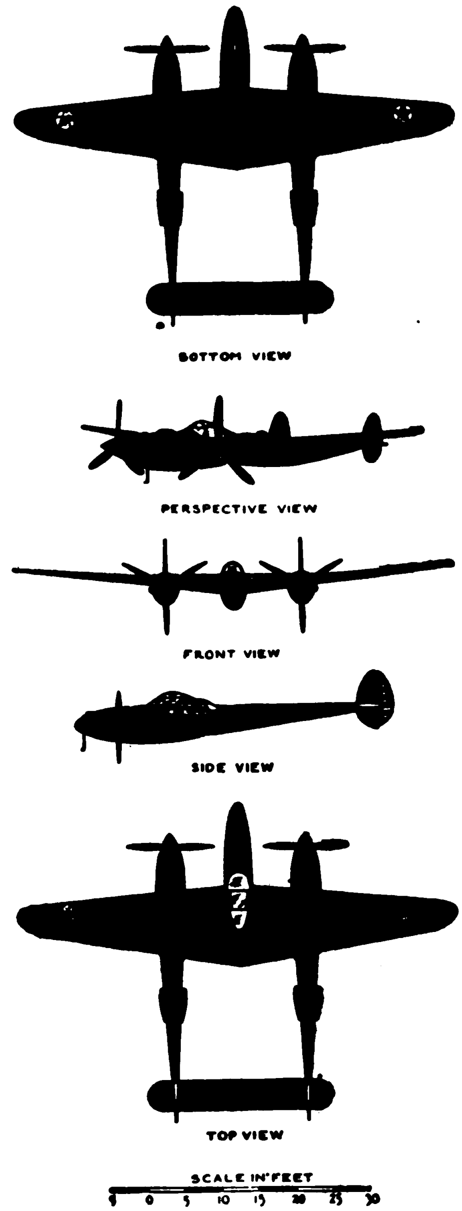


FIGURE 92.—Pursuit USA P-38.

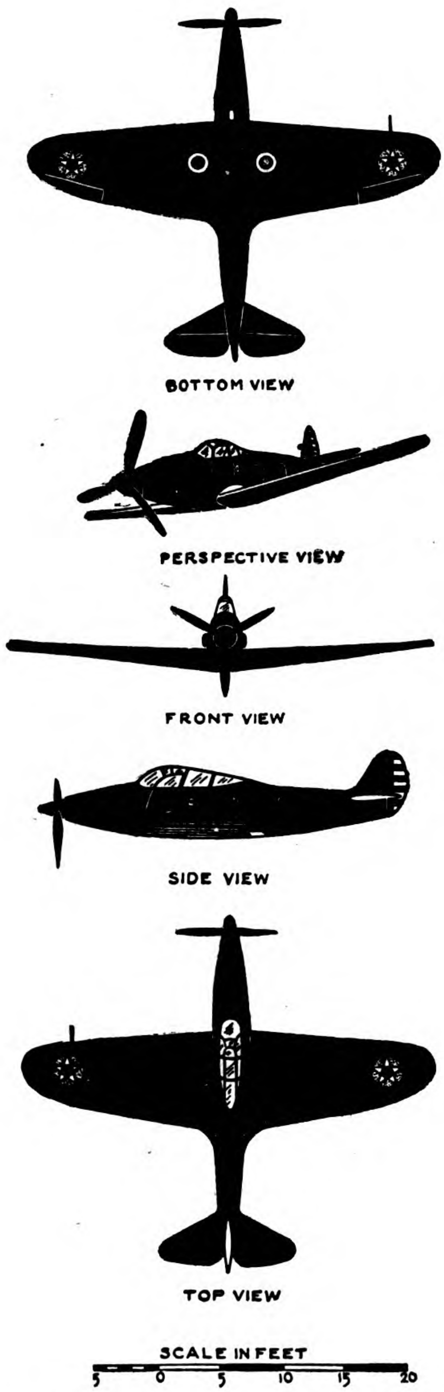


FIGURE 93.— Pursuit USA P–39, P–39A, P–39C.

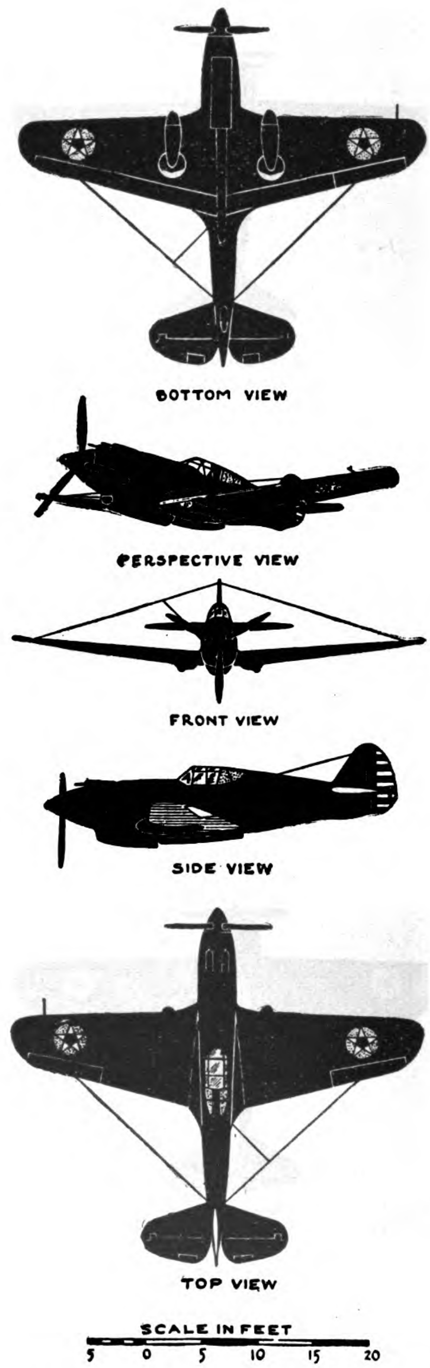


FIGURE 94.—Pursuit USA PX40.

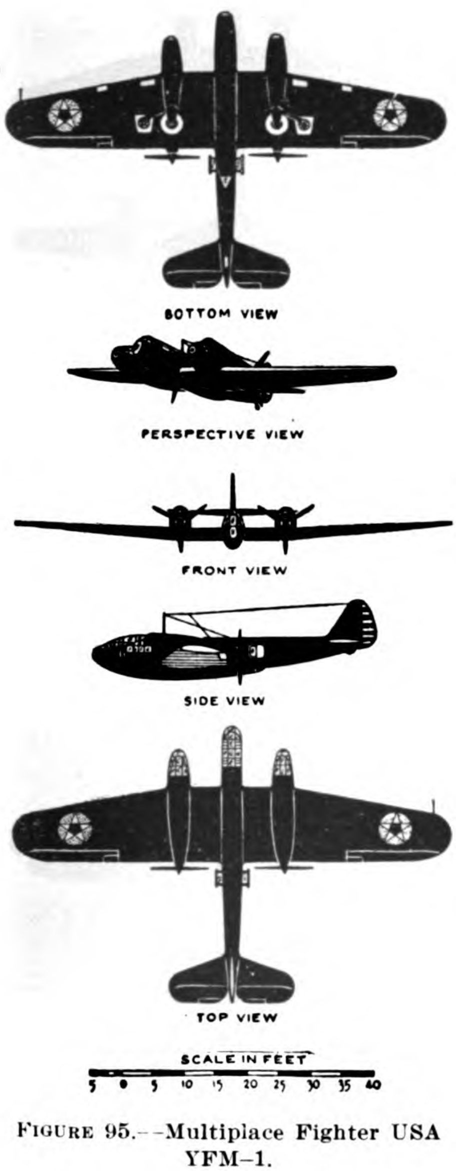


FIGURE 95.—Multiplace Fighter USA YFM–1.

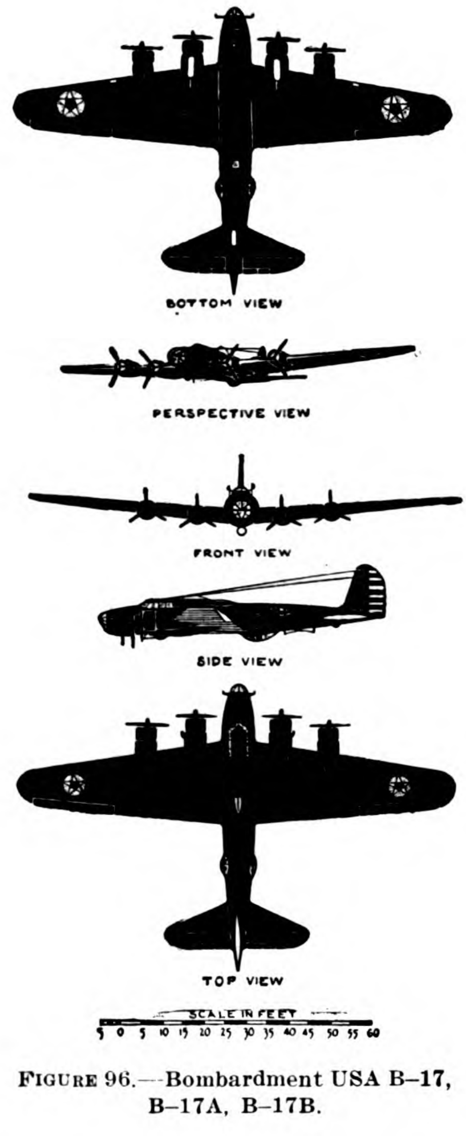


FIGURE 96.—Bombardment USA B–17, B–17A, B–17B.

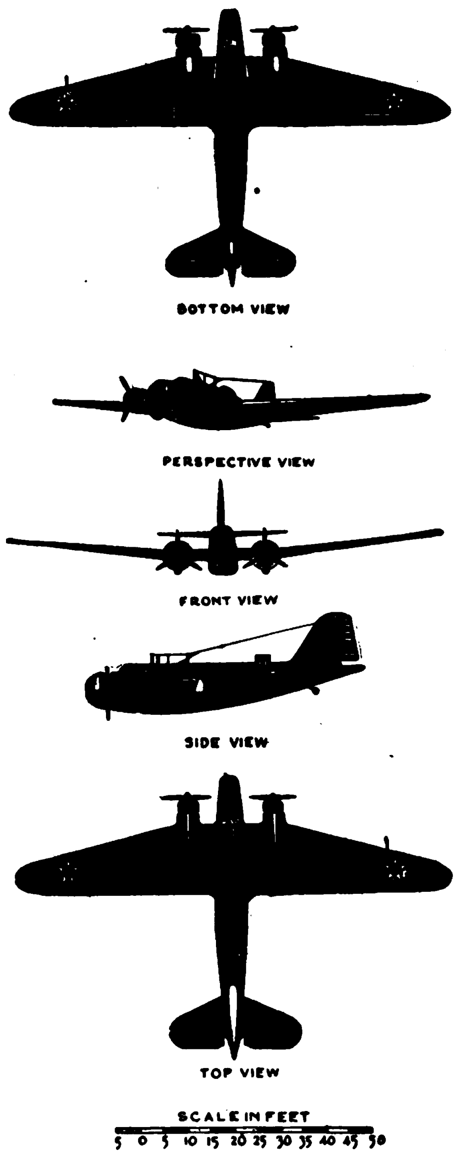


FIGURE 97.—Bombardment USA B-18.

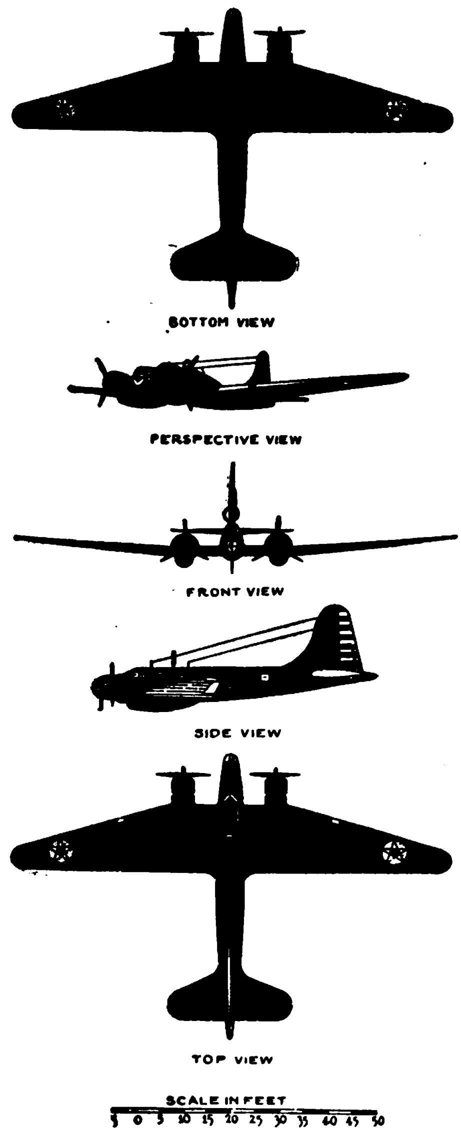


FIGURE 98.—Bombardment USA B-23.

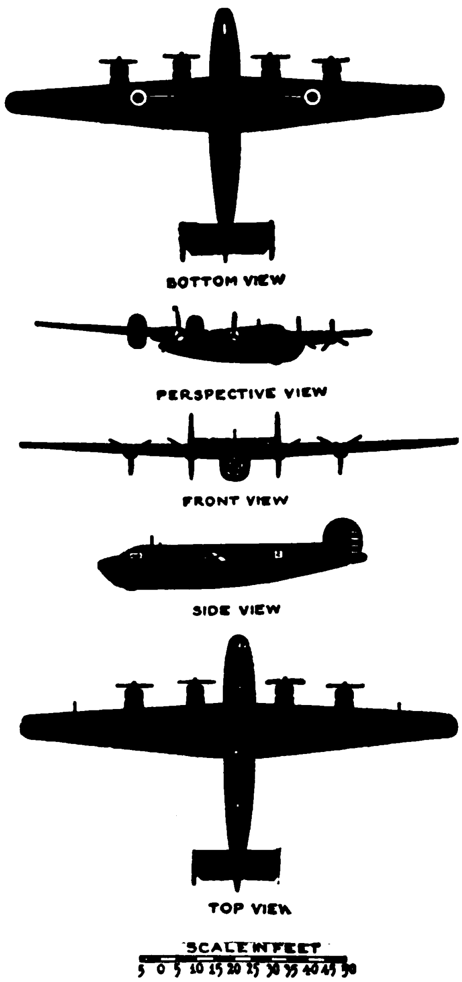


FIGURE 99.—Bombardment USA B-24, B-24A.

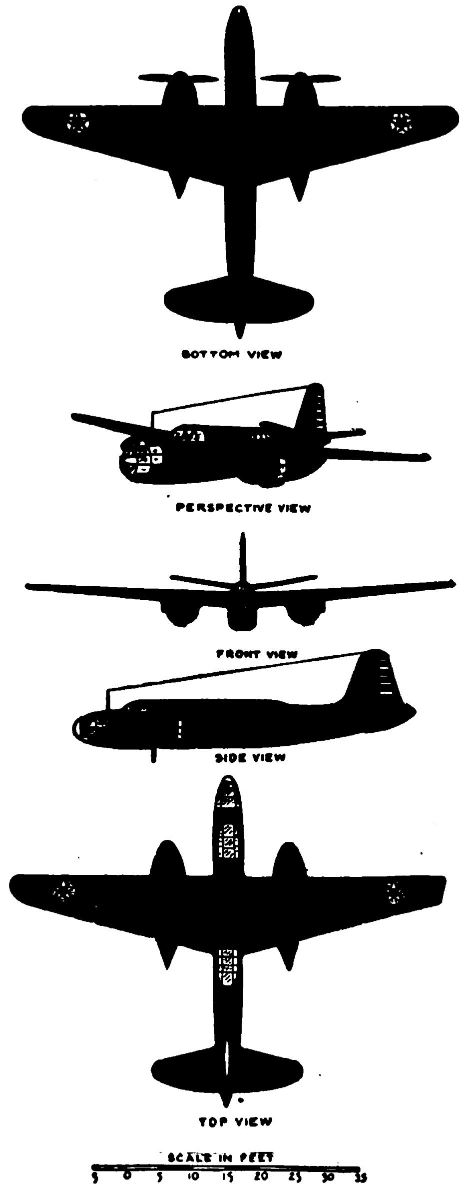


FIGURE 100.—Light bombardment USA A-20, A-20A.

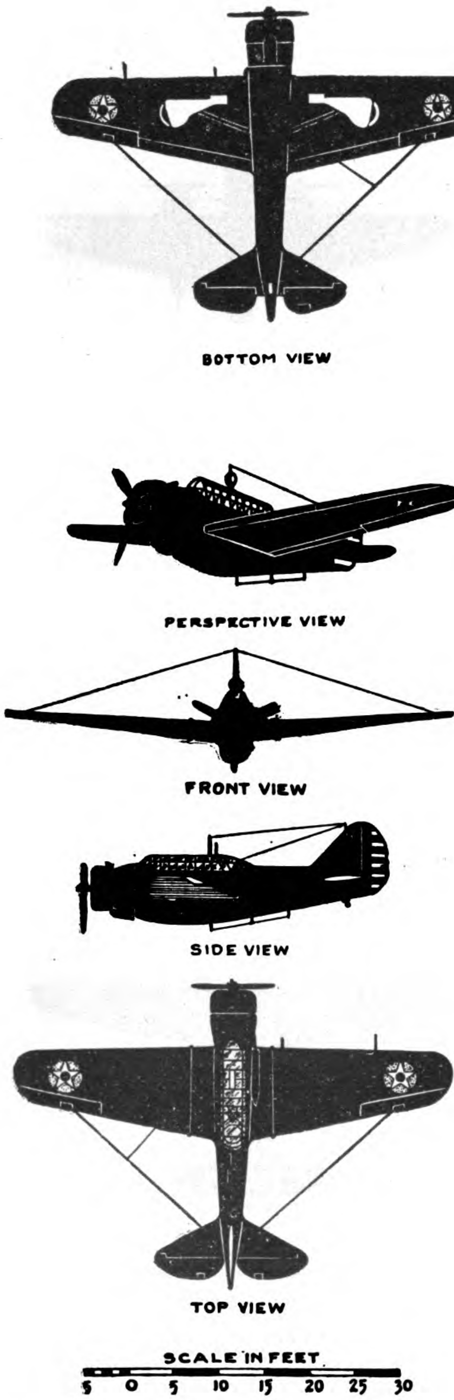


FIGURE 101.—Observation USA O-47A, O-47B.

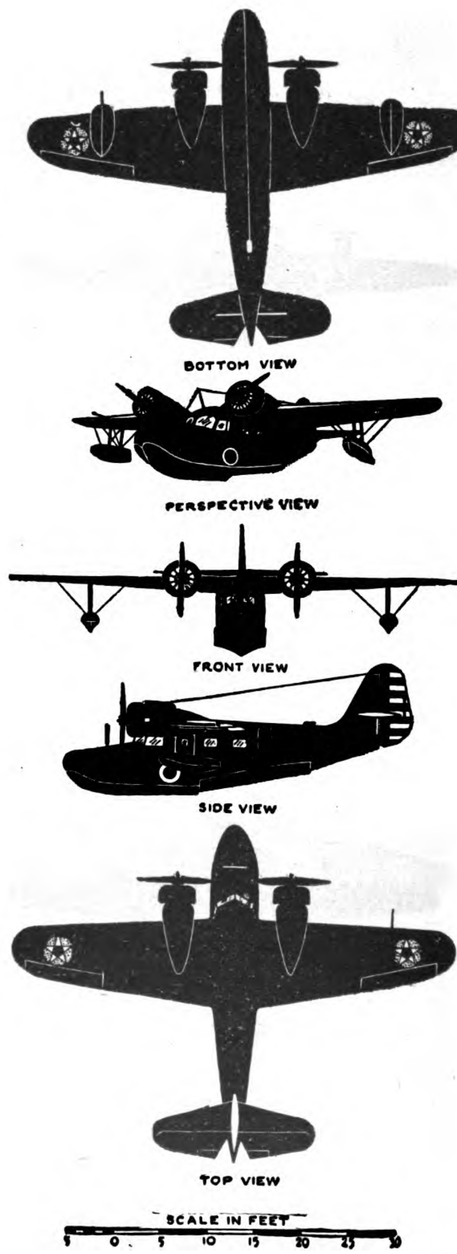


FIGURE 102.—Observation amphibian USA OA-9.

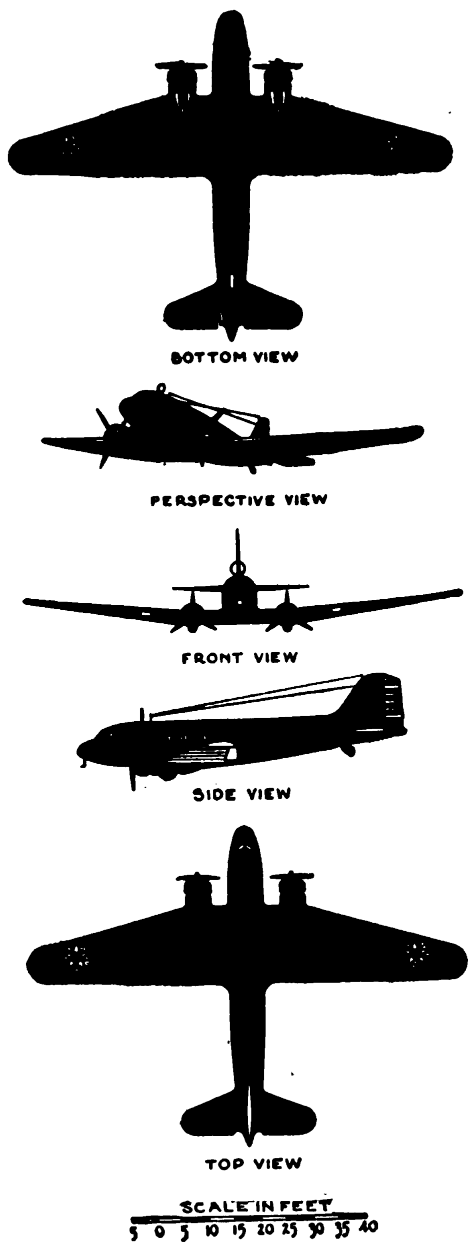


FIGURE 103.—Transport USA C-38, C-39, C-41, C-41A, C-42.

Chapter 14

TARGET PRACTICE

Section I

PREPARATION FOR SUBCALIBER AND SERVICE PRACTICE

63. Preliminary preparation.—*Q*. What preparations are made for subcaliber firing? *A*.

(1) Clean and adjust the breech mechanism.

(2) Test the firing mechanism.

(3) Test the firing circuit.

(4) Examine and test all primers to be used.

(5) Install and adjust the subcaliber tube.

(6) Have the hand extractor and short lanyard ready for use.

(7) Attach the subcaliber platform if necessary.

(8) Oil and check the elevating and traversing mechanisms.

(9) Check and adjust the sight (or azimuth circle) and quadrant (or range drum).

(10) Prepare the subcaliber ammunition.

(11) Prepare the sponging solution.

Q. What preparations are made for service firing? *A*.

(1) Clean and adjust the breech mechanism.

(2) Test the firing mechanism and all safety features on the gun.

(3) Test the electric firing circuit.

(4) Examine and test all primers to be used.

(5) Clean and examine the bore and powder chamber.

(6) Oil and check the elevating and traversing mechanisms and all gears and bearing surfaces.

(7) Check the recoil and recuperator mechanisms, filling them if necessary. Check all valve settings.

(8) Prepare and check all equipment used in the service of ammunition. If shot trucks are used, see that the buffers are adjusted and that all wheels have tires.

(9) Check and adjust the sight (or azimuth circle) and quadrant (or range drum).

(10) Prepare the service ammunition.

(11) Prepare the sponging solution.

(12) Have an extra lanyard ready for use.

Q. How are the safety features of the firing mechanism tested? *A.*

(1) Translate the breechblock into the breech recess.

(2) Insert a service primer into the primer seat and lower the leaf.

(3) Attach a lanyard and put a steady pull of about 40 pounds on it.

(4) Slowly rotate the breechblock until it is closed. The primer should not fire until the block is completely rotated, or until the rotating crank passes a previously located mark indicating that the block is just short of the closed position.

Q. How is the electric firing circuit tested? *A.* By inserting a test light in the primer seat and operating the firing magneto.

Q. What test of the electric firing circuit of a primer should be made? *A.* None by the battery personnel. When primers are drawn from the ordnance officer, it should be ascertained that they have been tested by ordnance personnel for continuity of circuit and for resistance.

Q. How is the primer tested by battery personnel? *A.*

(1) See that the primer is clean and not corroded. Put a thin film of oil on the outside of the primer body.

(2) Insert the primer into the primer seat. Rotate it to see that it turns easily. It should fit snugly without looseness or binding.

(3) Lower the leaf.

(4) Raise the leaf and catch the extracted primer. It should come out easily.

Q. What is wrong if all primers fit loosely? *A.* The primer seat is worn and should be replaced.

Q. What must be done before tripping a gun on a disappearing carriage? *A.*

(1) Remove the drip pans and covers.

(2) See that the recoil cylinders are full and plugs are tightened.

(3) See that retracting cables are not hooked to the gun.

64. Safety precautions.—*Q.* What safety precautions must be taken in handling powder charges? *A.*

(1) On cannon not equipped with gas ejectors the powder chamber will be sponged with a wet sponge after each shot.

(2) On cannon equipped with gas ejectors the use of a wet sponge is not required, but a new projectile will not be inserted until the bore has been inspected and announced clear. The bore will not be announced clear unless the chamber is clear of smouldering fragments, and in addition—

(*a*) By day, until daylight can be seen through the bore.

(*b*) By night, until the bore is clear from flame of luminous gases.

(3) The powder charge for any given round will not be brought near the breach until the preceding round has been fired, and—

(*a*) On cannon not equipped with gas ejectors, until the wet chamber sponge has been withdrawn from the breach.

(*b*) On cannon equipped with gas ejectors, until the bore has been announced clear.

(4) The powder charge will be inserted into the powder chamber so that it will be pushed into place by the mushroom head when the breech is closed.

Q. What safety precautions must be taken regarding handling primers? Lanyards? Pointing? *A*.

(1) Primers must not be inserted until after the breechblock is completely closed and locked in its recess.

(2) The lanyard will not be hooked until the piece has been given sufficient elevation to clear any mask in front of it, except on a disappearing carriage.

(3) For target practices, a safety pointing observer is required at each gun. No firing should be permitted unless he is at his post.

Q. If, during a target practice, the command CEASE FIRING is given after a piece is loaded and ready to fire, what action is taken? *A*. Except when a misfire has occurred, the primer and powder charge should be removed from the gun. If this is not done, the piece should be kept pointed at a safe part of the field of fire.

Q. When firing high-explosive shells in time of peace, what safety precautions are required? *A*. All persons at the emplacement must take cover in the place designated, before the piece is fired, unless the ammunition is equipped with bore-safe features.

Q. If firing becomes unsafe, who may stop it? *A*. Any person in the military service who observes the danger.

SECTION II

PREPARATION OF RECORDS AND REPORTS, ANALYSIS OF DRILL, AND TARGET PRACTICE

65. Records, reports, and analysis.—*Q*. What is meant by analysis of drill? *A*. It is the process of making a check of all records kept during drill, a replot of the course of the target, and a check of operation of all plotting-room instruments.

Q. Why is analysis of drill conducted? *A*. To find personnel errors and to eliminate them.

Q. What is the purpose of record firing? *A*. To train the battery for battle, and to determine the proficiency of the battery and performance of the matériel.

Q. What is a target practice report? *A*. It is a complete report of the practice, containing records of all data used, records of all spotters, corrections applied, and deviations of all shots.

Q. How are records of the data kept in step during a practice? *A*. By periodic announcements from the plotter, "Next bell time ———," and by making a check opposite data on which a shot is fired.

Q. Show in detail how to keep the record of the work in the plotting room, explaining the use of all forms. *A*. (Practical demonstration.)

Q. What is the first step in analysis of record practice? *A*. Collect all records from data-board recorders and recorders in the range section, and cross-check them.

Q. What is next done? *A*. Replot the course on the plotting board, using a clean sheet of paper or covering the original plot with tracing cloth.

Q. What record kept by an official is necessary to complete the replot, and how is it used? *A*. The report of "Azimuth of Target at Instant of Splash." It is kept by an officer stationed at or near the directing point of the battery. The azimuths shown are laid off so that they intersect the course. These intersections represent the true positions of the target at the instants of splash.

Q. What data are obtained from the replot? *A*. The uncorrected range to the target and the angle gun-target-tug for each shot or salvo.

Q. What is a tabular analysis? *A*. A form which includes data and computations pertaining to the practice. It consists of uncorrected range for each shot, ballistic corrections which should have been applied, BC corrections, true and spotted deviations, total battery errors, spotting errors, and DAPE of the guns for the practice.

Q. From what sources are the various data for the tabular analysis obtained? *A*.

(1) *Line 2.*—Ranges obtained from the replot.

(2) *Line 3.*—Ballistic corrections which should have been applied by reoperation of the range correction board using ranges of line 2.

(3) *Line 5.*—BC correction actually ordered from record of adjustment board.

(4) *Line 7.*—Range at which piece was actually laid from display board record, as checked by pointing checker.

(5) *Line 9.*—Range deviation of splash. (Line 14 of Form No. 26.)

(6) *Line 16.*—Spotted deviations from spotting board record.

(7) *Other lines.*—Filled in by computations on the form.

Q. How are the actual range deviations of the splash from the target determined? *A.* From computations made on target practice form, W. D., C. A. C. Form No. 26 (Work Sheet for Determination of Range Deviations).

Q. What data are necessary for computations on Form No. 26, and where are they obtained? *A.*

(1) Record of lateral deviations from officer detailed as lateral observer.

(2) Record of range deviations from the tug officer.

(3) Record of gun-target-tug angles as read from the replot.

(4) The length of towline, from the tug officer.

(5) Certain tabular values from regulations governing target practices, as required by Form No. 26.

Q. How is the record of range deviations obtained? *A.* By photographing each shot from the tug, then measuring on the film and computing the deviation; or by using the range rake readings and computing the deviations in case no photograph is obtained.

Q. When it is not possible to distinguish the separate shots in a salvo, how are the range and lateral deviations matched? *A.* The greatest range deviation is matched with the greatest lateral deviation, the next greatest range deviation with the next greatest lateral deviation, and so on.

Q. What is a graphical analysis? *A.* A drawing showing in detail the important features of the practice. In addition, the graphical analysis form contains spaces at the top for data which are required by the Chief of Coast Artillery, and for recording the score. The back of the form contains spaces for computing the score, and for recording comparisons of spotting when both air and terrestrial spotting are used.

Q. How are target practice forms disposed of? *A.* All data sheets, the replot, plot of impacts, forms furnished by officials, camera records, and tabular analysis are retained in the battery for 1 year and then destroyed. The retained copies of graphical analysis, matériel and powder report, indorsements concerning the target practice report, and record of subcaliber firings, are kept as a permanent record in the emplacement book.

Q. What is a matériel and powder report? When is one made? *A.* A record of performance of the guns for a practice; record of powder, projectiles, fuzes, and primers used; meteorological message; and number of rounds fired from each gun. It is rendered for each practice fired.

CHAPTER 15

MOBILE SEACOAST SEARCHLIGHTS

SECTION I

SEARCHLIGHT APPARATUS

66. Types and general characteristics.—The following tables present a general view of mobile searchlight equipment. This equipment was designed for and is provided as AA searchlight equipment but is provided also, without sound locators, for use as mobile seacoast searchlight equipment.

TABLE I.—*Older equipment*

Model of light	Type of distant electric controller	Model of control station	Power unit
36-inch Mack	None	None	Mack, 5½-ton.
60-inch open (1918)	None	None	Cadillac M57.
M–I	Impulse	M–I (d-c)	Cadillac V–63.
M–II	Impulse	M–I (d-c)	Cadillac M341.
M–III (experimental)			
M–IV	Brush shifting	M–III (a-c)	Cadillac.
M–V (experimental)			

NOTE.—Very few lights of the models listed in table I are still in use, and further details concerning them are not included in the subject matter in this manual.

TABLE II.—*Newer equipment*

Model of light	Type of distant electric controller	Model of control station	Power unit
M-VI	Brush shifting	M-III (a-c)	Duplex.
M1934	D-c step-by-step	1934 Binocular (Sperry).	General Motors.
M1937	D-c step-by-step	1937 Binocular (Sperry).	Duplex.
M1939	D-c step-by-step	1939 Binocular (Sperry).	U. S. Motors.
M1940 (Sperry)	D-c step-by-step	1940 Binocular (Sperry).	U. S. Motors.
M1940 (G. E.)	A-c self-synchronous.	1940 Binocular (G. E.).	General Electric.
M1941 (Sperry)	D-c step-by-step	1941 Binocular (Sperry).	Duplex.

67. Sperry searchlights.—*Q.* Describe the characteristics of the Sperry M1941 searchlight. *A.* This is a 60-inch, 150-ampere light. It possesses the following characteristics:

(1) A high-intensity arc as a source of light.

(2) A current through the arc of 150 amperes with an arc voltage of 78 volts.

(3) Automatic focusing of the positive crater, and continuous rotation of the positive carbon.

(4) A ventilating system which exhausts the gases formed by the burning of the carbons.

(5) Metal mirror.

Q. Is the M1941 Sperry searchlight much different in its characteristics from previous Sperry models? What are the differences? *A.* No. The characteristics and operation of the M-VI, M1934, M1937, M1939, and M1940 searchlights are practically identical with the M1941 searchlight. The M-VI is equipped with a glass mirror. However, only M1941 provides for continuous rotation of the positive carbon, and has a time delay mechanism and thermal circuit breaker in the arc switches.

Q. How does the high-intensity arc function in the Sperry searchlight? *A.* The incandescent ball of vapor which forms the source of light in the high-intensity arc is derived from the rare earths, cerium and lanthanum. By mixing these rare earths in the soft core of the positive carbon, and by forcing a high current through the carbon, the earths are volatilized and projected into the positive crater. Electrons flow from the negative to the positive carbon and tend to keep the burning gases in the positive crater.

Q. Briefly describe how the Sperry automatic feed mechanism causes the positive and negative carbons to feed in the 1941 model? *A*. The feed motor operates at "arc" or "listening" load voltages. The feed motor drives the positive rod through a train of gears. A miter gear on the end of this rod drives another miter gear which is shafted to a yoke carrying a set of gears and a ratchet. The yoke also carries the positive carbon which rotates with it. When the feed plunger prevents rotation of a ratchet, which uses the yoke as a shaft, a planetary gear travels around a spur gear which is rigidly fastened to the ratchet, thereby causing the feed roller to drive the positive carbon forward. On feeding sufficiently far forward, the plunger is disengaged, and the large spur gear rotates freely with the yoke without there being any relative movement between this gear and the planetary gear. The feed motor also drives through an eccentric gear which causes the negative reciprocating feed member and the feed pawls to oscillate. Depending on the position of the negative feed-control guard, the proper pawl will operate to drive the negative control rod in the direction necessary to feed the negative carbon forward, or to retract it.

Q. Describe how the positive carbon is fed forward on the M1941 searchlight. *A*. A positive feed-control electromagnet is mounted on the positive head. When the electromagnet has current flowing through it, it attracts a feed plunger, causing the feed plunger to move into one of a series of holes machined in the side of the ratchet, thereby preventing the ratchet from rotating. Attached to the ratchet is a spur gear. Both the ratchet and the spur gear are mounted on, and can rotate with respect to, the yoke. The exterior surface of the yoke serves as a shaft and bearing surface for the bearing of the ratchet and spur gear. When the ratchet stops the spur gear stops. A planetary gear is mounted on, and rotates continuously with, the yoke. This planetary gear meshes with the spur gear which is attached to the ratchet. When the ratchet and spur gear are stopped from rotating by the feed plunger, the planetary gear "walks around" the spur gear which, through shafting and gearing, causes the positive carbon feed rollers to drive the positive carbon forward. The length of time the positive carbon feed contacts are closed may be controlled by means of a positive carbon feed-rate adjustment screw, thereby allowing the positive carbon to feed forward at the desired rate of feed. When the positive feed-control electromagnet has no current flowing through it, the feed plunger is held away from the ratchet by a spring.

Q. There are two methods of causing current to flow through the positive feed electromagnet. What are these two methods? *A*.

(1) *Normal automatic positive carbon feed.*—The feed motor, through gearing, rotates a positive control rod. Mounted on and rotating with this control rod is an eccentric cam. During each revolution of the cam, its high surface closes electric contacts which allow current to flow through the positive feed-control electromagnet, thereby causing the positive carbon to feed forward at a rate equal to one-half the rate of burning of the positive carbon.

(2) *By action of thermostat.*—When the positive carbon burns back $1/64$ of an inch, rays of light coming from the positive crater are concentrated by the thermostat lens on the thermostat bimetallic strip. The bimetallic strip heats and bends so as to close the thermostat electric contacts before the positive crater burns back from the focal point more than $1/32$ of an inch. This allows current to flow through the positive feed-control electromagnet, thereby feeding the positive carbon forward to the focal point of the mirror.

Q. How does the automatic feed mechanism function in the M1940 and prior models? *A*. The feed motor drives a disk, which in turn drives an oscillating feed member forward (toward front of light) and rearward. On this oscillating feed member are mounted three pawls, one positive and two negative. The positive feed pawl engages a positive feed ratchet during the forward movement only of the oscillating member, thereby causing the positive carbon to feed forward and to rotate. The two negative feed pawls, one to drive the negative carbon forward, the other to retract it, engage with corresponding negative feed ratchets. The correct negative feed pawl engages with its corresponding feed ratchet during the rearward movement only of the oscillating feed member.

Q. How is the positive carbon on the M1940 and prior models fed forward? *A*. The feed mechanism feeds the carbon forward so that the normal rate of feed is slightly less than the rate of burning of the carbons. The positive carbon is also rotated during this forward movement so as to cause the positive crater to burn evenly.

Q. What device keeps the incandescent ball of vapor at the focal point of the mirror? *A*. A thermostat, in conjunction with the feed mechanism.

Q. How does the thermostat keep the positive carbon at the focal point of the mirror in the M1940 and prior models? *A*. The thermostat control increases the rate of feed when the crater burns back. When the crater is out of focus to the extent of $1/64$ of an inch, a pencil of light, focused by means of a lens, falls through a slit in the thermostat housing and strikes a bimetallic strip. Heat causes this strip to warp and close a circuit to an electromagnet which draws a guard away from the positive feed pawl, thus increasing the rate of positive feed. The positive crater is thus restored to the focal point before it can get more than $\frac{1}{32}$ of an inch out of focus. The rate of feed of the positive carbon can be regulated by the positive feed-rate adjusting knob.

Q. Can the positive carbon be fed backward as well as forward? *A*. No. The feed mechanism allows the positive carbon to be fed forward only.

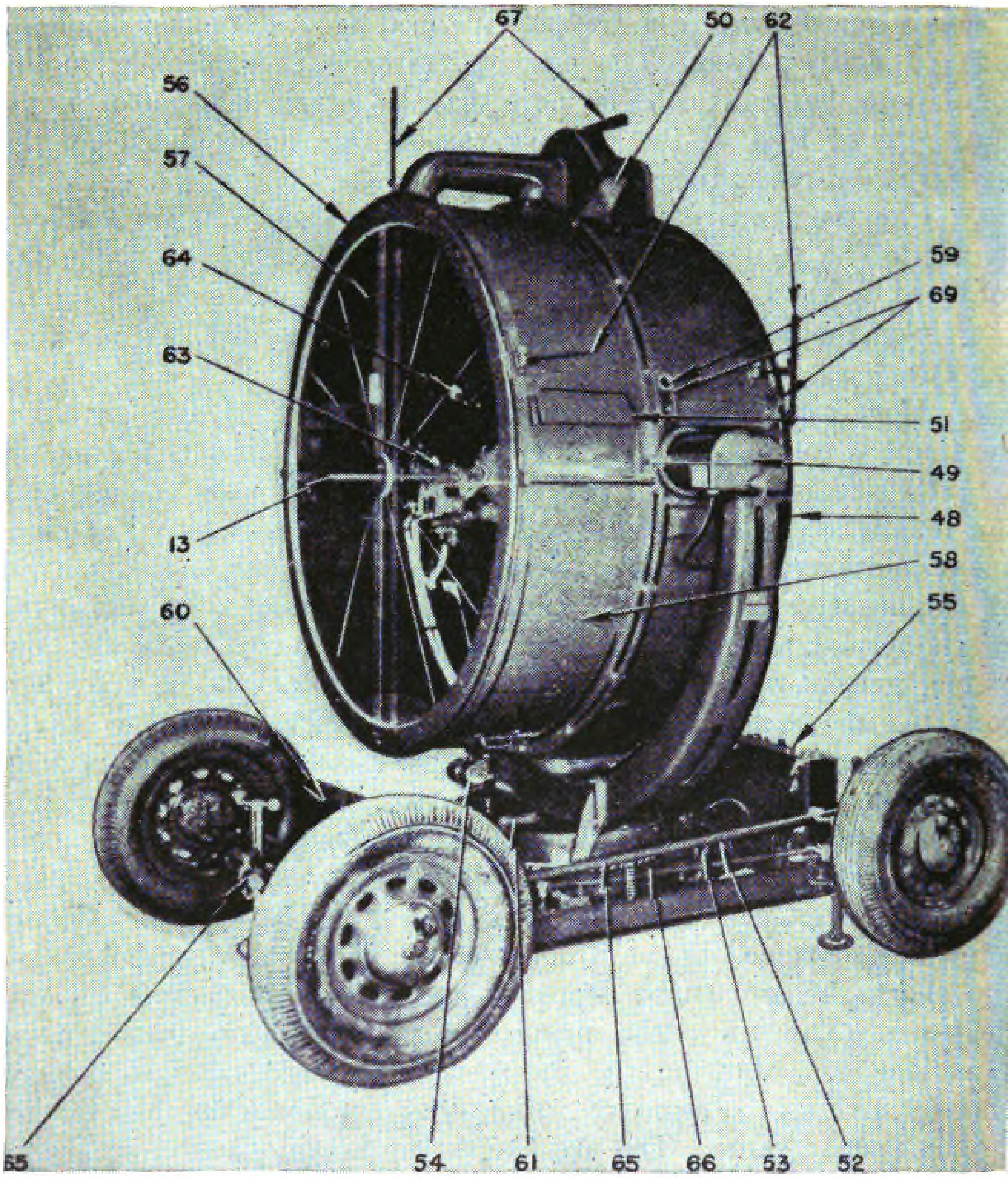
Q. Can the negative carbon be fed backward as well as forward? *A*. Yes.

Q. How does the negative feed control function? *A*. It is governed by the arc voltage coil. This coil is connected directly across the arc and acts as a magnet. As the arc voltage increases or decreases, the magnetic strength of the coil increases or decreases. The magnetic field exerts a pull on an armature which controls the position of the negative feed guard. As long as the voltage drop across the arc is normal, the negative guard holds the negative feed pawls out of engagement with the ratchet wheels which rotate the negative feed rod. As the carbons burn back, the arc lengthens and the voltage across the coil increases, thereby increasing the strength of its magnetic field. The magnetic field of the arc voltage coil attracts the armature toward it against the action of a spring which pulls on the opposite side of the armature, allowing the lower negative feed pawl to become engaged. The negative carbon is fed forward and the arc length is shortened to the proper value. If the arc length becomes too short, the arc length decreases and the voltage across the coil decreases. This allows the spring to pull the armature farther away from the coil allowing the upper negative feed pawl to engage, thereby making the negative carbon draw back and lengthen the arc to the proper value. The arc length can be regulated by varying the tension of a spring attached to the armature of the voltage-regulating coil. The arc is struck automatically by the negative feed mechanism. When the switch is closed, the voltage coil receives full-line voltage and the rate of feed is maximum, bringing the two carbons in contact.

Q. Can the positive and negative carbons be fed other than by automatic feed control? Explain. *A*. Yes. They can be fed by semiautomatic feed control or by hand control.

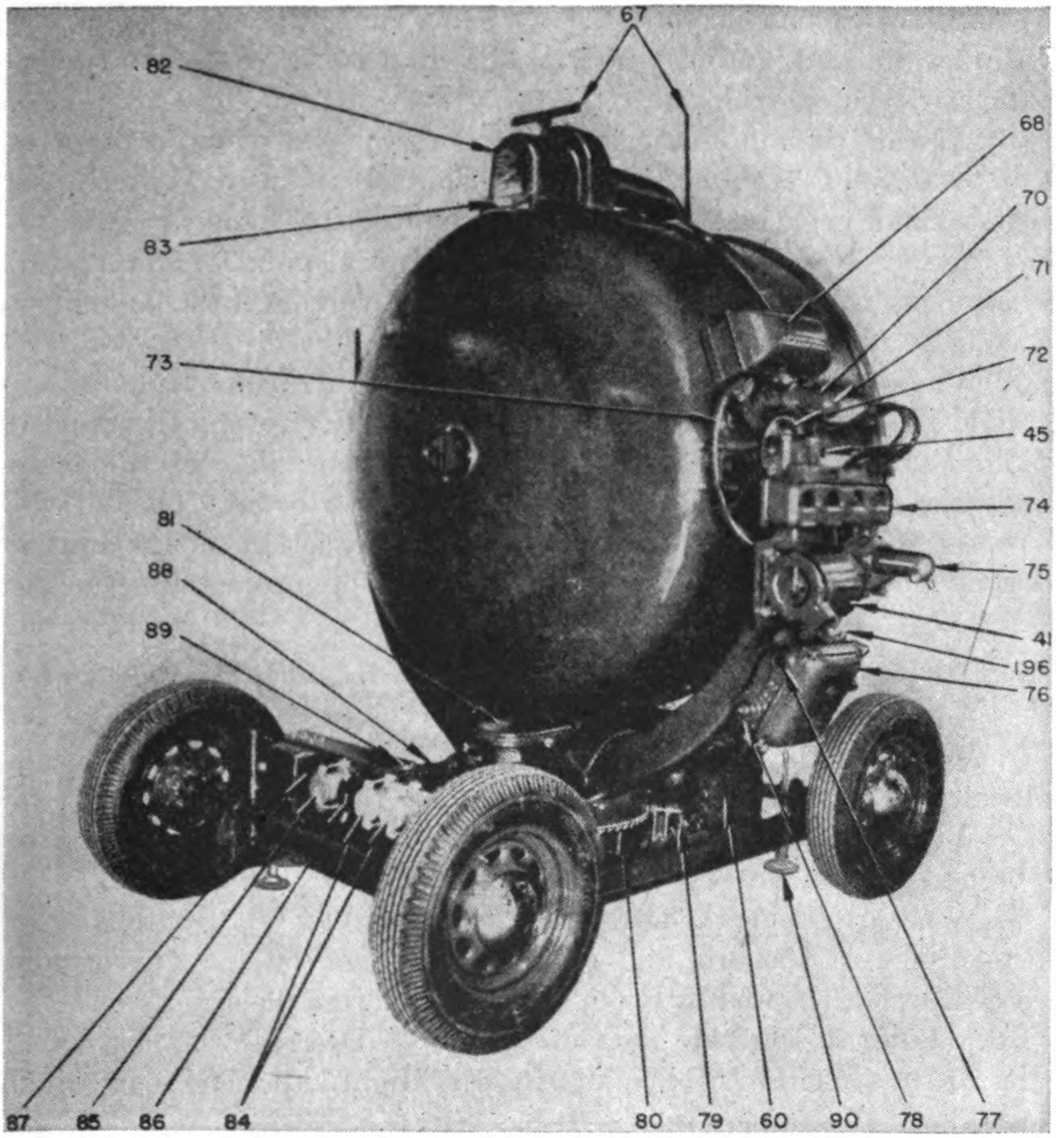
(1) If the positive carbon feed develops trouble, the positive carbon may be fed by hand while the negative carbon continues to feed automatically.

(2) In a like manner, if the negative carbon feed develops trouble,



13. Positive carbon.
48. Rear drum.
49. Elevation data receiver housing. (Not part of M1934 and M-VI lights. M-VI light has a transmitter instead of a receiver at this location.)
50. Ventilating motor and exhaust vent.
51. Ventilating fan intake vents.
52. Azimuth control motor.
53. Azimuth motor clutch lever.
54. Azimuth scale lamp.
55. Junction box.
56. Front drum.
57. Glass door.
58. Sliding panel.
59. Arc view peep sight.
60. Ballast resistor.
61. Handhold plate.
62. Elevation daylight sights.
63. Lamp unit.
64. Recarboning lamp.
65. Steering tongue and lug.
66. Transportation bar.
67. Azimuth daylight sights.
69. Orienting sights.

FIGURE 104.—Sperry M1941 mobile searchlight (front quarter view).



41. Elevation control motor.
45. Arc view peep sight.
60. Ballast resistor.
67. Azimuth daylight sights.
68. Lamp control mechanism box.
70. Recarboning lamp switch.
71. Elevation scale lamp.
72. Elevation scale.
73. Elevation gear sector.
74. Meter box.
75. Hand controller socket.
76. Arc switch box.
77. Extension lamp receptacle.
78. Scale and meter light switch.
79. Azimuth lock.
80. Azimuth scale.
81. Azimuth data receiver housing. (Not part of M1934 and M–VI lights. M–VI light has a transmitter instead of a receiver at this location.)
82. Ventilating motor housing.
83. Transportation lock bar lug.
84. Power cable receptacles.
85. Control station cable receptacle.
86. Sound locator cable receptacle. (Not part of the M–VI and M1934 lights since this cable goes to comparator directly on these models. The M–VI light has a white receptacle and a green receptacle at this location.)
87. Signal buzzer. (Not part of the M–VI or M1934 lights.)
88. Dynamotor (behind wheel). (For the M–VI light it is located at the power plant. For the M1934 unit it is located at the control station.)
89. Dynamotor pilot light.
90. Leveling jacks.
196. Recarboning safety switch. (Found only on the M1941 light.)

FIGURE 105.—Sperry M1941 mobile searchlight (rear quarter view).

the negative carbon may be fed by hand while the positive carbon continues to feed automatically. The above two cases are "semi-automatic feed control."

(3) In case the automatic feeds for both the positive and negative carbons develop trouble, full "hand control" is used to feed the positive and negative carbons. A ground glass finder is used so that the source of light may be kept at the focal point of the mirror. When using the negative hand feed, the arc voltage must be kept at 78 volts by referring to the voltmeter.

Q. Why is a ventilating system necessary in drum type lights? *A*. The purpose of the ventilating system is to prevent the deposit of light-absorbing film on the interior surfaces, to cool the lamp head, and to exhaust gases and soot from the drum. One of the byproducts of the combustion has a corrosive action on the mirror so that a check should be made to insure the proper functioning of the ventilating system.

NOTE.—Always clean mirror and interior surfaces of drum *immediately* after use.

Q. What is the effect of improper focus? *A*. Loss of beam intensity.

Q. What percentage of light is lost by allowing the positive crater to become 1/8 inch out of focus? *A*. Approximately 40 percent.

Q. What are some other causes of loss of light? *A*. Sputtering or unsteadiness of the arc, and deposits of vapor on the mirror and front door, both caused by excessive current across the arc.

68. General Electric searchlight.—*Q*. Describe the characteristics of the General Electric M1940 searchlight. *A*. The searchlight is a 60-inch, 150-ampere light. It has—

(1) A high-intensity arc as a source of light.

(2) A current through the arc of 150 amperes with an arc voltage drop of 78 volts.

(3) Automatic focusing of the positive crater.

(4) A ventilating system to exhaust gases formed by the burning of the carbons.

(5) Metal mirror.

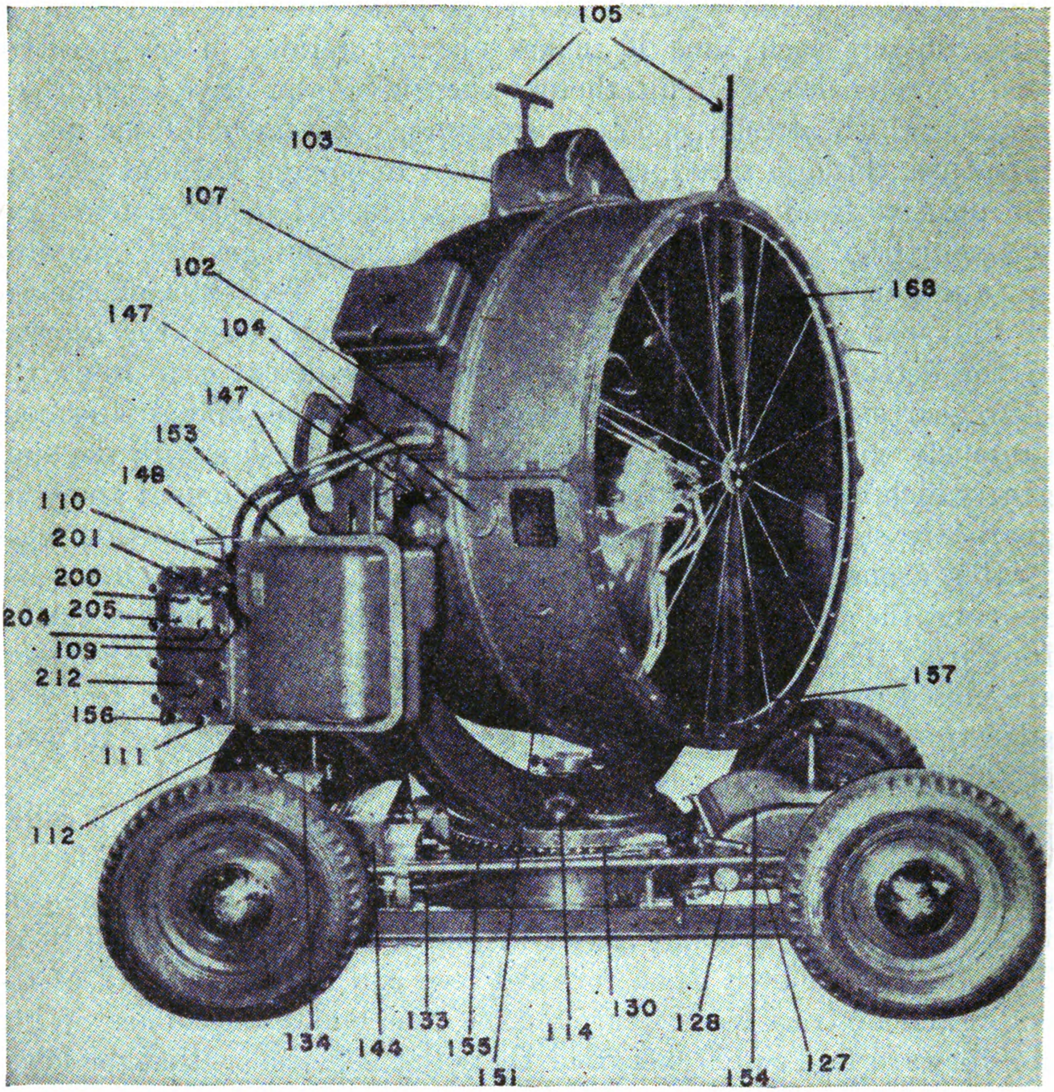
Q. Describe briefly how the General Electric automatic feed mechanism functions. *A*. The feed motor operates at "arc" or "listening" load voltages. The armature shaft is geared on the front end (toward front of searchlight) to a positive drive shaft and is geared on the rear end to the negative drive shaft.

(1) The positive drive shafting is geared to a positive drive rod which rotates the positive carbon continuously. On the positive

drive shaft is a cam which is shaped so as to close the positive feed-rate contacts each time it makes one revolution. These positive feed contacts close a circuit, thereby energizing a positive carbon feed magnet which attracts a detent armature. Movement of the detent armature, through a rod, causes a detent to engage a detent gear on the positive head feed gear assembly. Attached to the detent gear is a spur gear. Both the detent gear and the spur gear are mounted on, and can rotate with respect to, the yoke. The exterior surface of the yoke serves as a shaft and bearing surface for the bearing of the detent gear and spur gear. When the detent gear stops, the spur gear stops. A planetary gear is mounted on, and rotates continuously with, the yoke. This planetary gear meshes with the spur gear which is attached to the detent gear. When the detent and spur gears are stopped from rotating by the detent, the planetary gear "walks around" the spur gear, which causes, through shafting and gearing, the positive carbon feed rollers to drive the positive carbon forward. The length of time the positive carbon feed-rate contacts are closed may be controlled by means of a positive carbon feed-rate adjustment knob, thereby allowing the positive carbon to feed forward at the desired rate of feed.

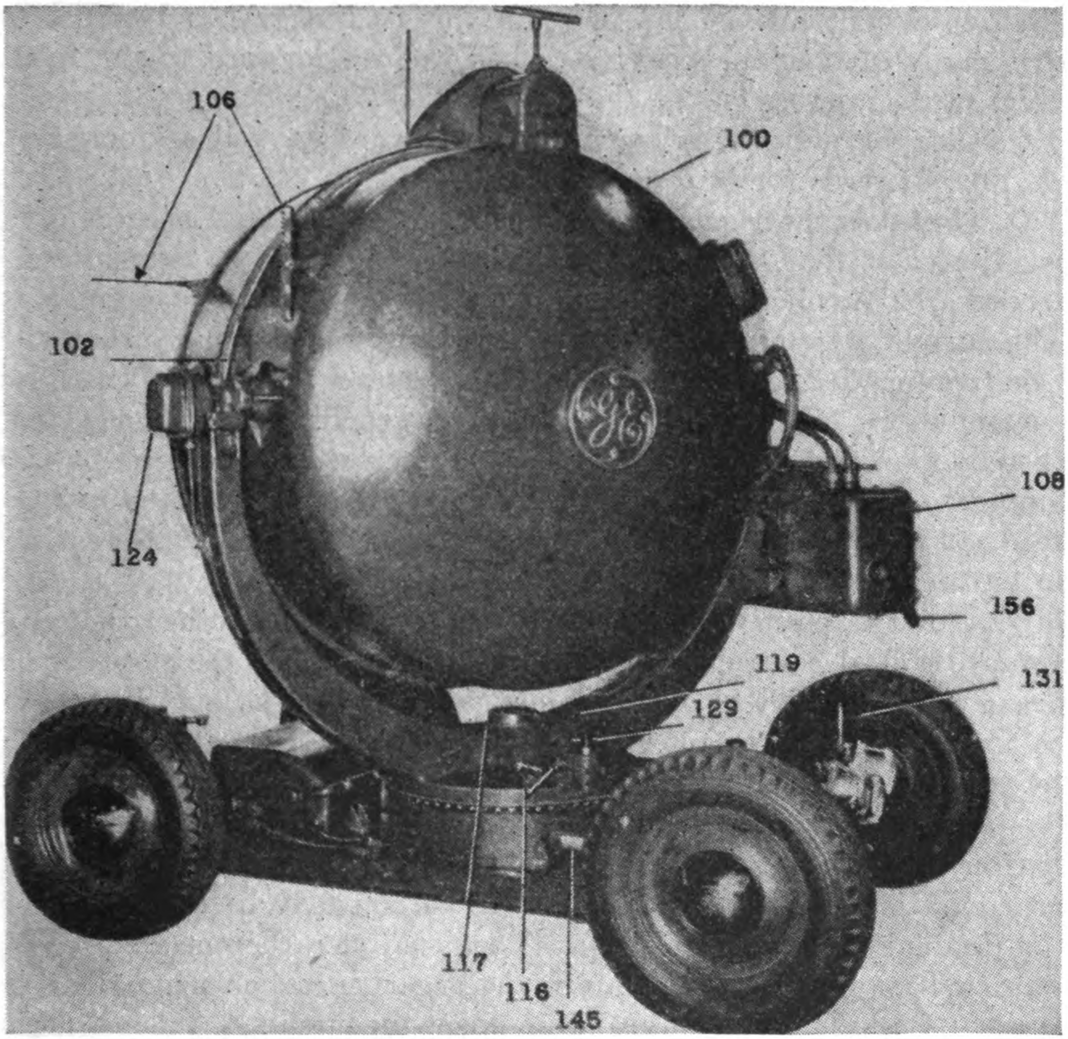
(2) The negative drive shaft has a collar mounted on it. This collar is splined to the negative drive shaft so that it rotates, but it is free to slide along the shaft. On each end of this collar is a disk. The negative drive shaft and collar have a magnetic clutch built around them. This magnetic clutch has a forward feed coil around one end of the collar and a retract feed coil around the other end of the collar. When the forward feed coil is energized, the collar is moved so that the lower disk drives a friction-driven disk. This friction-driven disk rotates the negative drive rod and moves the negative carbon forward. When the retract coil is energized, the upper collar disk engages and causes the negative carbon to retract.

Q. Explain how the thermostat functions. *A*. The thermostat, together with the regular positive feed, causes the positive crater to remain at the focal point of the mirror. It is mounted on the positive head. By means of a concave mirror, rays of light from the positive crater are focused on the thermostat. Within the thermostat are two bimetallic strips, each with contacts on its free end. When the light rays fall between the two, both are heated equally, and neither moves with respect to the other. When the positive crater burns back, the light rays fall on the right bimetallic strip which warps so as to cause its contact to meet the contact of the left bimetallic strip. When these contacts meet, a circuit closes which energizes the positive carbon feed magnet, thereby feeding the positive carbon forward.



102. Arc viewing window.
103. Ventilating fan and motor housing.
104. Arc image screen.
105. Daylight sights.
107. Lamp control mechanism box.
109. Elevation brake handle.
110. Extended hand control bar socket cover.
111. Recarboning lamp switch.
112. Scale lamp switch.
114. Azimuth scale lamp.
127. Azimuth clutch switch.
128. Dynamotor switch.
130. Elevation stowing rod.
133. Towing bar.
134. Junction box.
144. Ballast resistor.
147. Focusing knob.
148. Extended hand control bar clamp.
149. Elevation scale lamp.
151. Drum access door.
153. Elevation control box.
154. Azimuth control box.
155. Azimuth scale.
156. Arc switch handle.
157. Counterweight.
168. Glass.
200. Azimuth zero indicator.
201. Elevation zero indicator.
204. Arc ammeter.
205. Arc voltmeter.
212. Dynamotor a-c indicating lamp.

FIGURE 106.—60-inch M1940 General Electric mobile searchlight (front quarter view).



100. Drum.	119. Azimuth correction handle.
102. Arc viewing window.	124. Elevation data receiver cover.
106. Elevation daylight sights.	129. Azimuth stowing lock.
108. Elevation clutch switch.	131. Leveling jacks.
116. Levels.	145. Dynamotor.
117. Spindle cover.	156. Arc switch handle.

FIGURE 107.—60-inch M1940 General Electric mobile searchlight (rear quarter view).

Q. There are two methods of energizing the positive carbon feed magnet. What are these two methods? *A*.

(1) *Normal automatic positive carbon feed*.—When the positive carbon feed contacts are closed by the cam on the continuously rotating positive drive shaft, an electric current flows through this feed magnet and energizes it, thereby causing the positive carbon to feed forward.

(2) *By action of thermostat*.—When the positive carbon burns back $\frac{1}{64}$ of an inch, the rays of light are focused on the thermostat causing its contacts to close before the positive crater burns back from the focal point more than $\frac{1}{32}$ of an inch. When the thermostat contacts

close, an electric current flows through this feed magnet and energizes it, thereby causing the positive carbon to feed forward to the focal point of the mirror.

Q. Can the positive carbon be fed backward as well as forward? *A*. No. It feeds forward only.

Q. How does the negative feed control function? *A*. The arc length is adjusted so that 150 amperes flow through it. It is a current-controlled arc. A coil in series with the arc energizes a current regulator. The current regulator closes contacts, thereby energizing either the negative forward feed coil or the negative retract feed coil. When the current drops below 150 amperes the forward feed coil is energized, thereby causing the arc to shorten and increase the current to 150 amperes. When the current increases above 150 amperes the retract feed coil is energized and the arc is lengthened, the current decreasing to 150 amperes.

Q. Can the positive and negative carbons be fed other than by automatic feed control? Explain. *A*. Yes. Either the positive or negative carbon may be operated manually. The positive carbon may be fed manually by means of the positive carbon manual drive crank by pushing it in and turning it clockwise. If it is necessary to feed the positive carbon forward rapidly, push in the positive carbon feed button in order to cause the detent to engage the positive head feed gearing. Manual feed of the positive carbon may be used whether the feed motor is running or not. The negative carbon may be fed or retracted manually by pushing in the negative carbon manual drive crank. Pushing the drive crank in, opens the circuit of the magnetic clutch.

69. Control stations (Sperry).—*Q*. For what purpose is a control station used? *A*. To train the searchlight from a remote point.

Q. Of what does the control station consist? *A*. The control station consists of a control unit and a tripod.

Q. Of what does the control unit consist on the 1937 to 1941 models? *A*. It consists of the elevation control mechanism, the azimuth control mechanism, the binocular mount, and the azimuth and elevation zero reader indicators (the zero readers being used for AA searchlight only).

Q. What switch must be turned on before using the D. E. C.? *A*. The D. E. C. switch on the control unit.

Q. What type of distant electric control transmitters are used? *A*. Direct current step-by-step transmitters that operate on the same voltage as the arc.

Q. How many times does the azimuth D. E. C. transmitter rotate for one complete revolution of the control unit? *A.* One hundred fifty times. For this reason, when the power is "off," be careful not to disturb the control station or the searchlight as it will throw the two out of orientation when power is put back "on." This also holds for elevation.

Q. Of what does the D. E. C. consist on 1934 to 1941 models? *A.*

(1) One azimuth D. E. C. transmitter and one elevation D. E. C. transmitter at the control station.

(2) Interconnecting circuits from the control station to the D. E. C. receivers at the searchlight.

(3) One azimuth receiver and one elevation receiver are located at the searchlight. These receivers are positioned by movement of their corresponding transmitters. The receivers are powerful enough to cause the searchlight, through shafting and gearing, to move in azimuth or elevation, thereby pointing the searchlight in the desired direction.

Q. Of what does the D. E. C. consist on the M–VI control station? *A.*

(1) One azimuth D. E. C. transmitter and one elevation D. E. C. transmitter at the control station.

(2) Interconnecting circuits from the control station to the D. E. C. receivers at the searchlight.

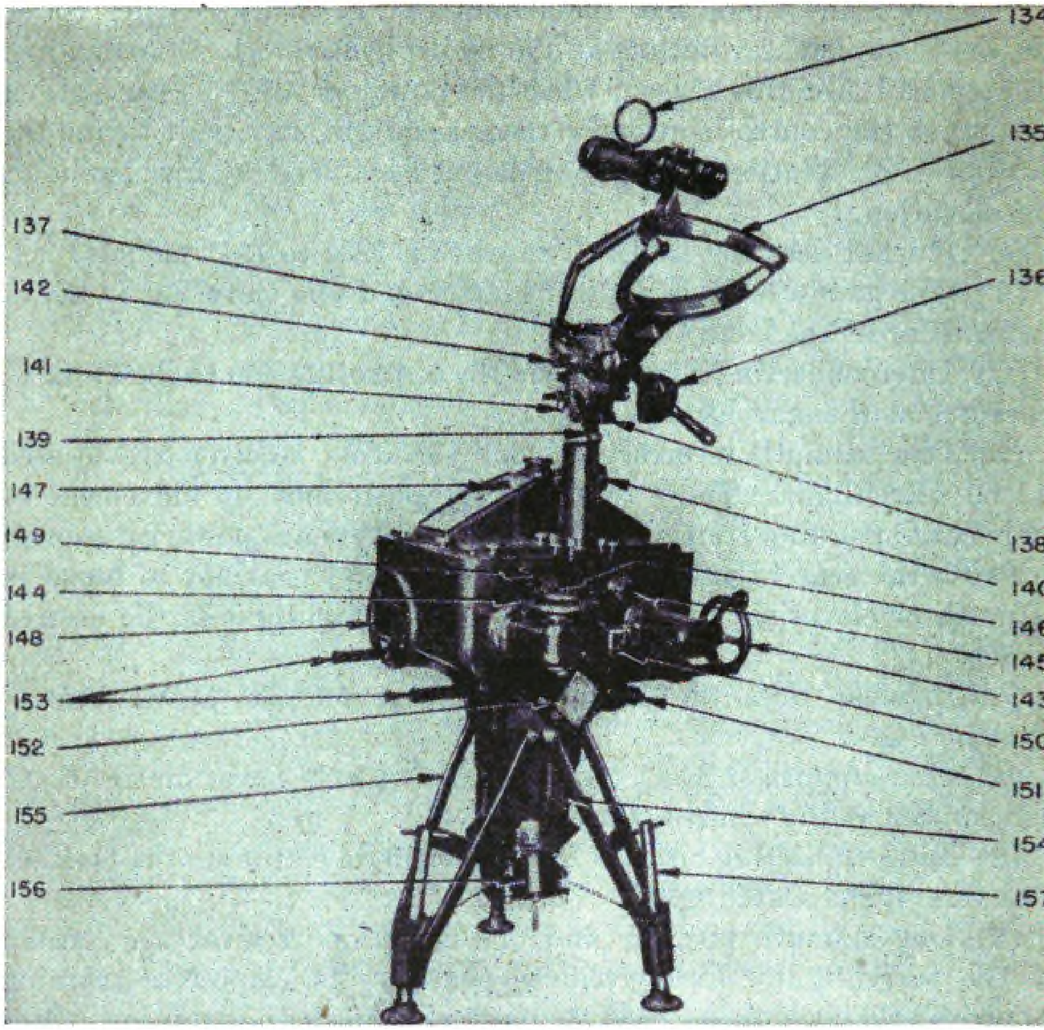
(3) One azimuth receiver and one elevation receiver are located at the searchlight. Each receiver controls its respective training motor, so that when the receiver moves it causes the training motor to turn the light.

Q. How is the parallax between the searchlight and control station compensated for? *A.* On control stations equipped with the binocular mount, the binocular mount may be adjusted in azimuth and elevation with reference to the control unit. The observer points on the desired part of the beam by manipulating the binocular mount adjustment handles.

70. Control station (General Electric).—*Q.* Does the General Electric control station differ greatly in appearance from the Sperry M1940 control station? *A.* No. Outwardly, both are similar.

Q. For what purposes is the control station used? *A.* To control the searchlight movements electrically from a remote point.

Q. What switches must be turned "on" before using the D. E. C.? *A.* With the power plant delivering power to the searchlight; turn on the dynamotor switch at searchlight and the D. E. C. switch at the control station.



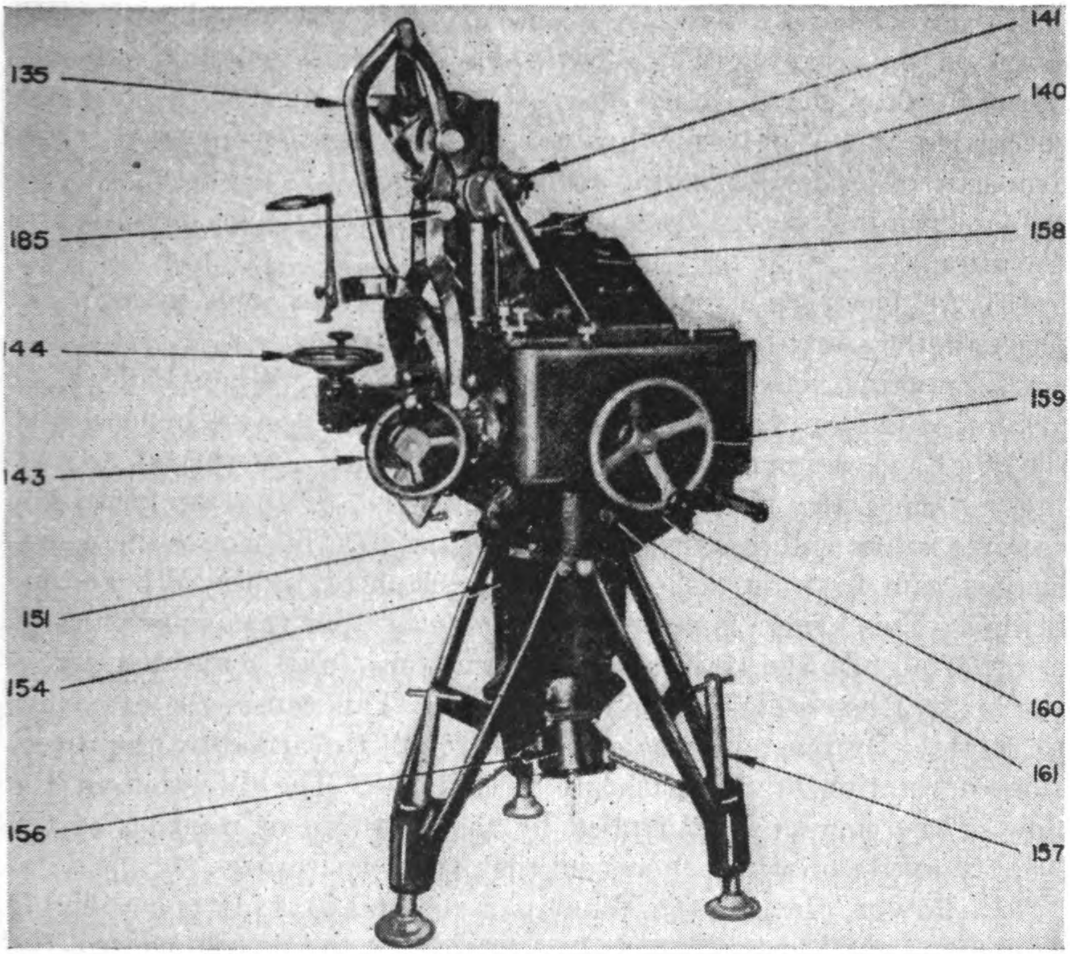
134. Open sight.
135. Binocular mount.
136. Binocular mount counterweights.
137. Binocular elevation zero marker.
138. Binocular azimuth zero marker.
139. Binocular mount adjustment handles.
140. Binocular height adjusting knob.
141. Binocular mount azimuth adjustment.
142. Binocular mount clutch adjustment.
143. Observer's elevation handwheel.
144. Observer's azimuth handwheel.
145. Elevation drive slip clutch.
146. Azimuth drive slip clutch.
147. Azimuth zero reader.
148. Azimuth zero reader handwheel.
149. Signal buzzer push button.
150. Zero reader light switch.
151. D-C switch.
152. Alinement lug.
153. Carrying handles.
154. Handhold cover plate.
155. Tripod.
156. Fifteen-point receptacle.
157. Leveling jack.

FIGURE 108.—Sperry M1941 control station (binocular mount in position).

NOTE.—The nomenclature of the M1937, M1939, and M1940 Sperry control stations is the same as the M1941 control station.

Q. What must be done in order to turn the control station in azimuth without disturbing the azimuth D. E. C. transmitter? *A*. The azimuth clutch knob must be in the "release" position.

Q. How many synchronous positions may be had between the control station and the searchlight in azimuth? What precautions should



135. Binocular mount.
140. Binocular height adjusting knob.
141. Binocular mount azimuth slip clutch.
143. Observer's elevation handwheel.
144. Observer's azimuth handwheel.
151. D-c switch.
154. Handhole cover plate.
156. Fifteen-point cable receptacle.
157. Leveling jacks.
158. Elevation zero reader.
159. Elevation zero reader handwheel.
160. Spirit levels.
161. Clamp knob.
185. Binocular mount locking pin.

FIGURE 109.—Sperry M1941 control station (binocular mount folded down).

NOTE.—The nomenclature of the M1937, M1939, and M1940 control stations is the same as the M1941 control station.

be taken after orientation and synchronization? *A.* Thirty-six. For this reason, care must be exercised so that the control station, once oriented and synchronized with the searchlight, is not traversed when the D. E. C. power is "off." For a similar reason, the control station should not be elevated or depressed when the D. E. C. power is "off."

Q. Of what does the distant electric control consist? *A.* It consists of the following main parts:

(1) One Selsyn a-c azimuth transmitter and one Selsyn a-c elevation transmitter at the control station.

(2) Interconnecting circuits from the control station to the D. E. C. receivers at the searchlight.

(3) Two Selsyn a-c receivers, one azimuth and one elevation, located on the searchlight. A heart-shaped cam is mounted on each receiver rotor shaft. Each heart-shaped cam controls a series of resistances in a Wheatstone bridge. Each bridge is connected to the armature of its corresponding training motor.

(4) Training motors are geared to the searchlight in azimuth and elevation.

(5) An electric antihunting device is a part of this system. It prevents the searchlight from "hunting."

Q. Explain briefly how the D. E. C. operates. *A.* When the D. E. C. azimuth and elevation controllers rotate their respective handwheels, the D. E. C. azimuth Selsyn transmitter rotors are turned accordingly. Since the transmitters are connected to the receivers, the receiver rotors will be moved correspondingly. This causes the heart-shaped cam to rotate, shorting out resistances in the Wheatstone bridge. This bridge is powered in such a manner that as resistances are shorted out, the training motor armature (also connected across the bridge) has a current delivered to it. This causes the armature to rotate. By reversing the current through the armature the direction of rotation of the armature is changed. The direction of the flow of the current is controlled by the direction of rotation of the heart-shaped cam which shorts out the proper resistances.

71. Power plants.—*Q.* What is a rheostat? *A.* It is a variable resistance, which, when inserted in an electric circuit, can control the amount of current which will flow.

Q. Explain how a rheostat is used on the searchlight power plants. *A.* By placing a rheostat in the field circuit of the generator, the amount of exciting current flowing in this circuit can be controlled. This exciting current energizes the electromagnets of the generator field. The more current that flows, the stronger the electromagnets, thereby causing an increase of generated voltage. Decreasing the exciting current decreases the generated voltage. By varying the resistance of the rheostat the voltage of the generator may be regulated.

Q. What is the purpose of placing fuses in an electric circuit? *A.* Fuses are made of wire which will conduct currents of a given amount through them but which will immediately heat and melt, breaking the circuit, when the current increases beyond its rated current-carrying capacity. Fuses are used to protect delicate electrical instruments or expensive parts of an electrical system.

Q. What other type of interrupter is used by the searchlight unit? *A.* Circuit breaker.

Q. Briefly explain how a circuit breaker operates. *A.* There are many kinds of circuit breakers. Some are controlled magnetically, some by heat, and others by a combination of heat and a magnetic field. Some are adjustable for different current ratings; others are built for but one current rating. When a current larger than the current rating for that particular circuit breaker flows through it, the breaker opens the circuit so as to prevent damage to the equipment.

Q. Can a person be injured by improper maintenance or operation of searchlight equipment? *A*. Yes. A person can be killed.

Q. What precautions should be taken to prevent injury? *A*. Always be certain that the power plant main switch is "off" when maintenance work is done on the searchlight. Always be certain the power plant is not running when performing the normal power plant maintenance work. Repairs of an electrical nature should be made by the electrical sergeant attached to the platoon. An operator should know where his current comes from and where it goes—in other words he should know how to trace the electrical circuits on the equipment. This will not only make him more efficient but will prevent his sustaining injuries or burns by touching a live lead at some exposed point.

Q. Describe the power plant with which the (candidate's) searchlight is powered. *A*.

(1) *M1941, M1940, M1939, and M1937 power plants* (*Sperry*).—Each unit is a complete power plant consisting of a gasoline engine directly connected to a d-c generator, control equipment and power panel, and the chassis and housing.

(*a*) The power plant is equipped with standard automobile wheels and tires and can be towed by a truck for short distances over good roads.. On long hauls it is transported in a truck or trailer.

(*b*) The engines are Hercules JXD, six-cylinder, with one spark plug per cylinder. They are equipped with engine accessories found commonly on all gasoline engines, including radiator, distributor, generator, ignition coil, starting motor, and battery. Engines are equipped with governors to control engine speed as follows:

Model	Revolutions Per Minute	
	Arc load on	Arc load off
M1941	1, 100	1, 150
M1940	1, 000	1, 050
M1939	1, 200	875–900
M1937	1, 200	875–900

(*c*) The d-c generators are rated as follows:

Model	M1941	M1940	M1939	M1937
Make	Westinghouse SK 90 Special	Westinghouse SK 93 Special	Westinghouse SK 93 Special	General Electric type CT-1501-EI
Rpm:				
Arc load off	1, 150	1, 050	875–900	875–900
Arc load on	1, 100	1, 000	1, 200	1, 200
Volts (arc on or off)	100	100	100	100
Amperes:				
Arc load off	12	12	15	15
Arc load on	162	162	165	165
Kilowatts output	16. 2	16. 2	16. 5	16. 5

(*d*) The engine and generator may be completely controlled from the power panel. Control is automatic, but provision is made for hand control.

(2) *M1940 power plant* (*General Electric*).—The General Electric power plant consists of—

(*a*) A gasoline engine and auxiliaries, including radiator, fan, and governor for control of engine speed, having the following characteristics:

1. The engine is a Hercules JXD, six-cylinder, with one spark plug per cylinder.

2. It has a force feed system of lubrication and an oil filter.

3. It is equipped with a governor to control engine speed at 1,200 rpm.

4. It is equipped with engine accessories found commonly on all gasoline engines, including radiator, distributor, generator, ignition coil, starting motor, and battery.

(*b*) A d-c generator direct-connected to the engine with four main and two commutating poles, weighing 650 pounds, and having the following electrical characteristics:

	Volts	Amperes	Rpm	Kilowatts
Arc load off	100	8	1, 200	0. 8
Arc load on	100	160	1, 200	16. 0

(*c*) A control panel on which are mounted—

1. Power-indicating instruments.

2. Power main switch.

3. Field rheostat.
4. Tachometer (to indicate engine speed).
5. Engine indicators, to include a temperature indicator and an oil pressure gage.
6. Lighting facilities.

(*d*) Suitable chassis and housing for military purposes. Standard automobile wheels and tires are used. The power plant may be towed by a truck for short distances over good roads.

(3) *M1934 portable power plant* (*Sperry*).—The M1934 portable power plant is a complete portable unit mounted on chassis provided with four small steel wheels. This unit can be moved for short distances over hard surfaces. For long hauls this unit is transported on a "portable equipment trailer."

(*a*) The generator is a 31.25-kilowatt, 125-volt, 250-ampere, 1,400-rpm, differential compound generator, directly coupled to the engine. It supplies power for the arc as follows:

	Volts	Amperes	Rpm
Arc load on	100	165	1, 200
Arc load off	102	15	850

(*b*) The control panel or switchboard is mounted on the rear end of the power plant, and contains the following main units.

1. Circuit breaker for the arc load.
2. Load setting switch, which is used to select 150-, 200-, or 250-ampere load.
3. Voltage manual rheostat, which is used to adjust the voltage when using manual control.
4. Voltage automatic rheostat, which provides a fine adjustment of voltage when generator is on automatic operation.
5. D-c load ammeter.
6. D-c generator voltmeter.
7. Tachometer.

(*c*) The control of the power unit is fully automatic. If desired, it may be manually controlled.

(*d*) The engine is a Hercules model WXC-3, six-cylinder gasoline engine and has both battery and magneto ignition with two spark plugs per cylinder.

(4) *M1934 mobile power plant* (*Sperry*).—The M1934 power plant utilizes the engine of the Duplex truck for driving the generator.

The vehicle engine is a six-cylinder General Motors engine, delivering 112.5 horsepower, at 2,800 rpm.

(*a*) The generator is a d-c commutating pole type with self-excited, shunt-wound fields mounted in rear of the transmission. The voltage of the generator is controlled by an automatic regulator. The speed of the engine and generator is controlled by a mechanical governor driven by, and located on, the engine. With certain minor adjustments the generator supplies power for the arc under the following conditions:

	Volts	Amperes	Rpm
Arc load on	98	165	1, 100
Arc load off	101	15	900

(*b*) The control panel is mounted directly behind the driver's seat. The panel contains the necessary control apparatus to adjust and maintain constant voltage. There are, in addition, necessary protective devices such as relays, instruments, and resistors. The front of the control panel contains the following:

1. D-c voltmeter.
2. D-c ammeter.
3. Rheostat to select and adjust the voltage.
4. Circuit breaker for the searchlight current.

(*c*) The rotary converter is a portable unit and is usually placed near the control station.

(5) *M-VI power plant* (*Sperry*).—(*a*) A duplex truck transports the searchlight and furnishes the power for operation of the searchlight.

(*b*) A 15-kilowatt, flat-compounded, d-c generator, designed to deliver 150 amperes at 100 volts with an engine speed of 1,800 rpm, is mounted on the chassis in rear of the transmission. A hand clutch is located in the cab so that the tail shaft may engage and operate the d-c generator or the rear axle.

(*c*) The power panel is mounted directly behind the driver's seat and includes the following:

1. Circuit breakers for the searchlight current.
2. Field rheostat for adjusting the voltage.
3. D-c voltmeter.
4. D-c ammeter.
5. A-c voltmeter to indicate a-c voltage from rotary converter.
6. A switch for starting the rotary converter.

(*d*) A ¾-kva, 3,600-rpm, 60-cycle, single-phase, rotary converter is mounted on the right-hand running board. It converts 100 volts d-c from the searchlight generator into 120 volts a-c (used with AA searchlights for the a-c data transmission system employed by the comparator).

(*e*) The truck engine serves as the power plant. It is a six-cylinder, 55-horsepower, Buda type DW–6 engine. A flywheel governor is provided for maintaining an engine speed of 1,800 rpm when driving the generator.

72. Orientation.—*Q*. Briefly describe how a searchlight unit is oriented. *A*. Level the searchlight and control station. Two methods commonly used are—

(1) Direct the sights of the searchlight and control station at a star (or distant point) and set all azimuth scales correctly. In units equipped with the M–VI control station, point control station in the same general direction as the searchlight, using orienting stakes. For elevation, set searchlight and control station binoculars to zero elevation.

(2) Point the searchlight by its sights on the control station and backsight the control station on the searchlight by pointing the large end of the binoculars at the center of the searchlight drum. Set azimuth scales to correct azimuth. For elevation, proceed as in (1) above.

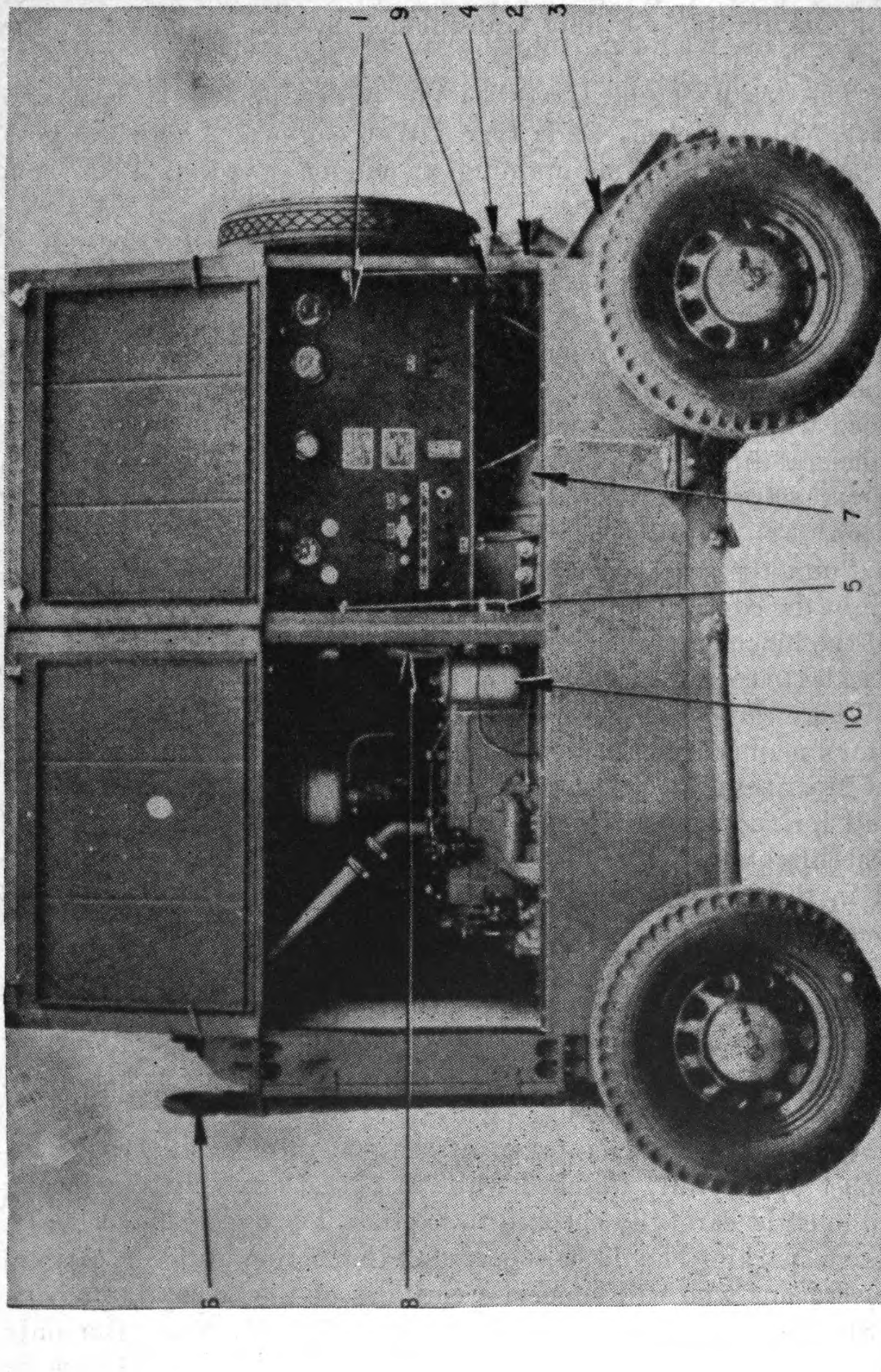
Q. Where can detailed instructions be found for orienting? *A*. In operator's manual furnished with the equipment.

73. Maintenance, care, and adjustment of parts.—*Q*. Where can full instructions covering maintenance, care, and adjustment of the searchlight unit equipment be found? *A*. This information is found in the operator's manual issued with the equipment. *These instructions should be followed exactly.*

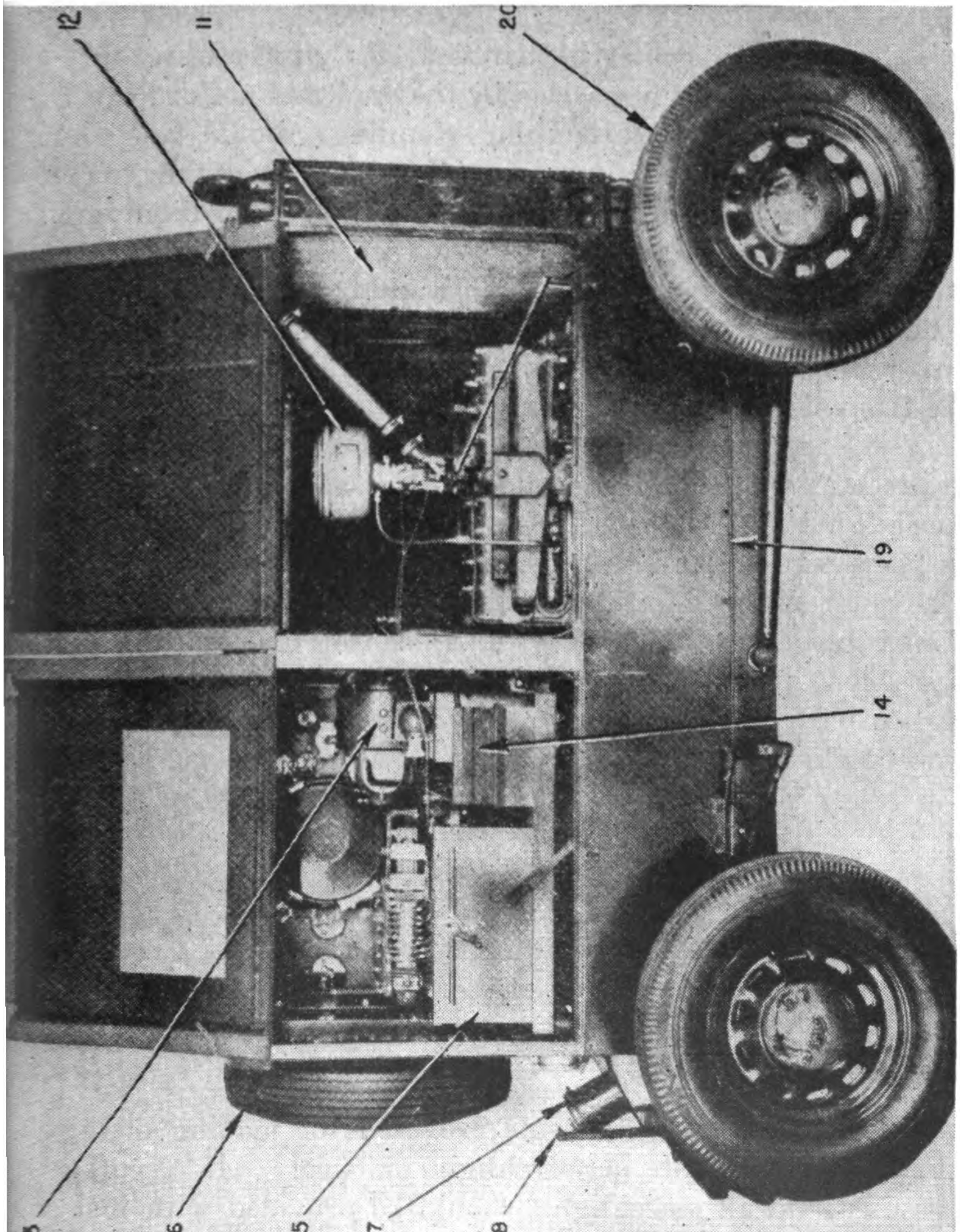
Q. What is the chief responsibility of the searchlight lamp operator? *A*. To see that the carbons are properly placed at all times and are functioning properly. Failure to do this will cause burning of the positive or negative head which in turn will drop hot metal on the mirror, thereby damaging it.

Q. What care should be taken of the generator? *A*. The generator must be carefully watched while in operation. The ventilating system must be carefully checked to see that it is operating correctly. Excessive sparking should be reported to the section leader or maintenance sergeant who will supervise cleaning of the commutator bars.

Q. Should the generator be oiled? Explain. *A*. Yes. But only at the points indicated by oil cups or grease receptacles. Grease on the commutator bars or other electrical contact points should be avoided.



1. Control panel.
2. Power receptacles.
3. Fuel tank.
4. Tail lamp.
5. Control panel door bracket.
6. Tow bar.
7. Power generator.
8. Fan.
9. Tail lamp switch.
10. Oil filter.



11. Radiator.
12. Air filter.
13. Fan motor.
14. Battery.
15. Tool box.
16. Spare wheel and tire.
17. Fuel tank filler pipe.
18. Brake lever.
19. Safety chain brake cable.
20. Exhaust.

FIGURE 111.—Sperry M1941 power plant (right side).

Q. How should carbons be stored? *A.* In a cool, dry place and if possible in the original container until ready for use.

Q. What care should be taken of the lamp mechanism? *A.* It should be properly cleaned and lubricated at all times. Care should be taken not to permit grease to collect around the contact elements as this will impair the contacts of the brushes and cause faulty functioning.

Q. How should electric cables be handled so that they are not damaged? *A.* Cables should be carried by the crew and not dragged along the ground. Especially the plug couplings should not be dragged. These are made of aluminum alloy and when they are dragged along the ground in winding cable, they become distorted in shape and will not fit properly in the receptacle. Also, each contact is connected within the plug to a small lead of the cable. Dragging will cause breaking of these small conductor leads, thus interrupting the system. No pulling strain should ever be applied on cables while removing plugs. Take hold of the plug itself and pull it out.

Q. What are some general rules pertaining to loading and unloading the searchlight? *A.* Do not use excessive speed in loading or unloading. Never force the searchlight into position in the vehicle. Seek out the cause of the interference and remove it. Be sure that the bows do not interfere when loading and unloading the searchlight. Do not leave a long positive carbon in the searchlight when loading it. The carbon will probably break off and may drop on the front door window, breaking the glass.

SECTION II

TROUBLES AND REMEDIES

74. Circuits.—*Q.* What instruments are used for making ordinary tests of defective circuits in searchlight matériel? *A.* A voltmeter can be used and all searchlights should be provided with test lamps, consisting of an incandescent globe with two insulated leads projecting from the socket containing the globe. With power on the circuit, the live lines can be tested with this light. For testing for faults in circuits where no power is applied during the test, a voltmeter, telephone receiver, or buzzer, with a battery in series, may be used. Numerous variations of the above method may be improvised.

Q. What are the chief sources of trouble in d-c electrical systems? *A*. Open circuits, short circuits, and grounds.

Q. How is the test for each made? *A*.

(1) *Open circuits*.—Complete a known circuit by wiring together any open leads, for instance the positive and negative power leads in a nine-conductor cable. Locate the other ends of the two leads and test across these two with the buzzer arrangement described above. If the circuit is complete, there will be a buzz or click. If no impulse is received, the circuit is open.

(2) *Grounds*.—Connect one terminal of the test set to a live lead. The other terminal of the test set should then touch the frame of the searchlight or instrument where a ground is suspected. If there is a ground in the circuit, an impulse will be received in the test set. If the line is clear, there will be no sound.

(3) *Short circuits*.—Be sure that the two lines being tested are not connected so that there is no completed circuit through them normally. Test at several places along the cable and if there is a short circuit some place in the line there will be a completed circuit through the test set.

75. Lamps.—*Q*. Power on the system of an electrically controlled searchlight is indicated by the glow of the incandescent bulbs at various points of the system. If an incandescent lamp goes out, what does this indicate and what is the remedy? *A*. Usually this indicates a blown fuse. Examine the fuse with a test lamp but do not replace it without first attempting to discover the cause of the excessive current. This trouble may also be caused by open circuits, loose or broken contacts, or burned-out bulbs.

Q. What are some of the causes of lamps becoming dim during operation of the searchlight? *A*.

(1) Wire connections to the switch defective.
(2) Lamp socket terminal loose.
(3) Halves of the connectors not making good contact.
(4) Defective connections at the lamp.
(5) Fluctuations in voltage.

Q. What causes lamps to flicker? *A*.

(1) Loose connections.
(2) Voltage fluctuations.
(3) Intermittent short circuits.

Q. In the automatic control searchlights, how are the functions of the various searchlight mechanisms tested prior to actually starting the arc? *A*. With no carbons in place, apply the supply voltage to the searchlight for a brief period and check up on the operation of the fan motor and positive and negative feed mechanisms. Operation of the feed motor should cause the positive and negative mechanisms to rotate in the proper directions.

Q. After the arc current has been supplied and the arc starts burning, what is the first thing the operator should do? *A.* Check up on the voltage. The voltage is indicated on the meter at the searchlight and should be 78 to 80 volts with a current of approximately 150 amperes.

Q. What is the maximum voltage permitted at the generator terminals, as indicated on the voltmeter at the power plant? *A.* 120 volts. The voltage should be regulated within 5 volts of 100 at all times by use of the field rheostat.

Q. When the arc is struck, what does the lamp operator do if the negative feed does not move the carbon back properly from the positive? *A.* First, shift the centralizing knob from "auto" to "hand." Then move the negative carbon back by the negative feed knob. Do not use the arc regulating mechanism to adjust the position of the negative carbon until the light has been burning for several minutes.

Q. What should be done with respect to the positive carbon? *A.* Check to be sure that it is rotating properly and that it is at the proper point with respect to the positive head. The crater of the positive carbon should normally be $1\frac{1}{16}$ inch in front of the positive head nose.

Q. How are hand adjustments of the positive carbon made? *A.* By means of the positive hand feed knob. It can be fed forward only.

76. Switches.—*Q.* Where is the main switch at the searchlight? *A.* On the later model searchlight the switch is on the trunnion arm. On other models the switch is on a terminal box mounted on one axle.

Q. Point out the switches on the searchlight in use by the (candidate's) organization and tell what each is for. *A.* (Practical demonstration.)

Q. What general care should be given to switches? *A.*

(1) They should be examined frequently to see that the blades seat properly.

(2) All leads should be tightly connected.

(3) All contact surfaces should be kept free from grease and dirt at all times.

(4) The switches must be thrown and released quickly to prevent arcing. Arcing will fuse some of the copper and roughen the contact surface.

(5) All fused metal should be filed off.

77. Ammeters and voltmeters.—*Q.* What care should be given to voltmeters and ammeters? *A.* They should be protected from jars. If the indicator needle in an instrument sticks, tap the instrument case gently. If it fails to respond to this treatment, do not try to repair it in the field. A voltmeter or ammeter is a delicate instrument and must be carefully calibrated during the process of readjustment.

Q. How should ammeters be connected in a circuit? *A.* In series with the line.

Q. How should voltmeters be connected in a circuit? *A.* Across the line.

78. Miscellaneous.—*Q.* Name some of the causes which necessitate removing and cleaning the generator brushes. *A.*

(1) If the ventilating windows of the generator are left open during road travel, dust, dirt, and dampness will enter and corrode both the brushes and commutator. In this case it will be necessary to remove the brushes and clean the contact surfaces. The commutator likewise should be cleaned.

(2) Sometimes the brushes wear unevenly or the commutator becomes rough in ordinary usage. The brushes should be removed as soon as this is detected and new ones inserted in their places. The old brushes may later be reground and used as spares. The commutator may be smoothed out by using light sandpaper, but care must be taken not to cut too much from the surface and not to fill up the insulation gap between the bars with sand dust. Under no circumstances should a metallic or emery cutter be used on the commutator.

(3) If oil accumulates on the contact surfaces of the brushes or on the commutator, the functioning of the generator will not be satisfactory and the commutator and brushes should be thoroughly cleaned.

Q. How should all clearances between electric contact points be set? *A.* Usually with micrometer tools. In adjusting the distant electric control, the instructions in the book furnished with the unit should be carefully followed. All other adjustments should be made according to instructions in the pamphlets issued.

Q. When dismantling equipment, what precautions should be taken to prevent loss of parts? *A.* A canvas or box should be made available so that the parts may be placed therein as soon as removed. Retaining screws and washers may be replaced in their threads for safekeeping. Care should be taken to keep the parts clean after their removal and they should be wiped off before being replaced.

Q. In general, what "trouble shooting" should a chief of section be prepared to do? *A.* He should be able to locate and repair minor troubles and keep the system in operation under ordinary conditions. He should have enough knowledge to protect the equipment from extensive damage, determine the apparatus at fault, and be able to assist the electrician sergeant in locating trouble and making repairs to the electrical equipment.

SECTION III

INSTRUCTION OF SEARCHLIGHT SQUAD

79. Instruction of members of searchlight squad.—The candidate should be required to demonstrate practically his ability to instruct members of the searchlight squad. Duties of the members of the searchlight squad are prescribed in TM 4-315.

CHAPTER 16

MOTOR TRANSPORTATION

SECTION I

PRINCIPLES OF INTERNAL COMBUSTION ENGINES

80. Theory of internal combustion engine.—*Q*. Explain briefly the basic principle involved in the operation of the internal combustion engine. *A*. A combustible mixture of fuel (gasoline) and oxygen (air) is introduced into a cylinder and compressed between the closed end of the cylinder and a piston. The mixture is then ignited. The burning of the mixture generates heat which causes expansion of the gases within the cylinder. The expanding gases act on the piston and force it downward. The movement of the piston is transmitted through a connecting rod to the crankshaft, thus converting heat energy into mechanical energy.

Q. What types of internal combustion engines are used in motor vehicles? *A*. The gasoline engine and the Diesel engine.

Q. What is meant by a cycle? *A*. A cycle is a series of events which are constantly repeated in the same manner and the same order. In a gasoline engine it consists of the four strokes of the piston and the events that occur with each stroke.

Q. What is meant by a four-cycle or four-stroke engine? *A*. One whose cycle consists of the following four distinct steps:

(1) Intake or admission of the charge of the air-fuel mixture.
(2) Compression of the charge.
(3) Ignition and explosion of the charge.
(4) Exhaust or expulsion of the burned charge.

When this complete process requires four strokes of the piston in any one cylinder, the engine is designated as a four-stroke cycle engine.

Q. Explain what takes place during each of the four strokes of the cycle. *A*.

(1) The piston being at top dead center and the intake valve having just opened, the piston going down on suction draws into the cylinder a charge of gasoline and air.

(2) Shortly after the piston has passed bottom dead center, the intake valve closes; and during the rest of the upward stroke, the charge is compressed.

(3) Just before the piston reaches top dead center on the compression stroke, a spark is produced at the spark plug and the burning of the charge forces the piston downward. (This is the power stroke.)

(4) Just before the piston reaches bottom dead center, the exhaust valve opens and the next upward stroke of the piston forces the burned gases out and clears the cylinder for the intake stroke of the next cycle.

Q. Why is a system of valves used in an engine? *A*. To allow the fuel to enter the combustion chamber, to close the chamber, and to allow the burned gases to escape from the combustion chamber at the proper time.

Q. What is the function of the camshaft? *A*. The camshaft has a cam for each valve. As the camshaft turns, the cam comes in contact with the valve lifter and raises the particular valve off its seat (opens it).

Q. How is the camshaft driven? *A*. Either by a chain or by a system of timing gears driven by the crankshaft gear.

Q. What is meant by valve timing? *A*. By valve timing is meant the proper adjustment of the opening and closing of the intake and exhaust valves in relation to the position of the piston. Since the distance of the piston from dead center is dependent on the position

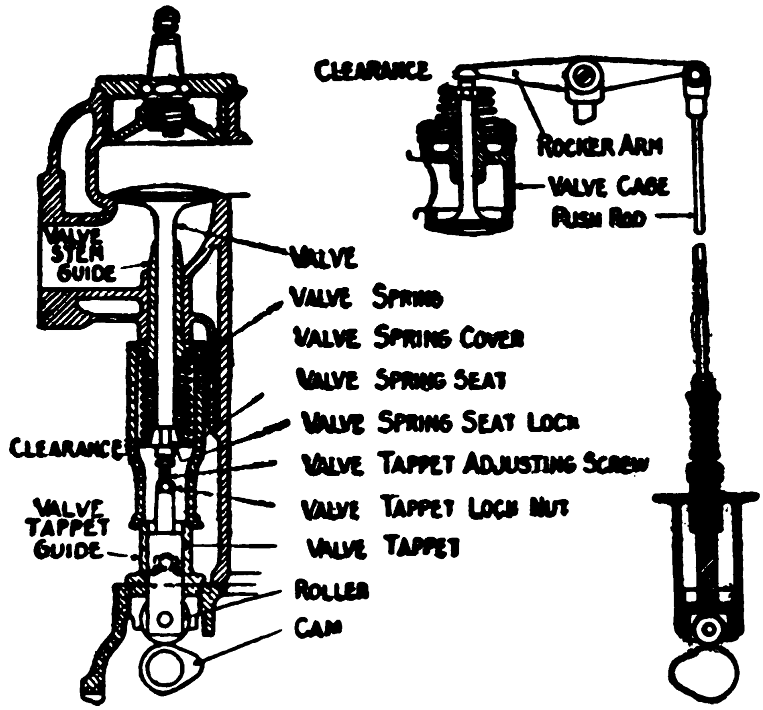


FIGURE 112.—Typical valve mechanisms.

of the crankshaft, valve timing resolves itself into the proper meshing of the crankshaft gear with the camshaft gear to obtain this correct relationship.

Q. When should the valve open in relation to the position of the piston? *A.* The average opening and closing of the valves of the modern high-speed engine are as follows: Intake valve opens 5° before top dead center. Intake valve closes 46° after bottom dead center. Exhaust valve opens 47° before bottom dead center. Exhaust valve closes 8° after top dead center.

NOTE.—Wherever values for any adjustments are given they should be understood as averages. Service manuals for particular vehicles should always be consulted.

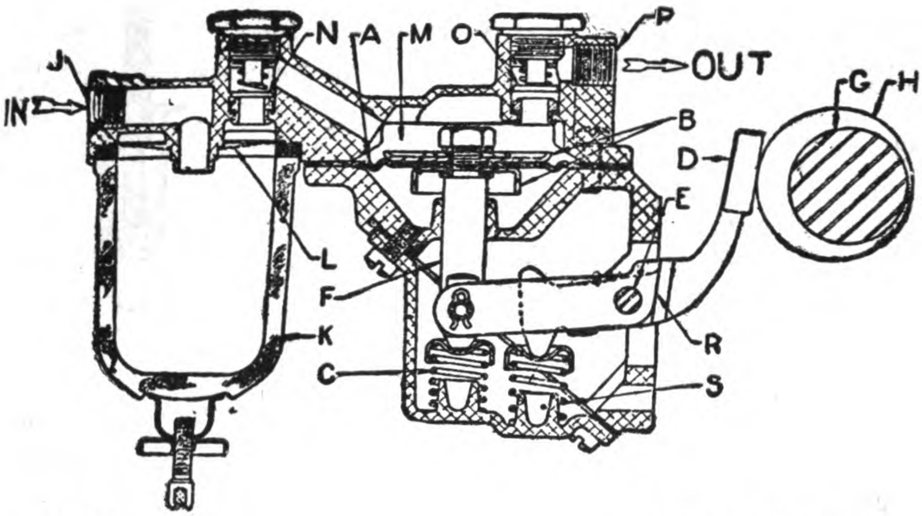
Q. Why is the power producing unit of a motor vehicle called an engine instead of a motor? *A.* To avoid any confusion with electric or starting motors.

81. Gasoline feed system.—*Q.* What type gasoline feed system is used on Army vehicles? *A.* The positive fuel feed system (fuel pump) is used on all modern vehicles.

Q. Describe the fuel pump. *A.* The fuel pump is a device used to pump the fuel from the fuel tank and force it to the carburetor. It has a diaphragm in the housing of the pump which is operated by a lever. The lever is in constant contact with a cam on the camshaft which operates the pump. The pump has a check valve in the inlet side which allows the gasoline to be drawn from the fuel tank but stops the flow back into the tank. There is another check valve on the outlet side which allows the gasoline to be forced into the carburetor.

Q. What troubles develop most frequently in a fuel pump? *A.* The diaphragm becomes punctured, gasoline lines become loose, or the strainer becomes clogged.

Q. What pump parts should be carried on a convoy? *A.* A complete fuel pump for replacement use.



A. Diaphragm.
B. Diaphragm metal disks.
C. Diaphragm pull rod spring.
D. Diaphragm operating rocker arm (two pieces).
E. Rocker arm pivot.
F. Diaphragm pull rod.
G. Camshaft.
H. Eccentric cam on camshaft.
J. Inlet from gas tank.
K. Glass sediment bowl.
L. Sediment bowl screen.
M. Pump chamber.
N. Inlet suction valve.
O. Pressure valve.
P. Outlet to carburetor.
R. Break in rocker arm.
S. Rocker arm spring.

FIGURE 113.—Fuel pump (sectionalized view).

Q. Name the essential parts of a carburetor. *A.* The carburetor throat, float chamber, float, float needle valve, low- and high-speed nozzles, primary and secondary air inlet, throttle valve, and choke valve.

Q. Why must a carburetor have a compensating device on it? *A.* The increase in rate of flow of air and fuel is not proportional, the increase in flow of fuel being much greater than that of air.

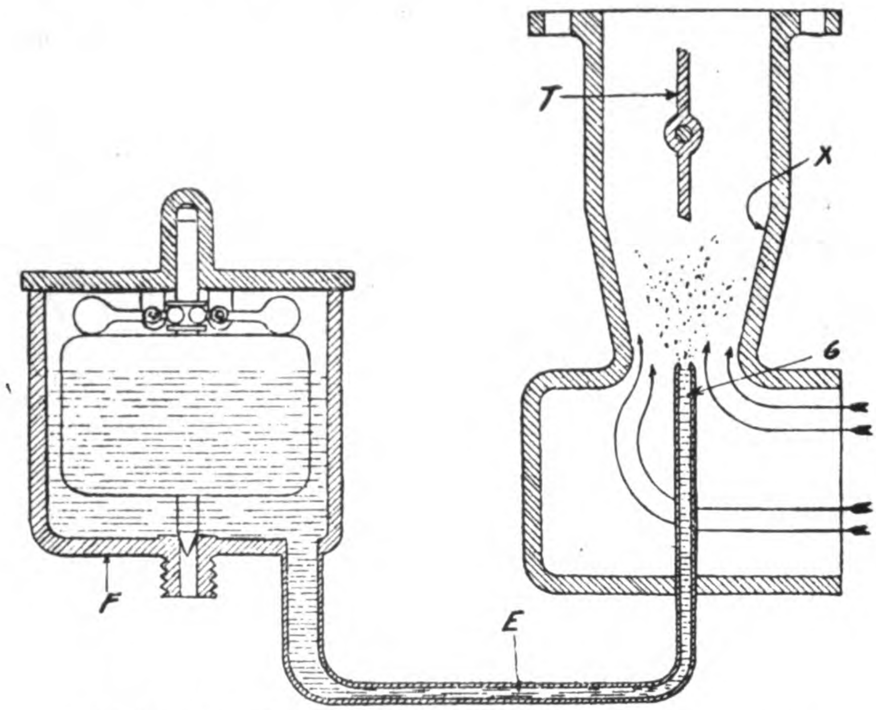
Q. What methods of compensation are used in the construction of carburetors? *A.*

(1) Automatically supplying a proportionate increase in fuel as the suction decreases.

(2) Increasing the air proportionally as the suction increases.

Q. Name some of the compensating devices used in carburetors. *A.* Auxiliary jet, metering pin, expanding venturi, compensating jet, air bleed system, and multiple jet.

Q. What is the advantage of a down-draft carburetor? *A.* The flow of fuel, being downward instead of upward, is aided by gravity, thereby increasing the capacity, while cooler air will enter at the top of the engine, giving an increase of power. This carburetor is more easily installed and it partially eliminates fire hazards, since a back-fire will be in the air above the engine.



F. Float chamber. G. Jet.
T. Throttle (butterfly) valve. X. Venturi tube.

FIGURE 114.—Simple carburetor.

82. Ignition system.—*Q.* What are the necessary parts of a battery ignition system? *A.* Storage battery; switch; primary circuit consisting of the breaker (or interrupter), condenser, and primary coil; and the secondary circuit, consisting of secondary coil, distributor, high-tension cables, and spark plugs.

Q. What is the function of the ignition system? *A.* To ignite the charge of fuel at the proper time.

Q. What is meant by ignition timing? *A.* Setting the ignition system so the breaker points will start to open at, or just before, the piston reaches top dead center on the compression stroke.

Q. What is the source of electrical power to operate the ignition system on the modern automobile? *A.* The storage battery and generator.

Q. Draw a wiring diagram of a typical battery ignition system. *A.* (See fig. 115.)

Q. What is the difference between the primary and secondary windings? *A.* The primary winding has a small number of turns of large wire wound on a soft iron core. The voltage of the primary is from 6 to 12 volts depending on the voltage of the battery. The secondary coil has many turns of fine wire wound on the primary coil. The primary coil, aided by the condenser action, induces a voltage of several thousand volts in the secondary coil.

Q. What is the interrupter? *A.* The interrupter is a mechanical switch which rapidly makes and breaks the primary circuit at intervals. When the primary circuit is broken, the primary current ceases to flow, thus causing the magnetic field around the coil to collapse. In so doing, it will induce a high voltage in the secondary coil having sufficient intensity to cause the secondary current to jump the spark plug gap.

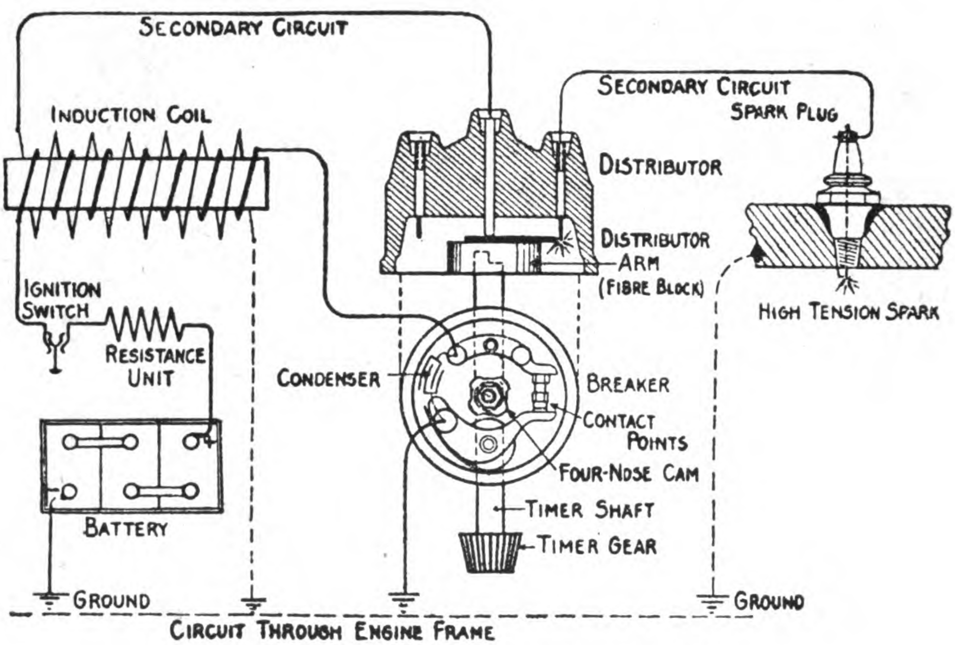


FIGURE 115.—Typical battery ignition system.

Q. Explain the construction of the interrupter. *A.* The interrupter consists of a stationary contact point and a movable contact point, a spring which tends to keep them together, and a rotating cam which separates them at regular intervals. The cam is geared to the camshaft and the speed of the cam is proportional to the engine speed.

Q. What is the ratio of the camshaft to crankshaft speed? *A.* The camshaft speed is half the speed of the crankshaft.

Q. Of what does a condenser consist? *A*. It consists of two strips of tinfoil separated by insulation and folded into a convenient size. The two strips of tinfoil are connected to separate terminals so that there is no electrical connection between them.

Q. What is the purpose of the condenser? *A*. The condenser is used in the primary circuit in parallel with the breaker points. When the breaker points open and the primary circuit is broken, the induced-kick voltage in the primary, which is in the same direction as the original battery current and which otherwise would cause an arcing across the breaker points, is impressed across the condenser and charges one side positive and the other side negative. The condenser will discharge back in a reverse direction through the primary windings. This backward surge of current will assist in reducing the magnetism of the core to zero, thus speeding up the collapsing lines of force and thereby aiding in securing the maximum induced voltage in the secondary winding.

Q. Describe the distributor head. *A*. The distributor head has a center terminal which connects with the secondary terminal of the induction coil, and has as many metal segments or terminals equally spaced around it as there are cylinders. Mounted on the distributor shaft is a rotating finger which turns at one-half crankshaft speed and makes contact with one of the terminals on the distributor. Just before the breaker points are opened, this center terminal makes contact with the rotor finger, thus closing the circuit from the induction coil to the spark plug when the piston is on top dead center (or firing point).

Q. What should the gap at the breaker points be? *A*. It should be from about 0.013 to 0.022 of an inch.

Q. What should the spark plug gap be? *A*. It should be from 0.025 to 0.035 of an inch.

Q. What should the valve tappet clearance be? *A*. The exhaust valve tappet should have about 0.006 to 0.012 of an inch. The inlet valve tappet should have about 0.004 to 0.010 of an inch.

83. Lubrication system.—*Q*. Name and explain the lubrication systems used in automobile engines. *A*. The full-force feed and the force feed (or pressure feed).

(1) In full-force feed, an oil pump, which is usually driven from the camshaft by means of gears, picks up the oil from the oil sump. The oil is then forced upward and conducted by means of tubes to the crankshaft bearings. These bearings become lubricated while the excess oil flows through holes drilled in the crankshaft and through the throws of the crankshaft into the crankpins lubricating the connecting rod bearings. The oil is forced from the connecting rod

bearing through tubes or holes drilled in the connecting rods to the piston pins. This is the only system in which the oil is forced to the piston pins. In the full-force feed, the camshaft bushings are also force-feed lubricated.

(2) In the force feed, the oil is pumped from the oil sump and forced to the crankshaft and connecting rod bearings only. The piston pins and cylinder walls are lubricated by splash.

Q. Explain the oiling system used on the Chevrolet. *A*. This system provides positive pressure lubrication to the crankshaft main bearings, the camshaft bearings, and valve rocker arm bushings. The oil is taken from the oil pan by the pump which delivers it under pressure to a common bearing lubrication point in the center of the engine and to the oil distributor on the left side of the engine. The center main and center camshaft bearings are lubricated directly from the common bearing lubrication point, and distributing pipes which extend the full length of the crankcase deliver oil to the front and rear main and camshaft bearings. From the low-pressure side of the oil distributor, oil is fed to the connecting rod dipper troughs in the oil pan to provide positive splash lubrication for the connecting rod bearings, piston pins, and cylinder walls.

Q. Why are oil filters used? *A*. To remove the dirt and grit from the oil.

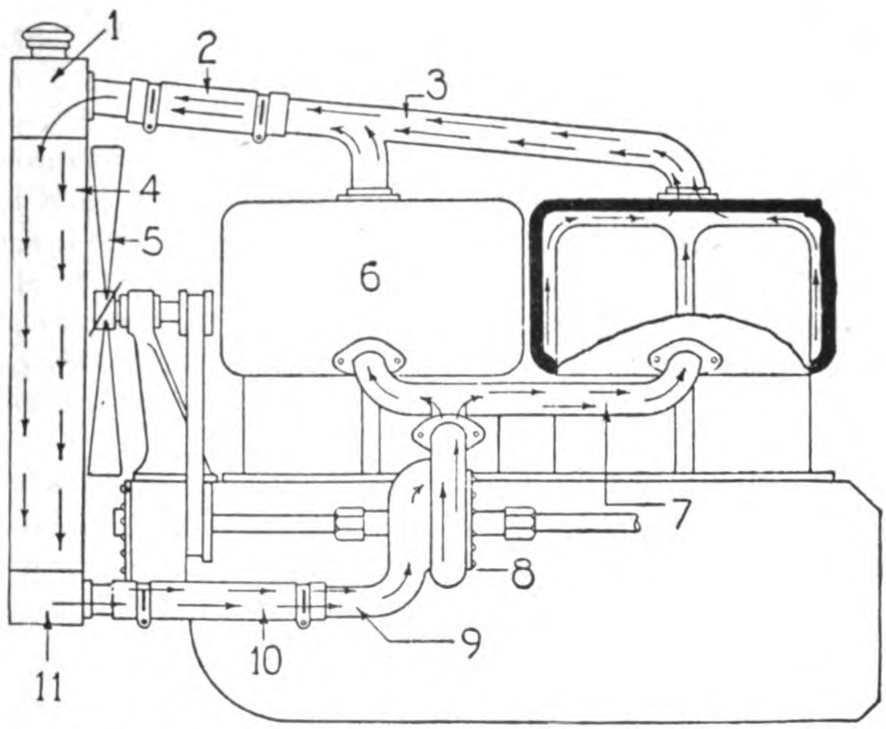
Q. What types of pumps are used in lubrication systems? *A*. The gear type, the vane type, and the plunger type.

Q. How are lubricating oils classified? *A*. Lubricating oils are classified according to their viscosity by an SAE rating. By this rating the higher number is given to the heavier oil. Oil with an SAE No. 50 rating is a thick oil, while No. 20 is a thin oil.

Q. Should an oil with the same viscosity number be used in winter and summer? Why? *A*. No. An oil with a high viscosity rating should be used in summer and an oil with a lower viscosity rating should be used in winter. If a heavy oil is used in the winter, it could not lubricate all the bearings properly because it is too thick to flow through the small clearance that a bearing has during the warming up of the engine.

Q. What is meant by crankcase dilution? *A*. It is the gasoline passing from the combustion chamber, along the cylinder walls, past the piston rings, down into the crankcase, and mixing with the oil.

84. Cooling system.—*Q*. How are engines cooled? *A*. There are two general types of cooling systems, the air-cooled and water-cooled. In the water-cooled engine a water jacket surrounds the cylinders and cylinder head. This water jacket is connected to the radiator by hose connections, one at the top and one at the lower part of the water jacket. A fan driven by the engine circulates air through the radiator. The radiator and jacket are filled with water which circulates through the system either under pressure of a centrifugal pump or by the difference in weight of hot and cold water (thermosiphon). In the air-cooled engine the cylinders are cooled by air, circulated by a fan or by the motion of the vehicle. The cylinders have many small fins around them for the purpose of increasing the radiating surface.



1. Upper tank.
2. Hose.
3. Hot water from water jacket.
4. Radiator.
5. Fan.
6. Water jacket.
7. Water inlet pipe.
8. Circulating pump.
9. Cold water from radiator.
10. Hose.
11. Lower tank.

FIGURE 116.—Force cooling system.

Q. Should a water-cooled engine be run without water in the cooling system? *A.* No. It will cause the engine to run hot, and the metal will expand and cause the pistons and rings to seize the cylinder walls due to the burning of oil from the cylinder walls.

Q. Should cold water be put in a hot engine? *A.* No. It may cause the cylinders and cylinder head to crack.

85. Storage batteries.—*Q.* Describe the storage battery. *A.* The lead-acid cell is made of plates of lead and lead oxide immersed in an electrolyte of sulfuric acid and water. The usual or common assembly is to connect these cells in series, that is, with the positive post of one cell connected to the negative post of the next cell and so on to the end of the row. With the cells in series, the voltage of the battery is the sum of the voltage of the cells, the voltage of each lead-acid cell being nominally 2 volts. The actual voltage at any time, however, depends on the condition of the material of the plates.

Q. What should the specific gravity of a fully charged, a half-charged, and a fully discharged battery be? *A*. In normal temperatures it should be, respectively: 1.300, 1.250, and 1.130 or lower.

Q. At what temperature will, first, a fully charged, and second, a fully discharged battery freeze? *A*.

(1) Approximately 96° F. below zero.

(2) About 32° F. above zero.

86. Generators.—*Q*. What is the purpose of the generator? *A*. To furnish a charging current for the storage battery, and furnish current for the lights, horn, and ignition when the engine is running.

Q. What is the purpose of the reverse current relay? *A*. It is an automatic electromagnetic switch connected in the battery-charging circuit between the generator and the storage battery. Its purpose is to prevent the current flowing from the battery to the generator when the battery voltage is the higher.

87. Power transmission and running gear.—*Q*. What is the purpose of the clutch? *A*. Its purpose is to connect or disconnect the engine from the transmission so that the vehicle may or may not move while the engine is running, and also, to allow the engine to be disconnected while shifting gears. A gasoline engine cannot carry the load when starting but must be turning over at a certain speed. The clutch enables the load to be applied gradually after the engine is running.

Q. Explain the construction of the plate clutch. *A*. Advantage is taken of the flywheel to form part of the housing and part of the driving mechanism of the clutch. The casing of the clutch is integral with the flywheel to which is directly attached the two asbestos friction rings. These friction rings are the driving rings, and are faced with a friction material. The clutch pressure plate contains a number of springs equally distributed on the friction rings which actuate the clutch pressure plate. The shaft which carries the polished steel disk, known as the driven member, is called the clutch shaft. This shaft is supported by a pilot bearing in the flywheel.

Q. What is the purpose of the transmission? *A*. By means of various gears the speed ratio between the engine and the driveshaft can be varied to meet the variations of the load, the direction of the rotation of the drive shaft can be reversed, and all gears can be disengaged so that the engine may be run without operating the driving gear, though the clutch is engaged.

Q. Name the classes of transmissions. *A.* Transmissions are divided into three classes according to their construction and method of operation, and are known as the selective-sliding, synchro-mesh, and constant-mesh, while the motorcycle uses the progressive type. Most of the military trucks have an auxiliary transmission in conjunction with the transmission to obtain a greater driving range.

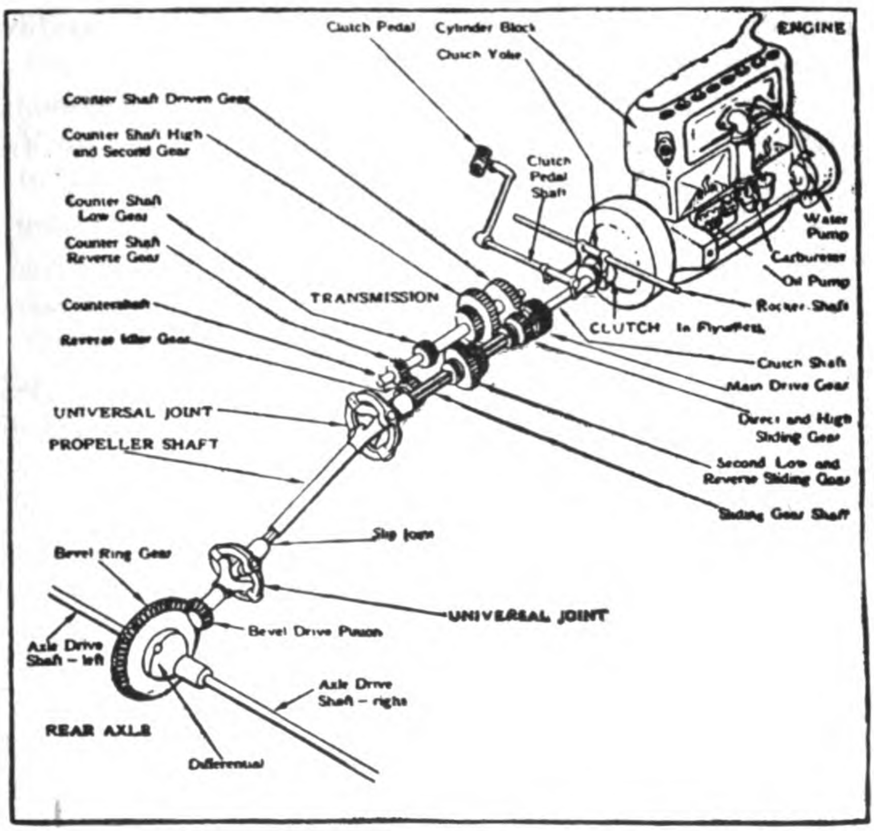


FIGURE 117.—Transmission of power.

Q. What is the principle of the synchro-mesh transmission? *A.* Small cone-type clutches are placed between the driving and driven gears for the direct and intermediate speeds. On shifting into either of these speeds, the clutch comes into action first. This brings the driving and driven gears to the same speed and they may then be meshed without clashing.

Q. Explain the auxiliary transmission. *A.* An auxiliary transmission, sometimes called a subtransmission, is used in direct conjunction with the transmission to obtain greater driving range, and is usually a two-speed transmission having an underdrive and a direct drive. The underdrive has a gear ratio of about 2 to 1, and is provided to give a low total reduction when operating in severe road conditions, or over uneven roads or grades with capacity loads. Direct drive is provided to be used when operating under ordinary road and load conditions and has a gear ratio of 1 to 1; that is, it has no effect on the normal transmission gear ratios.

Q. How is the transmission lubricated? *A*. By heavy oil contained in the transmission.

Q. How is the power transmitted to the rear axle? *A*. Through universal joints and a drive or propeller shaft. Four-wheel-drive trucks employ two drive shafts and require what is known as a transfer case for this purpose.

Q. What is a universal joint? *A*. It is a device for connecting two shafts which are slightly out of alinement, and to transmit power through these angles.

Q. What is a slip joint? *A*. A sliding or telescopic joint which is splined and permits variation in the length of the drive shaft. It is used to compensate for the variations in distance between transmission and rear axle due to the action of the springs.

Q. What is the purpose of the differential? *A*. It permits one axle shaft connected to it to rotate slower, faster, or remain stationary in reference to the other axle shaft. Such a device is necessary to compensate for the difference in speed of the rear wheels when going around curves.

Q. What are the principal types of differentials used? *A*. The bevel gear, spur gear, and worm gear differentials.

Q. Explain the principle embodied in the design of the bevel gear differential. *A*. The differential case is attached to and driven by the ring gear. Four small bevel gears are mounted inside the differential case on a spider, the latter being supported by the case. The four gears are in mesh with a bevel gear on each side to which the axle is attached. On a straight road with equal traction, the motion of the ring gear is transmitted to the differential case, and the spider gears remain stationary and cause the gears attached to the axle shafts to rotate in unison with the case. If one axle is retarded or stopped, as in rounding a curve, the gear attached to that axle is moving slowly or is stationary. The differential case being in motion turns the spider. The spider gears roll on the gear attached to the retarded or stationary axle, while the gear attached to the other axle is rotated at a higher speed. If one wheel stops, the other one will turn twice as fast as it did before the other wheel stopped.

Q. How is the power transmitted to the ring gear? *A*. From the propellor shaft to a piston shaft to the pinion gear to the ring gear.

Q. Is the same principle included in the spur gear differential? *A.* Yes; it differs from the bevel gear only in construction.

Q. Explain the double-reduction-drive differential. *A.* The only difference is that the first reduction is from the bevel-ring gear shaft to a small spur gear to a large spur gear connected to the differential case.

88. Axles and wheels.—*Q.* How many types of axles are in use? *A.* There are two general classes, the dead and live axle.

Q. To what stresses are the semifloating, three-quarter, and full-floating types of live axles subject? *A.*

(1) The semifloating axle is subject to the following stresses:

(*a*) Torsional stresses due to the driving torque and braking torque.

(*b*) Bending stresses due to the weight resting on the axle.

(*c*) Bending stresses resulting from transverse loads on the wheels due to centrifugal force when turning corners at high speed.

(2) The three-quarter floating axle is subject to torsional stresses and bending stresses due to the load on the axle.

(3) The full-floating axle is subject to torsional stresses only.

Q. Wherein do the live and dead axle differ? *A.* The dead axle is stationary, while the live axle revolves and delivers power to the wheels.

Q. What types of wheels are used on motor vehicles? *A.*

(1) Wood wheels with either wood or metal rims (artillery type).

(2) Wire wheels with metal hubs and rims and wire spokes.

(3) All-metal spoke wheels and all-metal disk wheels.

Q. What are the advantages of dual wheels? *A.* They give greater carrying capacity, longer tire life, and increased road contact with consequent better traction, while the tires can be smaller in diameter, giving a lower center of gravity to the vehicle.

89. Brakes.—*Q.* What types of brakes are used on motor vehicles? *A.* Ordinarily two separate brakes are mounted on a vehicle, a service or foot brake, and an emergency or hand brake.

Q. How are brakes operated? *A.* Mechanical, hydraulic, or air operated. A vacuum booster may be used to work in conjunction with the mechanical or hydraulic brake.

Q. What is the advantage of the vacuum booster brake? *A.* It lessens the brake pedal pressure necessary for brake application.

Q. Explain the operation of the vacuum booster. *A.* A power cylinder is mounted so that the piston in the cylinder can be connected to the brake pedal. The cylinder is connected to the intake manifold by means of a copper tube. When the brake pedal is pressed partly down, a valve is opened to the intake pipe, and the suction from the intake manifold causes the piston to move and applies the brakes through the linkage to the brake pedal. When the brake pedal pressure is released, the inlet valve is closed, a valve to the atmosphere is opened, and a spring forces the piston back, releasing the brakes.

Q. What advantage is gained by mounting the brake on the transmission? *A.* The braking effect is transmitted through the differential, drive shaft, and axle shafts, increasing the braking power.

90. Steering gear.—*Q.* Describe briefly the construction of a typical steering gear. *A.* The steering wheel is keyed to a shaft supported by the steering column. The shaft terminates in a worm; the worm engages in a worm gear the shaft of which carries the the steering lever arm. The steering lever arm is connected by the draglink to one of the steering knuckles. A tie rod connects the two steering knuckles.

Q. Explain the mounting of the front axle and wheels. *A.* The front axle is fastened to the frame by means of leaf springs, which are secured to the frame by shackles and shackle bolts. The axle is fastened to the springs by bolts. The wheels are mounted on spindles; the spindle is fastened to the end of the axle with a king-pin which allows the spindle to turn.

Q. Why are the steering arms curved toward the center of the vehicle instead of being straight? *A.* Because in turning a curve the path of the outside wheel is an arc of a larger circle than the path of the inner wheel. Therefore, the outside wheel must be inclined at a lesser angle than the inside wheel. The angularity of the steering arms provides for this difference in inclination of the wheel.

Q. What is meant by toe-in (gather) of the front wheels? *A.* It means the front wheels are so alined that the foremost edges are closer together than the rear edges. Since cambered wheels, like segments of a cone, have a tendency to roll outward in a circle, gathering the wheels in at the front is necessary to compensate for this tendency.

Q. What is meant by caster? *A.* Caster is the the angle of backward inclination between the steering knuckle bolts and the vertical, and its purpose is to stabilize steering.

Q. What is meant by camber? *A.* Camber is the outward tilt of the front wheels at the top and results in the wheels coming more nearly under the load. The purpose of camber is to support the greater part of the car weight on the inner wheel bearings, to reduce side thrust on the steering knuckle bolts, to compensate for looseness and wear in the steering knuckle and wheel bearings, and to bring the point of pivot near the road for center point steering.

Q. What is meant by irreversible steering gear? *A*. A steering gear in which turning motions can be transmitted to the steering knuckles by turning the steering wheel, but motions cannot be transmitted from the front wheels to the steering wheel.

Q. How is this accomplished? *A*. By the use of a worm in the steering gear. A worm is capable of turning a gear, but the motion cannot readily be transmitted from a gear to a worm.

Section II

INSPECTION AND MAINTENANCE OF MOTOR VEHICLES

91. Power plant.—*Q*. How are the causes of engine troubles determined? *A*. Since nearly all of the operating parts of the engine are inclosed and inaccessible, the cause of engine trouble must usually be deduced by a system of elimination.

Q. How can engine troubles be classed? *A*. They can be classed as—

(1) Mechanical troubles.

(2) Fuel feed and carburetion troubles.

(3) Ignition troubles.

Q. What conditions are necessary for an engine to start? *A*. If the following conditions exist, the engine should run:

(1) Engine turns freely without any indication of mechanical troubles and has compression.

(2) Gasoline reaches the cylinder, the cylinders being neither uncomfortably hot nor cold to the hand, the throttle being one-fourth open, and the intake clear and tight.

(3) There is a spark at the right time at the right place.

Q. In general, how are mechanical troubles remedied? *A*.

(1) By disassembling such parts of the engine as necessary to get at the defective parts.

(2) By replacing broken or worn parts.
(3) By regrinding or replacing valves.
(4) By refitting or tightening loose bearings.
(5) By removing carbon.

Q. How should a bearing be refitted. *A*. So that it is in contact with the shaft at all points.

Q. What inspection should be made whenever an engine is disassembled? *A*. Inspect all parts for defects and make a list of all parts needed.

Q. Why is a small clearance left at the end of the valve stem? *A*. To allow for expansion and to insure that the valve is closed.

Q. What is the result if a valve does not close all the way? *A*. There is a loss of compression. If it is an exhaust valve, the seat will burn and warp, due to the hot escaping gases.

Q. What is meant by valve grinding? *A*. The grinding of the valve face and seat to a gastight fit, with valve-grinding compound.

Q. What is meant by a valve seat insert? *A*. A very hard steel ring inserted in the valve port to form the valve seat.

Q. Is is possible to reseat valve seat inserts? *A*. Only by the aid of special valve seat insert grinding stones.

Q. How often should they be reseated? *A*. About every 50,000 to 65,000 miles. In some cases, they last the life of the vehicle.

Q. How is the compression of an engine tested? *A*. Remove all spark plugs, open the throttle wide open, insert a compression gage in No. 1 cylinder, and crank the engine either by hand or by battery about six revolutions. Take the reading of meter on a gage. If the reading is low, the compression is bad. Check each cylinder in the same manner. Compression in all cylinders should not vary more than 5 pounds. If no gage is available, leave all spark plugs in place. Crank the engine by hand. Each cylinder should have about the same resistance when cranked against compression. A cylinder with good compression will show a springy resistance and the engine can be rocked against compression.

Q. How much gap clearance should piston rings have? *A*. The top ring should have 0.003 of an inch per inch of piston diameter. The other rings should have 0.002 of an inch per inch of piston diameter.

Q. How are piston rings fitted? *A*. Place the rings in the cylinder, turn the piston upside down and push the ring down about 1 inch from the top of the cylinder. Check the gap with a feeler gage.

92. Carburetion.—*Q*. How is a carburetor adjusted? *A*. Start the engine and allow it to warm up. Retard the spark, close the throttle, and set the throttle-adjusting screw so the engine will idle. Adjust the idle-adjusting screw to where the engine runs smoothly without rolling or missing. Adjust the high-speed adjusting screw (if the carburetor has one) to where the engine, when suddenly accelerated, will spit back into the carburetor. It should spit back once and no more.

Q. Name the most frequent carburetor troubles. *A*. Strainers stopped up, jets stopped up, float too low or too high, and float punctured.

93. Battery ignition.—*Q*. Name the most frequent causes of ignition troubles in a battery ignition system. *A*.

(1) *Spark plugs.*—Dirty plugs, broken porcelain insulation, improper connections, or improper spark gap.

(2) *Cables.*—Defective insulation, not connected, connected to wrong spark plug or distributor contact, or broken wire inside of insulation.

(3) *Breaker points.*—Do not close, do not open at proper time, do not open enough, points pitted, or dirt between points.

(4) *Condenser.*—Short-circuited.

(5) *Battery.*—Run down, not connected, short-circuited, or grounded.

Q. How is the ignition timed on the battery ignition system? *A*. The piston of No. 1 cylinder is set at top dead center at the end of the compression stroke. The flywheel is usually marked to indicate this position by ignition timing marks, such as IGN 1-6 or D. C. The distributor housing clamping screw is loosened and the distributor cap is removed. The housing must be turned to where the rotor finger is in contact with No. 1 terminal and the breaker points are just beginning to open; the clamping screw should then be tightened.

94. Magneto ignition.—*Q*. Name the most frequent causes of ignition troubles in a magneto ignition system. *A*. Improper timing, short circuit, burnt armature, defective contact points or brushes, or weak magnets.

(1) *Coil.*—Short-circuited, or broken insulation.

(2) *Distributor.*—Broken contacts or brushes, water or dirt in distributor, distributor (or rotor finger) removed or broken, or distributor head cracked.

(3) *Switch.*—Open circuit, short circuit, or improperly connected.

Q. How can the timing of the spark be regulated to vary with engine speed? *A*. By automatic spark control, or by manual spark control.

Q. How are ignition troubles traced? *A*. By asking one's self the following questions and finding the answers: Test for a spark at the spark plug. If there is no spark, is the switch turned on? Is the battery all right? Are any wires disconnected or terminals corroded? Are wires connected correctly? Are any wires broken? Do the breaker points open and close properly? Is there a spark at the spark plug at the proper time? Are spark plug gaps of the proper width? Are porcelains and electrodes clean and unbroken? Is there too much gasoline in the cylinders so the spark plugs are fouled?

Q. If, when the breaker points open, there is an excessive spark or arc at the point of opening, what is the trouble? *A.* A disconnected or defective condenser.

95. Battery.—*Q.* When a new battery is received, what is the first thing to do? *A.* Unpack the battery, keeping the packing case right side up to avoid spilling the battery solution. Examine the battery carefully to see if there is any indication of injury during transit. Determine whether the battery has been shipped charged or unfilled.

Q. What care is necessary when installing a battery on a car? *A.* When connecting the battery to the battery cables, be sure they are connected properly and are tight, and the terminals are greased with vaseline or some lubrication grease.

Q. How can one determine whether the battery is connected properly? *A.* Look up the diagram in the service book, or turn the lights on and note the reading of the ammeter. If the engine is not running, the ammeter should indicate discharge if the battery is properly connected.

Q. What attention does the battery require in service? *A.* It requires very little attention, but that little is absolutely necessary and vital. Add nothing but pure distilled water to replace that lost by evaporation. Do this often enough to keep the plates covered about ½ inch. In freezing weather do not add water until just before the battery is to be used or recharged. Keep the connections tight and covered with vaseline. Keep the filling plugs tight and battery dry, clean, and clamped down tightly in the carrier. Take hydrometer readings and check water every 2 weeks in the summer. If the vehicle is to be stored or repaired, the battery should be removed, charged, and put into proper storage.

Q. How should corroded battery terminals be cleaned? *A.* By scrubbing thoroughly with ammonia, or a solution of baking soda and water.

Q. What should be the specific gravity of a fully charged, a half-charged, and a fully discharged battery? *A*. In normal temperatures it should be, respectively: 1.300, 1.250, and 1.130 or lower.

Q. At what temperature will, first, a fully charged, and second, fully discharged battery freeze? *A*.

(1) Approximately 96° F. below zero.
(2) About 32° F. above zero.

Q. Name some of the common lighting faults. *A*. Lamps in circuit will not burn because of—

(1) Lamps burned out.
(2) Blown fuse.
(3) Open circuit.
(4) Poor ground in single wire system.
(5) Battery discharged.
(6) Loose connections.

Q. What will cause the lights to burn out? *A*. Loose battery connection, reverse current relay points sticking, or lamp bulbs of the wrong voltage.

Q. If lights dim when engine is cranked with the electric starter, what is the trouble? *A*. Weak battery or loose battery connections.

Q. If the generator does not charge the battery, what may be the trouble? *A*.

(1) Generator not building up, usually due to dirty commutator or worn brushes.
(2) Corroded or loose battery terminals.
(3) Defective battery.
(4) Ammeter burned out.
(5) Defective reverse current relay.

Q. If the batteries do not stay charged, what may be the fault? *A*.

(1) Charging rate too low.
(2) Ground in car wiring.
(3) Reverse current relay not operating properly.

Q. In case of trouble with the electric starter, what should be done? *A*.

(1) See that the battery is charged.
(2) See that there are no short circuits.
(3) See that the battery terminals are not loose, rusty, or corroded.
(4) Examine the starting switch for proper connections and operation.
(5) See that the brushes are properly seated on motor commutator.

96. Clutch and transmission.—*Q*. Name the most usual clutch troubles. *A*. Slipping, grabbing, and chattering.

Q. What are the causes? *A*.

(1) Slipping is usually caused by friction material of the disk being

worn, the clutch springs failing to exert sufficient pressure, or from allowing the foot to rest on the clutch pedal while driving.

(2) Grabbing is caused by oil on the clutch plates, spring with too great a capacity, or faulty lining.

(3) Chattering is caused by the clutch shaft and driving members being out of alinement with the driven member.

Q. To what are most clutch troubles due? *A*. They are due to the clutch throw-out bearing becoming worn.

Q. Name the most usual transmission troubles and their causes. *A*.

(1) Difficulty in shifting gears, usually caused by broken parts, by oil which has become gummy, by insufficient or too much oil, or by the gear shift lever connections being out of order.

(2) Transmission gears stripped, caused by changing from a forward to a reverse gear when the vehicle is in motion.

Q. What troubles may develop in the drive? *A*. Broken drive shaft or universal joints. The drive shaft may break or bend by—

(1) Contact with road obstructions.

(2) Excessive differential gear clearance.

(3) Racing the engine and jerking the vehicle by suddenly applying the power to the axle shafts.

97. Wheels and brakes.—*Q*. What are the usual causes of troubles which are experienced with wheel bearings? *A*. Improper adjustments and insufficient lubrication.

Q. How should wheel bearings be adjusted? *A*. The bearing adjusting nuts should be tight enough to prevent end play, but not so tight as to prevent the wheel from turning freely.

Q. What are the results of insufficient lubrication of the wheel bearings? *A*. Heating of the bearings, rapid wear, and breaking of the bearing balls or rollers.

Q. What troubles are experienced with brakes? *A*. Worn-out brake lining, unequal adjustment of the brake bands or shoes, scored drums, brake lining stripping from the shoes and rolling up at the ends, oil leaks in the lines, brakes, or master cylinders in the case of hydraulic brakes, unequal linkage and rod adjustments, and oil on brake lining.

Q. What precautions must be taken with brakes? *A*. Brakes must be tested and inspected frequently, worn lining must be replaced, and the brake bands kept in proper adjustment.

Q. How can the wear of the brakes be reduced? *A*. By using the engine to produce braking effect. In descending long, steep grades, the vehicle should be run in second or low gear to help brake the vehicle.

Q. When does the greatest braking effect occur? *A*. Just before the wheels begin to slide.

Q. What troubles are experienced with the steering mechanism? *A*. Front wheels out of alinement, broken parts, and parts becoming worn and loose.

Q. What is the most common trouble? *A*. Wheels out of alinement, caused by wear or by hitting curves or obstructions on rough roads and detours.

Q. What care should be taken of tires? *A*. Keep sufficient air pressure in them, keep rims tight, and avoid running over glass or sharp stones as much as possible. Do not run on a flat tire. Never let a tire sit in oil or gasoline, as it will rot the rubber.

98. Cooling system.—*Q*. Should a water-cooled engine be run without water in the cooling system? Why? *A*. No. It will cause the engine to run hot, and the metal will expand and cause the pistons and rings to seize the cylinder walls due to the burning of oil from the cylinder walls.

Q. If the engine is overheated, how should water be added? *A*. The engine should be allowed to cool before water is added and then water should be added very slowly with the engine running.

Q. How should the radiator and water jackets be protected in cold weather? *A*. A close check should be kept on the antifreeze solution. Unless sufficient antifreeze solution is used, the radiator and water jackets should be completely drained when the vehicle is not in use, and a "drained" sign should be hung on the radiator. Sometimes it will be necessary to protect the lower front half of the radiator with tin, cardboard, or canvas during operation.

99. Steering mechanisms.—*Q*. How are kingpins (steering knuckle pivots) generally set with respect to the plane of the wheel? *A*. They are generally set at an angle with the plane of the wheel. This angle is referred to as the kingpin (or pivot) inclination angle.

Q. What is the caster angle? *A*. It is the slight backward tilt of the front axle and the kingpins (or pivots), the top of the front axle having been rotated backward through that angle.

Q. What is camber? *A*. It is the angle (or distance) that the wheel leans outward at the top.

Q. Are the front wheels closer together at the rear of the wheels or at the front of the wheels? *A*. They are closer together at the front.

Q. What is this difference (or angle) called? *A*. It is called toe-in.

Q. How is it set? *A*. By means of the tie rod between the steering knuckles.

Q. What is this series of angles and adjustments called? *A.* Front wheel geometry.

Q. What should be the values of these angles for a particular vehicle? *A.* As specified by the manufacturer.

Q. What type of lubricant is required for steering gears? Why? *A.* A light pressure-resistant lubricant is required because the slow sliding motion of the surfaces in contact tend to scrape off any film of lubricant and cause metal-to-metal contact.

Q. What is the usual method of lubricating the working parts? *A.* The inclosed oiltight steering gear housing is filled with steering gear lubricant so that the teeth and spirals are coated at all times.

100. Governors.—*Q.* What is the purpose of governors? *A.* To protect the vehicle engine and to insure economical accident-free operation.

Q. How are governors tested? *A.* By giving the vehicle a road test.

Q. How much adjustment is possible with the common types of governor? *A.* Governors are designed to give speed adjustments over about a 10-mile-per-hour range. If wider adjustments are attempted, erratic operation may result because of broken springs, or cams in the governor.

Q. How are drivers prevented from tampering with the governor? *A.* The governor is sealed. Frequent inspections are made to see that the governor has not been tampered with or damaged.

Section III

SHOP PRACTICES; SUPERVISION AND INSTRUCTION OF MECHANICS

101. Shop practices.—*Q.* What are some precautions to be taken in disassembling an automobile? *A.*

(1) Plan the quickest and easiest way to do the job.

(2) Drain oil, water, and gasoline.

(3) Plan to protect delicate parts and machined surfaces.

(4) Plan how to save gaskets from injury.

(5) Tag all electric wires.

(6) Look for any screws, bolts, or nuts which may allow any part to drop or otherwise be damaged before removing.

(7) Mark with a prick punch pieces which may be reassembled wrong.

(8) Provide containers for all parts.

(9) Secure proper tools and use them according to instructions.

(10) Inspect parts as taken down, so replacements can be secured promptly.

Q. How is a tight nut removed? *A.* Use as hard a direct pressure as can be applied safely with a wrench. Try jerking the wrench first one way and then the other. Apply kerosene or penetrating oil, allowing time for it to soak in between the threads. If all of the above fail; split the nut with a cold chisel, backing it up with a heavy bar or hammer.

Q. Give, in brief, several points to be observed when engaged in overhauling. *A.* Every part removed must be replaced *in exactly the same place occupied before overhaul.* To do this, all parts should be either tagged or marked with a steel stencil so that they may be easily identified. Always use the proper tools.

Q. Mention some important things to avoid in the repair and maintenance of automotive vehicles. *A.*

(1) Don't use adjustable wrenches for hammers.

(2) Don't use screw drivers as cold chisels.

(3) Don't use pliers on nuts or bolt heads.

(4) Don't use stillson wrenches on nuts or bolt heads.

(5) Don't attempt to loosen nuts with a hammer and cold chisel.

(6) Don't use screw drivers for prying.

(7) Don't use a wrench on a nut or bolt that it does not fit.

(8) Don't use a file without a handle.

(9) Don't strike polished parts of machinery with a steel hammer.

(10) Don't use a hammer on cast steel or iron.

(11) Don't use excessive force. If a part does not come off easily, investigate before using force.

(12) Don't use a hammer to separate parts which should be pulled or pressed apart.

(13) Don't neglect or mislay tools.

(14) Don't pound on end of a shaft with a bare hammer. Use a babbit hammer or a piece of wood or brass over the end of the shaft.

(15) Don't smear oil or grease on seats or paint. Remove seats and cover fenders.

(16) Don't leave a vehicle standing in a pool of grease.

Q. How should oils and grease be kept and issued? Who should lubricate the vehicle? *A.* All lubricants should be issued by one man. Due to the specialized lubrication requirements of modern vehicles, it is considered the best practice to have the actual lubrication of vehicles performed by a trained man, rather than by the individual drivers.

Q. How are supplies, spare parts, and special tools kept and issued? *A.* Every repair shop, no matter how small, should have a stock room with one man responsible for the issue of supplies and tools.

Q. How are open-end wrenches classed as to size? *A.* U. S. S. wrenches are numbered from 21 to 45 and the SAE type is marked as to size.

Q. Why are two systems necessary? *A.* Because of the two kinds of bolts; for example, a ½-inch U. S. S. nut is ⅞ of an inch on the outside while a ½-inch SAE nut is only ¾ of an inch. SAE is the common type.

Q. What two kinds of threads are there on bolts? *A.* U. S. S. and SAE. They differ in the pitch, or number of threads to the inch.

102. Precautions as to fires in garages.—*Q.* Name some of the precautions that should be taken to prevent fires in garages. *A.*

(1) No smoking should be allowed where there are gasoline fumes.

(2) Gasoline cleaning mixtures must not be used.

(3) Covered metal containers should be provided for discarded oily waste, and these containers should be emptied every day at closing time.

(4) Soiled overalls and fatigue clothes should be kept in metal lockers.

Q. What care should be taken when welding or repairing gasoline tanks? *A.* After the gasoline is drained off, the tank should be washed out *several times* and then live steam run through to rid the tank of all liquid and vapor.

Q. What inspection should be made of portable light cords? *A.* They should be inspected for breaks and short circuits.

Q. Should gasoline be handled or used inside a building? *A.* Only when absolutely necessary, in which case the windows should be open.

Q. Should water be thrown on burning gasoline? *A.* No. It only spreads the fire.

Q. What means should be available to extinguish fires? *A.*

(1) Fire extinguishers should be hung in convenient places about the shop and tested frequently.

(2) Pails of sand should be provided.

Q. Should vehicles that are left in a garage be locked? *A.* No. They should be unlocked so they can be run out easily in case of fire. Keys should be in the vehicles or in some convenient nearby spot.

103. Supervision and instruction of mechanics.—*Q.* What texts are available for the basic training of mechanics? *A.* Technical Manuals of the TM 10-series.

Q. Where may the mechanic find instructions for performing jobs assigned to him? *A*. In the instruction manuals of the vehicles concerned.

Q. What, briefly, are the duties of the transportation sergeant in the supervision and instruction of mechanics? *A*.

(1) He assigns the mechanics to jobs according to their ability.

(2) He checks each job step by step.

(3) In case a mechanic gets in difficulty, he shows such mechanic how to do the job.

(4) He acts as the motor officer's executive.

SECTION IV

LOADS AND THEIR PROPER DISTRIBUTION

104. Loads and their proper distribution.—*Q*. What information should be obtained at the time an order for transportation is taken? *A*. Orders should never be taken for transportation without learning the weight of the load it is desired to transport, the points between which it is desired to transport it, and the nature of the load, in order that suitable vehicles may be furnished for the work.

Q. What are the duties of the convoy commander with respect to the cargo? *A*. Loading and unloading in the field will often require work under adverse conditions. Whatever the conditions are, it is the duty of the convoy commander to deliver the freight in the best possible condition, in the least possible time, with due regard to the condition of his command, and, when possible, to park the trucks so as to minimize the work of unloading and handling the cargoes.

Q. What is the effect of poor loading? *A*. A poorly loaded vehicle not only reduces the capacity of that truck but endangers the safety of the entire convoy.

Q. What may be the effect of a swaying load? *A*. A poorly loaded truck with a swaying load is always in danger of overturning.

Q. Give some general rules for loading. *A*.

(1) Heavy goods should be placed at the bottom, near the rear of the truck and as close to the rear axle as possible.

(2) Loads should be distributed equally on both sides of the truck. Every load should be securely lashed and covered.

(3) Lumber should be loaded with heavy pieces on the bottom, grading up to lighter on top, to a height of about twice the body;

2-inch by 4-inch uprights should be placed every 3 feet along the sides.

(4) Baled goods, sacks, and similar loads should be piled evenly over the body and, when they extend above the sides of the body, should be pyramided until there is a single row parallel to the body length.

(5) In mixed loads, common sense is the only rule that can be laid down.

(6) Never overload a vehicle.

Q. What precautions should be taken when loading ammunition? *A.*

(1) Do not load fuzes or detonators with explosives.

(2) Cover the iron strips of the truck body with wood or its equivalent.

(3) Cover the load with paulin to protect it from weather or possible sparks.

(4) Do not unload with engine running.

(5) Brace the load if the truck body is not full.

Q. What may result if a load is placed entirely on one side of a truck? *A.* Skidding into a ditch, if roads are at all wet, or the breaking of a spring.

Q. What may result if a load is placed entirely on the rear of the truck body? *A.* On dirt roads there are often bog holes into which the rear wheels will sink if load is entirely over rear axle or behind.

Q. How should a small but heavy object be loaded on a truck? *A.* Two pieces of timber about 4 by 4 inches should be placed on each side of the body, running its entire length. Two other pieces of timber of the same size should be placed across the first two near the center of the truck body and near enough together to support the object to be loaded. This will give a well-distributed load, the strain being divided among all the members.

Q. Where can the data giving the loading capacity of a truck be found? *A.* On a plate on the dash.

Q. What will be the result of overloading a truck? *A.* Excessive wear and strain on all parts, including the engine; springs will become weak and allow the load to rest on the axles.

Q. What equipment for lashing loads should be on each truck? *A.* Two 60-foot lengths of rope and the lash hooks or rings through which the lines are passed.

Q. How can the motor sergeant make a quick check on overloading? *A.* By noting the set of the springs.

Q. What determines the loads and distribution of loads for a motorized regiment in the field? *A.* The loading table which is based upon the Tables of Allowances of the regiment. Under such circumstances there will be no cargo space for items not on the Tables of Allowances.

SECTION V

TRAINING OF DRIVERS

105. Training of drivers.—*Q.* What, in general terms, determines the mobility and dependability of the motor vehicle fleet? *A.* The manner in which the individual drivers perform their duties.

Q. What should be the preliminary step to the training of drivers to operate motor vehicles? *A.* The preparation of a training schedule to include a systematic and progressive course of instruction.

Q. What relative time value should be given practical instruction and classroom work in the training schedule? *A.* Training schedules should include a maximum of practical instruction and a minimum of classroom work.

Q. What should be the qualifications of an individual selected for training as a motor vehicle driver? *A.* He should be dependable, alert, sober, steady, and ambitious, and should have good judgment and mechanical sense. He should react quickly and properly in given test situations. He should be able to differentiate promptly between red, green, and amber lights.

Q. What is the principal object in the training of motor vehicle drivers? *A.* To turn out drivers who are capable of good performance under all reasonable operating conditions.

Q. What instruction should be given to cover subjects on organization and safety? *A.* Instruction regarding—

(1) Motor transport personnel and general duties.

(2) The organization of the motor park and the duties of the driver in connection therewith.

(3) Fire prevention and fire fighting, to include precautions against fire, proper methods of fighting fire, location of fire-fighting equipment, and the method of reporting fire.

(4) Accident prevention, to include precautions against accidents and carbon monoxide poisoning, and whom to call to get assistance.

Q. What motor vehicle controls should be explained and demonstrated? *A.* Carburetor choke control, carburetor throttle control (to include accelerator), ignition switch, spark control, transmission gear shift lever, subtransmission gear shift lever, clutch pedal, steering wheel, and brakes (hand and foot).

Q. What procedure would one follow in this explanation and demonstration? *A.*

(1) Securely block up the motor vehicle with all wheels off the ground.

(2) Have the candidate familiarize himself with the location and manipulation of the clutch pedal, the transmission gear shift lever, the brake lever, and brake pedal.

(3) Start and warm up the engine.

(4) Demonstrate the operation of the accelerator; coordinated movements of the accelerator, clutch pedal, and transmission gear shift lever; gear shifting, to include reverse; operation of the brake controls; manipulation of the steering wheel; and the use of the engine as a brake.

(5) Upon completion of the demonstration, have the candidate assume the correct position in the driver's seat and practice manipulating the controls until he becomes reasonably proficient. Exercise careful supervision to insure correct performance.

Q. Explain the correct position a driver should assume when in the driver's seat. *A.* He should sit erect, without stiffness, squarely behind the steering wheel; head erect, eyes looking to the front; hands on opposite sides of the steering wheel, on a horizontal line generally through the center of the wheel, grasping the steering wheel rim firmly but without tenseness; both feet flat on the floor boards except when actually manipulating the accelerator, the clutch and brake pedals, or the starter switch.

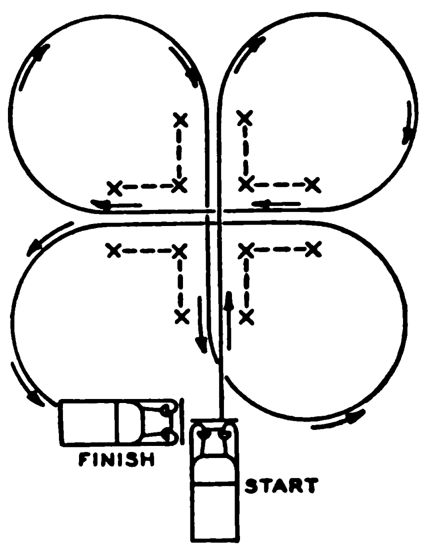
Q. What aids to motor vehicle control should be explained and demonstrated? *A.* Light switches, horn button, rear-view mirror, windshield wiper, speedometer, and tachometer.

Q. What information should be given regarding the instrument-board gages? *A.* The purpose of each gage should be explained, its normal reading given, and the driver instructed as to what he should do when an abnormal reading is observed.

Q. Why is careful instruction and painstaking supervision necessary during the driving instruction period? *A.* To insure that the driver learns the correct performance of his duties and forms the proper habits.

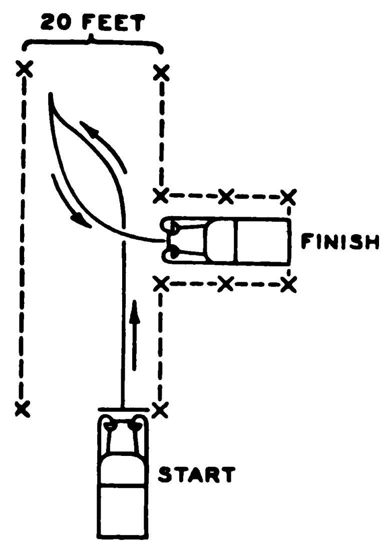
Q. Name the subjects that should be covered during the driving instruction period. *A.* Gear shifting and use of clutch, use of transmissions, use of brakes, turning, backing, parking, starting engine under unusual operating conditions, signals, road rules and traffic regulations, chains and traction devices, marching, difficult and night driving, loads and loading, and map reading.

Q. How would one instruct a driver in gear shifting and use of clutch? *A*. Conduct the instruction on a large, open field where steering is of secondary importance. Explain procedure and demonstrate application. Permit the candidate to drive at will with the transmission in the lower gear ratios until he is reasonably familiar with the operation and control of his vehicle. After he has become reasonably proficient in shifting from lower to higher gears, instruct him in the procedure of double clutching.



(The figure should be symmetrical, with the stakes placed to allow an over-all side clearance of approximately 18 inches.)

FIGURE 118.—Reverse turning course.



(The figure should be symmetrical, with the stakes placed to allow an over-all side clearance of approximately 18 inches.)

FIGURE 119.—Backing course.

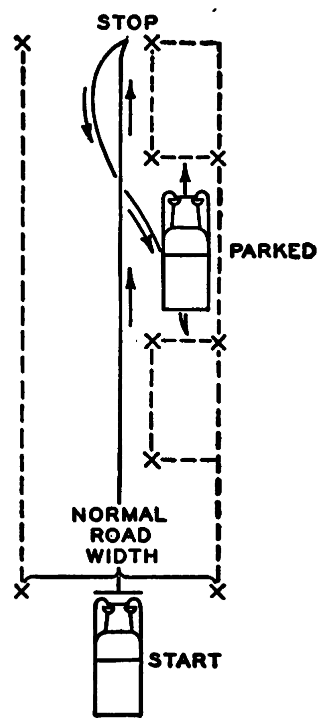
Q. How would one instruct drivers in turning, backing, and parking? *A*. By the use of stake driving courses. (See figs. 118, 119, and 120.)

Q. In what kinds of preventive maintenance would one instruct the drivers? *A*. Inspection, lubrication, tightening, servicing, cleaning of motor vehicles, the avoidance of vehicle abuse, and the performance of emergency adjustments and repairs.

Q. In what routine inspections should the driver be instructed? *A*. Inspection before operation, both before and after starting engine; inspection during operation; inspection at the halt; and inspection after operation.

Q. What forms of vehicle abuse should be the subject of special instruction? *A*. Improper use of controls, particularly gear shift, clutch, brakes, and choke; racing engine, especially when cold; overspeeding, particularly over rough roads and across country; improper lubrication; deferred maintenance, including lack of proper servicing and adjustments; lack of systematic inspection and follow-up; overloading and improper loading.

Q. Name the driver's reports which are generally applicable to all arms and services operating and maintaining motor vehicles, the preparation and use of which would be covered in (candidate's)



(Stakes should be placed so that when parked the vehicle will have an over-all longitudinal clearance of approximately 10 feet and a lateral clearance of approximately 3 feet.)

FIGURE 120.—Parking course.

instruction. *A*. Standard Form No. 26 (Driver's Report—Accident, Motor Transportation); W. D., Q. M. C. Form No. 237 (Driver's Trip Ticket and Performance Record).

Q. To whom will motor vehicle operators' permits be issued? *A*. Only to individuals who have satisfactorily passed an examination conducted by a qualified commissioned officer.

Q. What subjects does this examination cover? *A*.

(1) *Mechanical*.—Nomenclature and functions of major units of the motor vehicle.

(2) *Operation*.—Actual driving of the vehicle, involving use of controls, reversing, and parking under usual conditions of traffic and

terrain; traffic regulations, road procedure, safety precautions, speed limits, and vehicle abuse.

(3) *Maintenance.*—First echelon (vehicle operator's) maintenance.

Q. What should the possession of a motor vehicle operator's permit guarantee? *A.* That the individual is a safe driver.

Section VI

CONVOY DISCIPLINE, RULES OF THE ROAD, AND ROAD INSPECTIONS

106. Rules of the road.—*Q.* What are the general rules of the road with regard to warning signals? *A.* Appropriate warning signals will be given before changing direction, slowing down, or stopping.

Q. What are the rules with regard to passing traffic moving in the same direction? *A.*

(1) Never pass when going around a corner or a blind curve.

(2) Never pass when going up or down hill unless safe passage is assured.

(3) Never pass at street intersections or crossroads.

(4) Never pass when the road is not wide enough to allow at least 2 feet between vehicles.

Q. What are the rules with regard to meeting and passing an oncoming vehicle? *A.*

(1) Pass on the right, giving at least half the road.

(2) Slow down if operating conditions are hazardous.

(3) Permit the vehicle having a clear road ahead to have the right-of-way.

Q. What is the rule with respect to speeds on dusty roads? *A.* Speeds will be reduced on dusty roads.

Q. What are the rules as to night driving? *A.*

(1) When driving with lights, the vehicle will be kept well to the right and lights will be dimmed when meeting another vehicle.

(2) When driving without lights, speeds will be reduced to accord with road conditions, degree of visibility, and skill of the drivers.

Q. What will be done at a railroad crossing? *A.* Vehicles will be halted unless the crossing is guarded by military personnel or civilian watchmen.

Q. What will be done at road intersections? *A*. Vehicles will be slowed down to a safe stopping speed at all road intersections not covered by traffic-control personnel or traffic-control devices.

Q. What are the rules as to halting? *A*.

(1) Vehicles will clear the roadway before being halted.

(2) Vehicles will not be halted on bridges, in defiles, at points where the vision of other drivers is restricted, or in such manner as to block cross traffic or entering side traffic.

Q. Which has the right-of-way in each of the following cases:

(1) Two vehicles approaching an intersection where there are no stop signs, traffic signals, or police officers?

(2) Two vehicles, one approaching an intersection and one already in the intersection?

(3) Two vehicles moving in the same direction at different speeds?

(4) Motor vehicles and pedestrians at an intersection where there are no traffic signals or traffic officers?

A. The following have the right-of-way:

(1) The vehicle on the right.

(2) The vehicle which has already entered the intersection.

(3) The faster moving vehicle.

(4) Pedestrians.

107. Convoy regulations and discipline.—*Q*. What is the purpose of a convoy? *A*. The efficient transportation of troops and matériel by groups of motor vehicles.

Q. On what does its success depend? *A*.

(1) Condition of vehicles.

(2) Training and discipline of personnel.

(3) Available roads.

(4) Climatic conditions.

Q. How many vehicles make a convoy? *A*. Two or more vehicles operating together constitute a convoy.

Q. When a convoy consists of more than 10 vehicles, how is it divided? *A*. If there are more than 10 vehicles, they should be divided into sections.

Q. Who rides on the first vehicle of each section? *A*. The truckmaster of that section.

Q. What operators are required for each vehicle and what are their duties? *A*. Whenever possible, there will be on each vehicle a driver and an assistant driver. The driver will drive the vehicle, keeping the vehicle to the right-hand side of the road. He will follow, at safe distance, the vehicle ahead of him in the convoy. The assistant driver will watch for all signals and communicate them to the driver. He will pass on the necessary signals to the vehicle following and will relieve the driver occasionally on long trips.

Q. What are the proper distances between vehicles in a convoy? *A*. In order to avoid excessive "accordion effect," no rigid distances between vehicles should be prescribed. However, minimum safe distances are prescribed, the distance in yards in closed formation being approximately twice the speedometer reading. In open formation, distances between vehicles should be increased.

Q. What is the easiest way for a large convoy to get through a city? *A*. The convoy commander or advance agent should make arrangements for a police escort through a city.

Q. What should the first vehicle do when it becomes necessary to open or close the convoy? *A*. When it is necessary to open the convoy, as when approaching a hill, the first vehicle should speed up so that those behind can take the proper distance. After the necessity for opening has been passed, the first vehicle must slow down in order to permit the following vehicles to close up to proper distance.

Q. What governs the speed of the first truck? *A*. The speed of the last vehicle. The speed of the first vehicle must be governed in such a way that the last vehicle may keep its place at the proper distance and not fall behind.

Q. How is a convoy started? *A*. All vehicles in a section should start at the same time. Vehicles should start at a slow speed so that they may take their proper distance in the section. A section should not start until the section commander has assured himself that all the vehicles are ready to start.

Q. Describe driver's arm signals. *A*.

(1) *Turn right.*—Extend the left arm outward at an angle of 45° above the horizontal.

(2) *Turn left.*—Extend the left arm outward horizontally.

(3) *Slow or stop.*—Extend the left arm outward at an angle of 45° below the horizontal.

(4) *Pass and keep going.*—Extend the left arm horizontally and describe small circles toward the front with the hand.

Q. Describe the commands and signals commonly used in a motorized unit. *A*.

(1) *Start engine.*—Simulate cranking.

(2) *Ready to start.*—Senior in truck stands on running board, faces leader, and extends arm vertically, fingers extended and joined, palm toward the leader.

(3) *Stop engines.*—Cross arms in front of body at the waist and then move them sharply to the side. Repeat several times.

(4) *Increase speed.*—Carry the closed fist to the shoulder and rapidly thrust it vertically upward several times to the full extent of the arm.

(5) *Close up.*—Extend the arms horizontally straight to the front, palms in. Move the hands together and then resume the first position. Repeat several times.

(6) *Open up.*—Extend the arms horizontally straight to the front, palms out. Move the hands outward and then resume the first position. Repeat several times.

(7) *Danger.*—Use three long blasts of a whistle or automobile horn repeated several times or three equally spaced shots from a rifle or pistol. The person making the signal points in the direction of the impending danger. This signal is reserved for warning of air or mechanized attack or other immediate and grave danger. Other signals may be found in FM 25–10.

Q. How is a convoy stopped? *A*. All vehicles should stop gradually and pull well over to the right of the road. Care should be taken not to block streets or crossroads. A straight open stretch of road outside of towns, where water is available, should be selected for such stops.

Q. Name some precautionary measures that should be taken while on the march. *A*.

(1) At each halt, truckmasters, mechanics, and drivers should make a general inspection of vehicles at once.

(2) Upon arrival at any doubtful bridge, the convoy should be halted and the bridge inspected before allowing any vehicle to proceed.

(3) If for any reason the convoy commander has occasion to leave his convoy, he should always appoint a commander to take his place, and he should give definite and explicit instructions to his successor.

(4) Local speed and other regulations should always be observed.

(5) Unnecessary delays should be avoided; time once lost is most difficult to make up.

Q. What provisions are made for the care of disabled vehicles? *A*. The last truck of the convoy should carry the tools, ropes, jacks, etc., which are necessary to effect simple road repairs. This vehicle should be under charge of the maintenance officer or an experienced mechanic who will act as file closer, and will have the assistant mechanics as near him as possible. His duties are to assist any disabled vehicle, and to make proper disposition of broken-down vehicles, subject to the orders of the commanding officer. The file closers will not leave any vehicle of the convoy without taking the proper measures either to repair the vehicle on the road, tow it along with the convoy, or make other proper disposition of it.

Q. What precautions should be taken at a crossroad where trucks are separated considerably or when crossing a railroad track? *A.* A man from the leading vehicle should be detailed to give proper directions to the following vehicles at a crossroad, or to watch the track. He should get on the last vehicle that passes and take his regular place at the next stop.

Q. In cold weather, what precautions are taken against a delay in starting? *A.* The drivers should be at their places in ample time to prepare the vehicles for the road, so that the convoy will start on time.

Q. What are the normal positions of—

(1) The convoy commander?

(2) The control car?

(3) The maintenance vehicle?

A. Normal positions are—

(1) At rear of convoy.

(2) Leading the convoy.

(3) Trailing the convoy.

Q. How is the normal day of a convoy divided? *A.*

(1) Breakfast, police of camp, preparations for starting, 1 to 1½ hours.

(2) Morning period on road, 5 hours.

(3) Noon halt, 1 hour.

(4) Afternoon period on road, 3 hours.

(5) Servicing vehicles and supper, 1½ to 2 hours.

Q. Should departures ever be made from this division of time? *A.* No, except in extending the driving periods in an emergency. Driving a heavy truck at road speeds over 30 miles per hour is very fatiguing. After 8 hours' driving, accidents will increase and, when camp is reached, the end-of-the-day servicing of vehicles will be neglected.

Q. How is the movement of convoys over public highways coordinated with civilian traffic? *A.* By means of rules promulgated by the Highway Traffic Advisory Committee of the War Department.

Q. What is done when the column is parked each night? *A.* Gasoline, oil, and water are replenished and the vehicles are cleaned as well as possible by the drivers. The truckmaster (section leader) supervises this and checks up on all defects reported by the driver. The maintenance section immediately starts the necessary repairs, assisted by the driver. At night, lights must be placed on each vehicle, if parked on the road. A guard is usually detailed to protect the column. This work takes about 1½ to 2 hours each evening and no one should be dismissed until it has been completed.

Q. At what times are troubles most likely to develop within the convoy? *A.* During the first hour or late in the afternoon.

Q. When should the first halt be made? Why? *A*. The first halt should be made during the first hour, or as soon as the vehicles have warmed up. Minor adjustments and repairs made at this time will save much delay later on in the day.

Q. What is convoy discipline? *A*. It is the observance and enforcement of the rules and regulations for convoys, especially as relates to the position of units in the column and the position and conduct of individuals and vehicles.

Q. Why is convoy discipline necessary? *A*. It is necessary to insure adequate control; care of equipment; correct formations, distances, and speeds; and to enable the convoy to pass over roads with a maximum of speed and safety and a minimum of interference with other traffic.

Q. How is convoy discipline acquired? *A*. Through training and experience.

108. Speed laws and regulations.—*Q*. What speed laws and regulations must be obeyed by the driver of a military motor vehicle? *A*. Speed laws of the locality in which the vehicle is being operated and speed regulations posted in the vehicle.

Q. In candidate's locality, what are the maximum speed limits—

(1) In a business district?
(2) In a residential district?
(3) For passenger cars?
(4) For motorcycles?
(5) For trucks?

A. Maximum speed limits are—

(1) ——— miles per hour.
(2) ——— miles per hour.
(3) ——— miles per hour.
(4) ——— miles per hour.
(5) ——— miles per hour.

Q. How fast does one have to drive to be guilty of reckless driving? *A*. At any speed which is too fast for conditions of traffic, weather, or the road.

109. Parking.—*Q*. What are a few "don'ts" with respect to parking? *A*.

(1) Don't park on the roadway.
(2) Don't park on a bridge.
(3) Don't park in a defile.
(4) Don't park at the top of a hill.
(5) Don't park at any point where the vision of other drivers is restricted.
(6) Don't park so as to block cross traffic or entering side traffic.

(7) Don't park "double."

Q. How is a convoy parked? *A*. The principal requirements are sufficient space, solid ground, water, and toilet facilities. Do not park on ground where a sudden rain may mire the vehicles, or servicing at night cannot be performed properly. When it is necessary to park in column, leave only enough clearance between vehicles to allow any vehicle to get out.

110. Road inspections.—*Q*. When should a road inspection be made? *A*. At each scheduled halt, when in convoy; at intervals during the day, when the vehicle is not in convoy.

Q. What is the object of a road inspection? *A*. To detect and correct defects, and to assure that the vehicle is ready for continued operation.

Q. What is the general procedure for making a road inspection of a vehicle? *A*.

(1) Allow the engine to run a short time. Listen for unusual noises.

(2) Walk around the vehicle, looking carefully for fuel, oil, and water leaks.

(3) Inspect all tires for inflation, cuts, nails, stones, and indications of misalinement. On track-laying vehicles, examine tracks for adjustment and for worn, loose, broken, or missing parts. Note condition of traction devices, if used.

(4) Feel brake bands, wheel hubs, and gear cases for evidence of overheating.

(5) Inspect the lights, if traveling at night with lights.

(6) Check the amount of fuel in the tank.

(7) Check the quantity of water in the radiator.

(8) Check the quantity and condition of the oil in the crankcase or oil reservoir. Add oil if necessary.

(9) Inspect the condition of the cargo and towed load, if any.

(10) Report promptly the result of the inspection to the chief of section, or other designated individual.

Section VII

MARCH RULES AND DISCIPLINE

111. General.—*Q*. What is a convoy? *A*. Any group of motor vehicles organized to operate as a military unit in contrast to organically motorized tactical units or service trains.

Q. What is the purpose of a convoy? *A*. The efficient transportation of personnel and matériel, especially with respect to the time required and condition upon arrival.

Q. Define each of the following: convoy commander, commander of troops, distance, guard, guide, march discipline, marker, regulating point, serial, and entrucking and detrucking points. *A*.

(1) *Convoy commander.*—The officer in charge of the motor transportation and personnel of a convoy.

(2) *Commander of troops.*—The officer in command of the unit being transported. He may be also the march or convoy commander.

(3) *Distance.*—The space from the rear of one vehicle (including the towed load, if any) to the front of the next vehicle in column; or the space from the rear element of a leading unit to the leading element of the following unit.

(4) *Guard.*—An individual, preferably a noncommissioned officer, placed at an extremely sensitive point, such as a railroad crossing or a turn into or off a main road, to control traffic.

(5) *Guide.*—An individual who leads or guides a unit or vehicle over a predetermined route or into a selected bivouac area.

(6) *March discipline.*—That quality acquired through training and experience in marching which insures adequate march control, care of equipment, obedience to march restrictions, proper conduct and performance of duty by individuals, correct formations, distances, and speeds, and effective use of cover.

(7) *Marker.*—An individual, or distinctive object, placed at a critical point to indicate a position, direction, procedure, or obstacle.

(8) *Regulating point.*—An easily recognizable point where the incoming motor transport column is separated into detachments for entrucking or detrucking purposes.

(9) *Serial.*—One or more march units, preferably with the same march characteristics, placed under one commander for march purposes.

(10) *Entrucking and detrucking points.*—The points where the head of a truck column halts for the entrucking or detrucking of troops or supplies.

Q. What is the assigned minimum distance between trucks in convoy? *A*.

(1) *Open formation.*—100 yards.

(2) *Closed formation.*—Twice the speedometer reading in yards.

(3) *At halt.*—2 yards.

(4) *Between sections.*—3 to 5 minutes' driving time.

Q. What are the driver's principal duties during a convoy? *A*.

(1) Attention to orders and to his driving.

(2) Constant inspection before, during, and after operation.

Q. What should the driver do if he has any trouble while on the march? *A*.

(1) If it is a major trouble, he should pull to the side of the road and signal the following vehicle to pass. He should then report the trouble to the maintenance officer who is at the rear of the convoy. If he is left behind, the driver remains with his truck as a guard.

(2) If it is a minor trouble, the driver reports it to the section mechanic or maintenance officer at the next halt.

Q. What should the driver do during halts of a convoy? *A*.

(1) He should make the prescribed inspections.

(2) He should keep to the right of his vehicle.

Q. In cold weather what precautions should be taken against a delay in starting? *A*. The drivers must be at their places earlier than usual to prepare their vehicles for the road so that the convoy can start on time.

Q. What is done when the column is parked each night? *A*. Gasoline, oil, and water are replenished, and the drivers clean their vehicles as well as they are able. The truckmaster (section leader) supervises this and checks up on all defects reported by the driver. The maintenance section immediately starts on any repairs that may be necessary, assisted by the driver. This work takes from 1½ to 2 hours each evening, and no one should be dismissed until it has been completed.

Q. What are the duties of an assistant driver during a convoy? *A*.

(1) He assists the driver in backing, parking, etc.

(2) He watches to the rear.

(3) He takes his turn at driving.

(4) He assists in first echelon maintenance.

Q. How is gasoline obtained in convoy? *A*.

(1) In an emergency, from the 10-gallon cans carried by the convoy.

(2) At halts, from tankers or some type of filling station.

112. Signals.—*Q*. Describe the driver's arm signals. *A*.

(1) *Turn right.*—Extend the left arm outward at an angle 45° above the horizontal.

(2) *Turn left.*—Extend the left arm outward horizontally.

(3) *Slow or stop.*—Extend the left arm outward at an angle of 45° below horizontal.

(4) *Pass and keep going.*—Extend the left arm horizontally and describe small circles toward the front with the hand.

Q. Describe the commands and signals commonly used in a motorized unit. *A*.

(1) *Start engine.*—Simulate cranking.

(2) *Ready to start.*—The senior in the truck stands on the running board, facing the leader, and extends his arm vertically, fingers extended and joined, palm toward leader.

(3) *Stop engine.*—Cross the arms in front of the body at the waist and then move them sharply to the side. Repeat several times.

(4) *Increase speed.*—Carry the closed fist to the shoulder and rapidly thrust it vertically upward several times to the full extent of the arm.

(5) *Close up.*—Extend arms horizontally straight to the front, palms in. Move the hands together and then resume the first position, repeating several times.

(6) *Open up.*—Extend the arms horizontally straight to the front, palms out. Move the hands outward and then resume the first position, repeating several times.

(7) *Danger.*—Use three long blasts of a whistle or automobile horn repeated several times or three equally spaced shots with a rifle or pistol. The person giving the signal points in the direction of the impending danger. This signal is reserved for warning of air or mechanized attack, or other immediate and grave danger.

(8) *Prepare to mount.*—Extend arm horizontally to the side, palm up, and wave the arm upward several times.

(9) *Prepare to dismount.*—Extend the arm diagonally upward to the side, palm down, and wave the arm downward several times.

(10) *Report when ready to move.*—Extend arm vertically, fingers extended and joined. (Given by unit commander.)

(11) *Drivers to turn around simultaneously.*—Extend both arms horizontally toward the drivers and describe small vertical circles, then signal forward in the desired new direction.

113. Traffic rules.—*Q*. What are some of the more general traffic rules? *A*.

(1) Vehicles will keep to the right side of the road.

(2) The appropriate warning signal will be given before changing direction, slowing down, or stopping.

(3) The driver will be alert and pay attention to road signs, convoy signals, and traffic directions.

(4) The right-of-way will be given promptly to faster-moving vehicles.

(5) Speed will be reduced on dry, dusty roads.

(6) Lights will be dimmed when meeting another vehicle at night.

(7) Unnecessary use of horns is prohibited.

(8) Vehicles will be halted at railroad crossings not guarded by military personnel or civilian watchmen.

(9) Vehicles will clear the roadway before being halted.

Q. In passing oncoming vehicles, what should be done? *A*.

(1) Pass on the right, giving at least half of the road.

(2) Slow down, if operating conditions are hazardous.

(3) Permit the vehicle having a clear road ahead to have the right-of-way.

Q. What are some of the rules for passing vehicles traveling in the same direction? *A*.

(1) Do not pass at a corner or blind curve.

(2) Do not pass on hills unless safe passage is assured.

(3) Do not pass at street intersections, crossroads, or on roads too narrow to leave at least 2 feet between vehicles.

(4) In passing, do not cut in or out too sharply.

Q. What rules governing speed should be observed? *A*.

(1) The speed indicated on the caution plate mounted on the vehicle should not be exceeded.

(2) Drive slowly over rough, slippery, or congested roads.

(3) State or local speed regulations should be observed.

Section VIII

RECORDS AND REPORTS, MOTOR TRANSPORTATION

114. Records and reports.—*Q*. Where may a descriptive list of records and reports pertaining to motor transportation be found? *A*. In AR 850–15, FM 25–10, and Circular 1–10, OQMG.

Q. What is the purpose of the records and reports required for motor transportation? *A*.

(1) They protect the driver, the Government, and the claimant in case of an accident.

(2) They insure that Government transportation is being used to the best interests of the Government.

(3) They aid the maintenance personnel in maintaining the motor transportation.

Q. List the forms that are used in connection with motor transportation. *A.*

(1) *Forms carried by driver.*

	Authority	Form No.
Driver's Report—Accident, Motor Transportation.	AR 850–15	Standard Form No. 26.
U. S. Army Motor Vehicle Operator's Permit.	AR 850–15	W. D., Q. M. C. Form No. 228.
Driver's Trip Ticket and Performance Record.	AR 850–15	W. D., Q. M. C. Form No, 237.

(2) *Forms required in second echelon.*

	Authority	Form No.
Investigating Officer's Report—Accident, Motor Transportation.	AR 850–15	Standard Form No. 27.
Delivery Order and Receipt (gasoline and lubricant issue slip).	AR 35–6560	W. D., Q. M. C. Form No. 437.
Motor Vehicle Service Record Book.	AR 850–15	W. D., Q. M. C. Form No. 248.
Daily Dispatching Record of Motor Vehicles.	AR 850–15	W. D., Q. M. C. Form No. 254.
Technical Inspection Report of Motor Vehicles.	AR 850–15	W. D., Q. M. C. Form No. 260.
Ordnance Motor Book	AR 850–15	W. D., O. O. Form No. 5956.
Lubrication, Work Order, and Bad Order Report Forms.	AR 850–15	Improvised.

(3) *Forms required by regimental supply officer or regimental motor officer.*

	Authority	Form No.
Data for Registration—Motor Vehicle.	AR 850–15	W. D., Q. M. C. Form No. 220.
Motor Vehicle Transfer Form	AR 850–15	W. D., Q. M. C. Form No. 221.
Annual Physical Inventory Report of Motor Vehicles.	AR 850–15	W. D., Q. M. C. Form No. 252.
Annual Report of Motor Vehicle Changes of Accountability.	AR 850–15	W. D., Q. M. C. Form No. 253.
Abstract of Issues of Fuel, Forage, Gasoline and Oils and Operating Supplies (Daily and Monthly).	AR 35–6560	W. D., Q. M. C.Forms Nos. 438 and 440.
Forms pertaining to the receipt, shipment, and issue of property.	AR 35–6560	

Q. In case of an accident, what forms must be made out by the driver? *A*. The accident report must be made out immediately at the scene of the accident.

Q. What should be the guiding factor in making out the reports required in case of an accident? *A*. They should be so clear that there is no doubt in the mind of any reviewing authority as to how the accident occurred. Charts, pictures, affidavits, and receipted bills are used to make the reports clear.

Q. In case a claimant inquires for forms to make a claim as the result of an accident, what does one do? *A*. Refers the claimant to the post adjutant who will furnish him the proper forms. It is contrary to regulations to furnish these forms or information concerning them except through official channels.

Q. Where can one find instructions as to how these forms are prepared and handled? *A*. Instructions for the preparation of a particular form are usually contained on the form itself. In addition, Army Regulations contain a complete description, the Army Regulations applying to a particular form usually being listed on that form.

Q. How are tools issued and accounted for? *A*. On memorandum receipt. But since the regular memorandum receipt form is too small and unsuited for this use, it is found more advantageous to use an improvised form for this purpose.

Q. How is replacement of parts secured? *A*. By means of requisition upon a higher echelon.

Q. Where can data be found as to the records needed to obtain and salvage supplies and equipment? *A*. In TM 10-310.

Q. What entries are made in the Motor Vehicle Service Record Book? *A*. The annual vehicle mileage and a record of assignments, repairs, accidents, and inspections. The service record book is designed to function also as a condensed instruction manual.

Q. What is the purpose of the form for routine scheduled lubrication? *A*. To insure that the vehicle is properly lubricated and that no parts are overlubricated.

SECTION IX

CARE, SERVICE, REPAIR, AND MAINTENANCE OF MOTOR VEHICLES IN THE FIELD

Paragraph

115. Power plant.—*Q*. Explain briefly the basic principle involved in the operation of the internal combustion engine. *A*. A combustible mixture of fuel (gasoline) and oxygen (air) is introduced into a cylinder and compressed between the closed end of the cylinder and a piston. The mixture is then ignited. The burning of the mixture generates heat which causes expansion. The expanding gases act on the piston inside the cylinder and force it downward. The movement of the piston is transmitted through a connecting rod to the crankshaft, thus converting heat energy into mechanical energy.

(For illustration of typical valve mechanism, see fig. 112.)

Q. What is meant by a four-cycle or four-stroke engine? *A*. One whose cycle consists of four distinct steps as follows:

(1) Intake or admission of the charge of the air-fuel mixture.
(2) Compression of the charge.
(3) Ignition and explosion of this charge.
(4) Exhaust or expulsion of the burned charge.

When this complete process requires four strokes of the pistons in any one cylinder, the engine is designated as a four-stroke cycle engine.

Q. Explain what takes place during each of the four strokes of the cycle. *A*.

(1) The piston being at top dead center, and the intake valve having just opened, the piston going down on suction draws into the cylinder a charge of gasoline and air.

(2) Shortly after the piston has passed bottom dead center, the intake valve closes and during the rest of the upward stroke the charge is compressed.

(3) Just before the piston reaches top dead center on the compression stroke, a spark is produced at the spark plug and the burning of the charge forces the piston downward. (This is the power stroke.)

(4) Just before the piston reaches bottom dead center the exhaust valve opens and the next upward stroke of the piston forces the burned gases out and clears the cylinder for the intake stroke of the next cycle.

Q. Why is a system of valves used in an engine? *A*. To allow the fuel to enter the combustion chamber, to close the chamber, and to allow the burned gases to escape from the combustion chamber at the proper time.

Q. What is the function of the camshaft? *A*. The camshaft has a cam for each valve. As the camshaft turns, the cam comes in contact with the valve lifter and raises the particular valve off its seat (opens it).

Q. How is the camshaft driven? *A*. Either by a chain or system of timing gears driven by the crankshaft gear.

Q. What is meant by valve timing? *A*. By valve timing is meant the proper adjustment of the opening and closing of the intake and exhaust valves in relation to the position of the piston. Since the distance of the piston from dead center is dependent on the position of the crankshaft, valve timing resolves itself into the proper meshing of the crankshaft gear with the camshaft gear to obtain this correct relationship.

Q. What is the result if a valve does not close all the way? *A*. There is a loss of compression. If it is an exhaust valve, the seat will burn and warp, due to the hot escaping gases.

Q. What should the valve tappet clearance be? *A*. The exhaust valve tappet should have about 0.006 to 0.012 of an inch. The inlet valve tappet should have about 0.004 to 0.010 of an inch.

Q. What is meant by a valve seat insert? *A*. A very hard steel ring inserted in the valve port to form the valve seat.

Q. Is it possible to reseat valve seat inserts? *A*. Only by the aid of special valve seat insert grinding stones.

Q. How often should they be reseated? *A*. About every 50,000 to 65,000 miles. In some cases, they last the life of the vehicle.

Q. How is the compression of an engine tested? *A*. Remove all spark plugs, open the throttle wide open, insert a compression gage in No. 1 cylinder, and crank the engine either by hand or battery about six revolutions. Take the reading of meter on a gage. If the reading is low, the compression is bad. Check each cylinder in the same manner. Compression in all cylinders should not vary more than 5 pounds. If no gage is available, leave all spark plugs in place. Crank the engine by hand. Each cylinder should have about the same resistance when cranked against compression. A cylinder with good compression will show a springy resistance and the engine can be rocked against compression.

Q. What is the ratio of the camshaft to crankshaft speed? *A*. The camshaft speed is half the speed of the crankshaft.

Q. How are the causes of engine troubles determined? *A*. Since nearly all of the operating parts of the engine are inclosed and inaccessible, the cause of engine troubles must usually be deduced by a system of elimination.

Q. How can engine troubles be classed? *A*. They can be classed as—

(1) Mechanical troubles.

(2) Fuel feed and carburetion troubles.

(3) Ignition troubles.

Q. What conditions are necessary for an engine to start? *A.* If the following conditions exist, the engine should run:

(1) The engine turns freely without any indication of mechanical troubles and has compression.

(2) Gasoline reaches the cylinder, the cylinders being neither uncomfortably hot nor cold to the hand, the throttle being one-fourth open, and the intake passage clear and tight.

(3) There is a spark at the right time at the right place.

Q. Why is the power-producing unit of a motor vehicle called an engine instead of a motor? *A.* To avoid any confusion with electric or starting motors.

Q. What inspection should be made whenever an engine is disassembled? *A.* Inspect all parts for defects and make a list of all parts needed.

116. Cooling system.—*Q.* Should a water-cooled engine be run without water in the cooling system? Why? *A.* No. It will cause the engine to run hot, and the metal will expand and cause the pistons and rings to seize the cylinder walls due to the burning of oil from the cylinder walls.

Q. If the engine is overheated, how should water be added? *A.* Cold water should preferably be heated before being added. If this is impossible, the engine should be allowed to cool before water is added or water should be added very slowly.

Q. How should the radiator and water jackets be protected in cold weather? *A.* A close check should be kept on the antifreeze solution. Unless sufficient antifreeze solution is used, the radiator and water jackets should be completely drained when the vehicle is not in use and a "drained" sign should be hung on the radiator. Sometimes it will be necessary to protect the lower front half of the radiator with tin, cardboard, or canvas during operation.

117. Gasoline feed system.—*Q.* What type gasoline feed system is used on Army vehicles? *A.* The positive fuel feed system (fuel pump) is used on all modern vehicles.

Q. What troubles develop in a fuel pump most frequently? *A.* The diaphragm becomes punctured, gasoline lines become loose, or the strainer becomes clogged.

Q. What pump parts should be carried on a convoy? *A.* A complete fuel pump for replacement use and a few extra diaphragms.

Q. What causes most fuel trouble in the field? *A.* Dirt or water in the fuel. This will cause more trouble with Diesel engines than with others because of the small clearances used in Diesels.

Q. Name the most frequent carburetor troubles. *A.* Strainers stopped up, jets stopped up, float too low or too high, and float punctured.

118. Ignition system.—*Q*. What is the function of the ignition system? *A*. To ignite the charge of fuel at the proper time.

Q. What is meant by ignition timing? *A*. Setting the ignition system so the breaker points will start to open at or just before the piston reaches top dead center on the compression stroke.

Q. What is the source of electrical power to operate the ignition system on the modern automobile? *A*. The storage battery.

Q. Draw a wiring diagram of a typical battery ignition system. *A*. (See fig. 115.)

Q. What is the interrupter? *A*. The interrupter is a mechanical switch which rapidly makes and breaks the primary circuit at intervals. When the primary circuit is broken, the primary current ceases to flow, thus causing the magnetic field around the coil to collapse. In so doing, it will induce a high voltage in the secondary coil having sufficient intensity to cause the secondary current to jump the spark plug gap.

Q. What is the purpose of the condenser? *A*. The condenser is used in the primary circuit in parallel with the breaker points. When the breaker points open and the primary circuit is broken, the induced-kick voltage in the primary, which is in the same direction as the original battery current and which otherwise would cause an arcing across the breaker points, is impressed across the condenser and charges one side positive and the other side negative. The condenser will discharge back in a reverse direction through the primary windings. This backward surge of current will assist in reducing the magnetism of the core to zero, thus speeding up the collapsing lines of force and thereby aiding in securing the maximum induced voltage in the secondary winding.

Q. What should the gap at the breaker points be? *A*. It should be from about 0.013 to 0.022 of an inch.

Q. What should the spark plug gap be? *A*. It should be from 0.025 to 0.035 of an inch.

Q. Name the most frequent causes of ignition troubles. *A*. Improper timing, short circuit, burnt armature, defective contact points or brushes, or weak magnets.

(1) *Coil*.—Short-circuited, or broken insulation.

(2) *Distributor*.—Broken contacts or brushes, water or dirt in distributor, distributor (or rotor finger) removed or broken, or distributor head cracked.

(3) *Switch*.—Open circuit, short circuit, or improperly connected.

Q. How can the timing of the spark be regulated to vary with engine speed? *A*. By automatic spark control or by manual spark control.

Q. How are ignition troubles traced? *A*. By asking one's self the following questions and finding the answers. Test for a spark at the spark plug. If there is no spark, is the switch turned on? Is the battery all right? Are any wires disconnected or terminals corroded? Are wires connected correctly? Are any wires broken? Do the breaker points open and close properly? Is there a spark at the spark plug at the proper time? Are spark plug gaps of the proper width? Are porcelains and electrodes clean and unbroken? Is there too much gasoline in the cylinders so the spark plugs are fouled?

Q. If, when the breaker points open, there is an excessive spark or arc at the point of opening, what is the trouble? *A*. A disconnected or defective condenser.

Q. How is the fuel ignited in a Diesel engine? *A*. The compression is so great that the heat generated by this compression is sufficient to ignite the fuel. If dirt enters the engine, the walls of the cylinders are liable to become scored, causing the compression to decrease. A loss of compression may cause the temperature induced to decrease to such an extent that ignition of the fuel will not take place and the engine will not operate.

119. Lubrication system.—*Q*. Name and explain the lubrication systems used in automobile engines. *A*. The full-force feed and the force feed (or pressure feed).

(1) In full-force feed, an oil pump, which is usually driven from the camshaft by means of gears, picks up the oil from the oil sump. The oil is then forced upward and conducted by means of tubes to the crankshaft bearings. These bearings become lubricated while the excess oil flows through holes drilled in the crankshaft and through the throws of the crankshaft into the crankpins, lubricating the connecting-rod bearings. The oil is forced from the connecting-rod bearing through tubes or holes drilled in the connecting rods to the piston pins. This is the only system in which the oil is forced to the piston pins. In the full-force feed the camshaft bushings are also force-feed lubricated.

(2) In the force feed, the oil is pumped from the oil sump and forced to the crankshaft and connecting-rod bearings only. The piston pins and cylinder walls are lubricated by splash.

Q. Why are oil filters used? *A*. To remove the dirt and grit from the oil.

Q. How are lubricating oils classified? *A.* Lubricating oils are classified according to their viscosity by an SAE rating. By this rating the higher number is given to the heavier oil. Oil with an SAE No. 50 rating is a thick oil, while No. 20 is a thin oil.

Q. How is the transmission lubricated? *A.* By heavy oil contained in the transmission.

120. Clutch and transmission, wheels and brakes.—*Q.* Name the most usual clutch troubles. *A.* Slipping, grabbing, and chattering.

Q. What are the causes? *A.*

(1) Slipping is usually caused by the friction material of the disk being worn, the clutch springs failing to exert sufficient pressure, or from allowing the foot to rest on the clutch pedal while driving.

(2) Grabbing is caused by oil on the clutch plates, spring with too great a capacity, or faulty lining.

(3) Chattering is caused by the clutch shaft and driving members being out of alinement with the driven member.

Q. To what are most clutch troubles due? *A.* They are due to the clutch throw-out bearing becoming worn.

Q. Name the most usual transmission troubles and their cause. *A.* Difficulty in shifting gears, usually caused by broken parts, by oil which has become gummy, by insufficient or too much oil, or from the gear shift lever connections being out of order. The transmission gear can easily be stripped by changing from a forward to a reverse gear when the vehicle is in motion.

Q. What troubles may develop in the drive? *A.* Broken drive shaft or universal joints. The drive shaft may break or be bent by contact with road obstructions, by excessive differential gear clearance, or by racing the engine and jerking the vehicle by suddenly applying the power to the axle shafts.

Q. How is the power transmitted to the rear axle? *A.* Through universal joints and a drive or propeller shaft. Four-wheel-drive trucks employ two drive shafts and require what is known as a transfer case or differential for this purpose.

Q. What is a universal joint? *A.* It is a device for connecting two shafts which are slightly out of alinement, and to transmit power through these angles.

Q. What is a slip joint? *A.* A sliding or telescopic joint which is splined and permits variations in the length of the drive shaft. It is used to compensate for the variations in distance between transmission and rear axle, due to the action of the springs.

Q. What is the purpose of the differential? *A.* It permits one axle shaft connected to it to rotate slower, faster, or remain stationary with reference to the other axle shaft. Such a device is necessary to compensate for the difference in speed of the rear wheels when going around curves.

Q. Can the auxiliary transmission be shifted into a lower gear while the vehicle is in motion? *A*. Regulations prohibit such a shift, as there is a great possibility of stripping the gears.

Q. Explain the principle embodied in the design of the bevel differential. *A*. The differential case is attached to and driven by the ring gear. Four small bevel gears are mounted inside the differential case on a spider, the latter supported by the case. The four gears are in mesh with a bevel gear on each side, to which the axle is attached. On a straight road with equal traction, the motion of the ring is transmitted to the differential case, and the spider gears remain stationary and cause the gears attached to the axle shafts to rotate in unison with the case. If one axle is retarded or stopped, as in rounding a curve, the gear attached to that axle is moving slowly or is stationary. The differential case being in motion turns the spider. The spider gears roll on the gear attached to the retarded or stationary axle, while the gear attached to the other axle is rotated at a higher speed. If one wheel stops, the other one will turn twice as fast as it did before the other wheel stopped.

Q. How is the power transmitted to the ring gear? *A*. From the propellor shaft to a piston shaft to the pinion gear to the ring gear.

Q. Explain the double-reduction-drive differential. *A*. The only difference is that the first reduction is from the bevel-ring gear shaft to a small spur gear, to a large spur gear connected to the differential case.

Q. What are the advantages of dual wheels? *A*. They give greater carrying capacity, longer tire life, and increased road contact with consequent better traction, while the tires can be smaller in diameter, giving a lower center of gravity to the vehicle.

Q. Describe briefly the construction of a typical steering gear. *A*. The steering wheel is keyed to a shaft supported by the steering column. The shaft terminates in a worm; the worm engages in a worm gear, the shaft of which carries the steering lever arm. The steering lever arm is connected by the drag link to one of the steering knuckles. A tie rod connects the two steering knuckles.

Q. Explain the mounting of the front axle and wheels. *A*. The front axle is fastened to the frame by means of leaf springs which are secured to the frame by shackles and shackle bolts. The axle is fastened to the springs by bolts. The wheels are mounted on spindles; the spindle is fastened to each end of the axle with kingpins, which allows the spindle to turn.

Q. Why are the steering arms curved toward the center of the vehicle instead of being straight? *A.* Because in turning a curve, the path of the outside wheel is an arc of a larger circle than the path of the inner wheel. Therefore, the outside wheel must be inclined at a lesser angle than the inside wheel. The angularity of the steering arms provides for this difference in inclination of the wheel.

Q. What difficulties are experienced with the steering mechanism? *A.* Front wheels out of alinement, broken parts, improper lubrication, and parts becoming worn and loose.

Q. What is meant by irreversible steering gear? *A.* A steering gear in which turning motions can be transmitted to the steering knuckles by turning the steering wheel, but motions cannot be transmitted from the front wheels to the steering wheel.

Q. How is this accomplished? *A.* By the use of a worm in the steering gear. A worm is capable of turning a gear, but the motion cannot readily be transmitted from a gear to a worm.

Q. What troubles are experienced with wheel bearings? *A.* Improper adjustments and insufficient lubrication.

Q. How are brakes operated? *A.* Mechanical, hydraulic, or air operated. A vacuum booster may be used to work in conjunction with the mechanical or hydraulic brake.

Q. What is the advantage of the vacuum booster brake? *A.* It lessens the necessary brake pedal pressure for brake application.

Q. What troubles are experienced with brakes? *A.* Worn-out brake lining, unequal adjustment of the brake bands or shoes, scored drums, brake lining stripping from the shoes and rolling up at the ends, oil leaks in the lines, brake, or master cylinders in the case of hydraulic brakes, unequal linkage and rod adjustments, and oil on brake lining.

Q. What precaution must be taken with brakes? *A.* Brakes must be tested and inspected frequently, worn lining must be replaced, and the brake bands kept in proper adjustment.

Q. How can the wear of the brakes be reduced? *A.* By using the engine to produce braking effect. In descending long, steep grades, the vehicle should be run in second or low gear to help brake the vehicle.

Q. When does the greatest braking effect occur? *A.* Just before wheels begin to slide.

Q. What care should be taken of tires? *A.* Keep sufficient air pressure in them, keep rims tight, and avoid running over glass or sharp stones as much as possible. Do not run on a flat tire. Never let a tire sit in oil or gasoline, as it will rot the rubber.

121. Battery.—*Q.* When a new battery is received, what is the first thing to do? *A.* Unpack the battery, keeping the packing case right side up to avoid spilling the battery solution. Examine the battery carefully to see if there is any indication of injury during transit. Determine whether the battery has been shipped charged or unfilled.

Q. What care is necessary when installing a battery on a car? *A.* When connecting the battery to the battery cables, be sure they are connected properly and are tight, and the terminals are greased with vaseline or some lubrication grease.

Q. How can one determine whether the battery is properly connected? *A.* Look up the diagram in the service book, or turn the lights on and note the reading of the ammeter. If the engine is not running, the ammeter should indicate discharge if the battery is properly connected.

Q. What attention does the battery require in service? *A.* It requires very little attention, but that little is absolutely necessary and vital. Add nothing but pure distilled water to replace that lost by evaporation. Do this often enough to keep the plates covered about ½ inch. In freezing weather, do not add water until just before the battery is to be used or recharged. Keep the connections tight and covered with vaseline. Keep the filling plugs tight and battery dry, clean, and clamped down tightly in the carrier. Take hydrometer readings and check water every 2 weeks in the summer. If the vehicle is to be stored or repaired the battery should be removed, charged, and put into proper storage.

Q. How should corroded battery terminals be cleaned? *A.* By scrubbing thoroughly with ammonia, or a solution of baking soda and water.

Q. What will cause the lights to burn out? *A.* Loose battery connections, reverse current relay points sticking, or lamp bulbs of the wrong voltage.

Q. If lights go dim when engine is cranked with the electric starter, what is the trouble? *A.* Discharged battery or loose battery connection.

Q. In case of trouble with the electric starter, what should be done? *A.*

(1) See that the battery is charged.

(2) See that there are no short circuits.

(3) See that battery terminals are not loose, rusty, or corroded.

(4) Examine the starting switch for proper connections and operation.

(5) See that the brushes are properly seated on motor commutator.

122. Miscellaneous.—*Q*. What repairs may be made in the field? *A*. The repairs are limited by the supplies and equipment on hand, and the ability of the personnel.

Q. What records are required to be kept in the field by the chief of section? *A*. The Motor Vehicle Service Record Book and such improvised forms as are necessary to collect data for the Motor Vehicle Service Record Book.

Q. What data are kept in the Motor Vehicle Service Record Book? *A*.

(1) Abbreviated instructions for the care and maintenance of the motor vehicle described on the cover of the record book.

(2) Mileage record.

(3) Accident record.

(4) Description of all repairs done.

(5) Tool and property record.

(6) Assignment record.

Q. Who is in charge of issuing gasoline, lubricants, and motor vehicle supplies in the field? *A*. The regimental supply officer, assisted by the transportation (motor) officer.

CHAPTER 17

COMMUNICATION

SECTION I

SYSTEMS OF COMMUNICATION

123. General.—*Q.* Name several of the means of communication commonly used by mobile artillery. *A.* Telephone; radio; visual signals including wigwag, semaphore, and panels; motorcyclists, orderlies, and runners.

Q. Which of these means of communication is most suitable for fire control? *A.* The telephone. The other systems are supplementary and may be used in emergency.

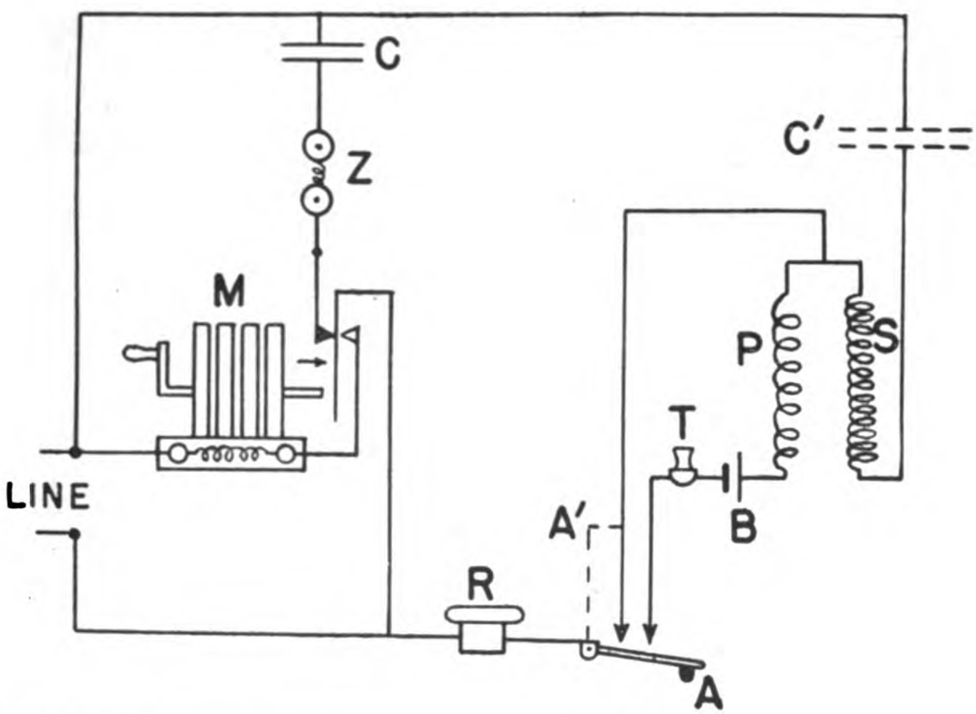
Q. What two types of telephone systems are used? *A.* Common battery and local battery systems.

Q. What feature distinguishes the local battery telephone system from the common battery telephone system? *A.* In a local battery system batteries are connected locally to each telephone used. In a common battery all telephones are energized by a storage battery at a central station.

Q. Which system is generally used in mobile seacoast artillery units? *A.* Mobile seacoast artillery units generally use the local battery system.

Q. Can the same type of telephone be used on local and common battery circuits? *A.* The internal circuits of common battery telephones differ from the circuits of the local battery type. Several types of local battery telephones can be connected to a common battery system, but it is necessary to use a local battery for each telephone so connected.

Q. Can the EE-5 telephone be used on a common battery system? *A.* Only the unmodified EE-5 telephone can be used on a common battery system. The modified EE-5 telephone requires the use of a condenser in series with the line in order to prevent direct current flow through the ringing circuit.



A. Push button.
A′. Jumper in handset of new type.
B. Local battery.
C. Condenser.
C′. Position of condenser in new type.
M. Magneto.
P. Primary coil.
R. Receiver.
S. Secondary coil.
T. Transmitter.
Z. Buzzer (substituted for bell or ringer).

FIGURE 121.—Simplified circuit of EE-5 telephone.

Q. Explain why a local battery is necessary when a local battery telephone is used on a common battery circuit. *A.* The local battery is necessary to energize the primary circuit, including the transmitter.

124. Telephones.—*Q.* Name the principal circuits of the telephone. *A.* The primary circuit, consisting of the battery, transmitter, and primary winding of the induction coil; the secondary circuit, consisting of the secondary winding of the induction coil, the receiver, and the receiver condenser; and the ringing circuit, consisting of the magneto and ringer, or buzzer.

Q. How are the magneto and buzzer connected? *A*. The circuits of both are bridged in parallel across the line. The magneto switch is so connected, however, that either the magneto or the buzzer will be connected at one time; both cannot be connected across the line at the same time.

Q. Is the current generated by the magneto transmitted through the receiver and transmitter? *A*. No. A button switch on the unmodified EE–5 telephone disconnects both receiver and transmitter from the magneto circuit. On the modified EE–5 and the EE–8 or EE–8A, the handset switch disconnects the transmitter only, but the receiver condenser offers such high impedence to the low-frequency

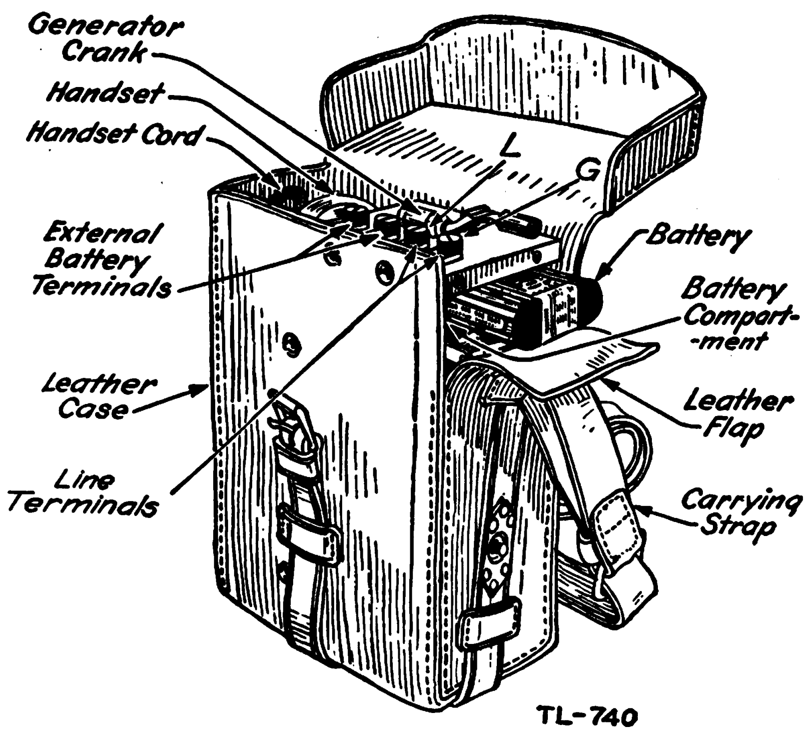


FIGURE 122.—Field telephone EE–5.

ringing current that in effect very little ringing current passes through the receiver.

Q. What type transmitter and receiver is used with the type EE–5 telephone? *A*. Handset type TS–7.

Q. Is the type TS–7 handset suitable for all conditions of service? *A*. No. For operation against naval targets when constant and prolonged telephone connections are necessary, the headset, type EE–70 should be used. However, this is to be considered exceptional, as the use of this headset necessitates internal connection to the telephone.

Q. What is the distinguishing feature of the EE–8 telephone, compared to other local battery telephones? *A*. The EE–8 telephone is an anti-side tone telephone, in which an auxiliary receiver circuit partially suppresses side-tone in the receiver while the operator is using the transmitter.

Q. Can the EE-8 telephone be used on common battery systems? *A*. Yes. The EE-8 telephone may be used on common battery systems by simply changing the position of the "LB-CB" switch. Turning this switch to the "CB" position connects a holding coil in such a manner that lifting the handset from the lever switch will connect the

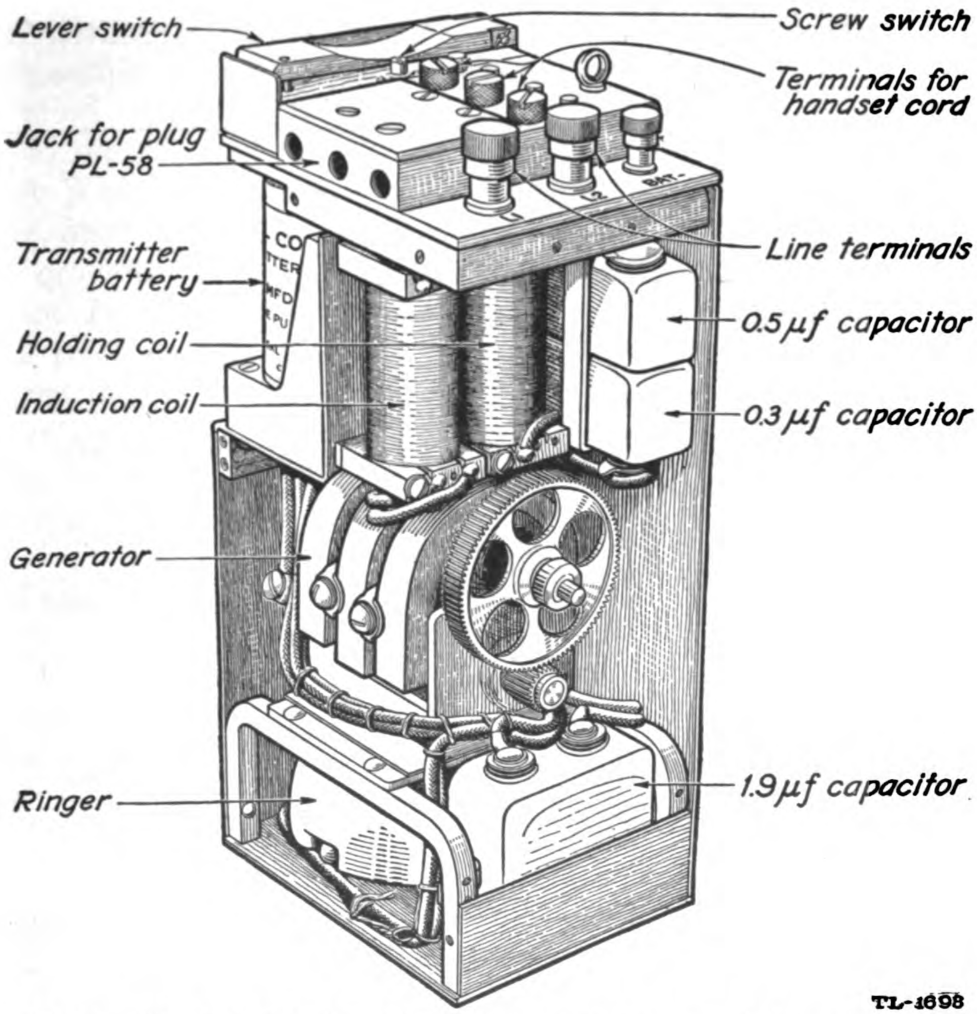


FIGURE 123.—Field telephone EE-8, showing interior view of frame assembly.

holding coil across the line and thus signal the switchboard operator. The local battery must still be used for excitation of the transmitter circuit.

Q. What are the two principal advantages of the anti-side-tone feature of the EE-8 telephone? *A*.

(1) When no side-tone is heard, the operator will speak louder.

(2) If no current flows through the receiver, there will be no loss in the receiver and more power will be available for operating the other telephone.

Q. How does the EE-8 telephone differ from the EE-8A? *A.* In the EE-8A telephone the small, flexible insert in the cover is omitted, and the three condensers are contained in a single case instead of being in three separate cases, as in the EE-8.

Q. Is it permissible to use a battery of more than 3 volts in the EE-8 telephone? *A.* This is never permissible, as any source of power of more than 3 volts will almost certainly damage the transmitter.

Q. Is it necessary to hold the diaphragm of the transmitter in a vertical plane? *A.* No. The transmitter in the EE-8 telephone has

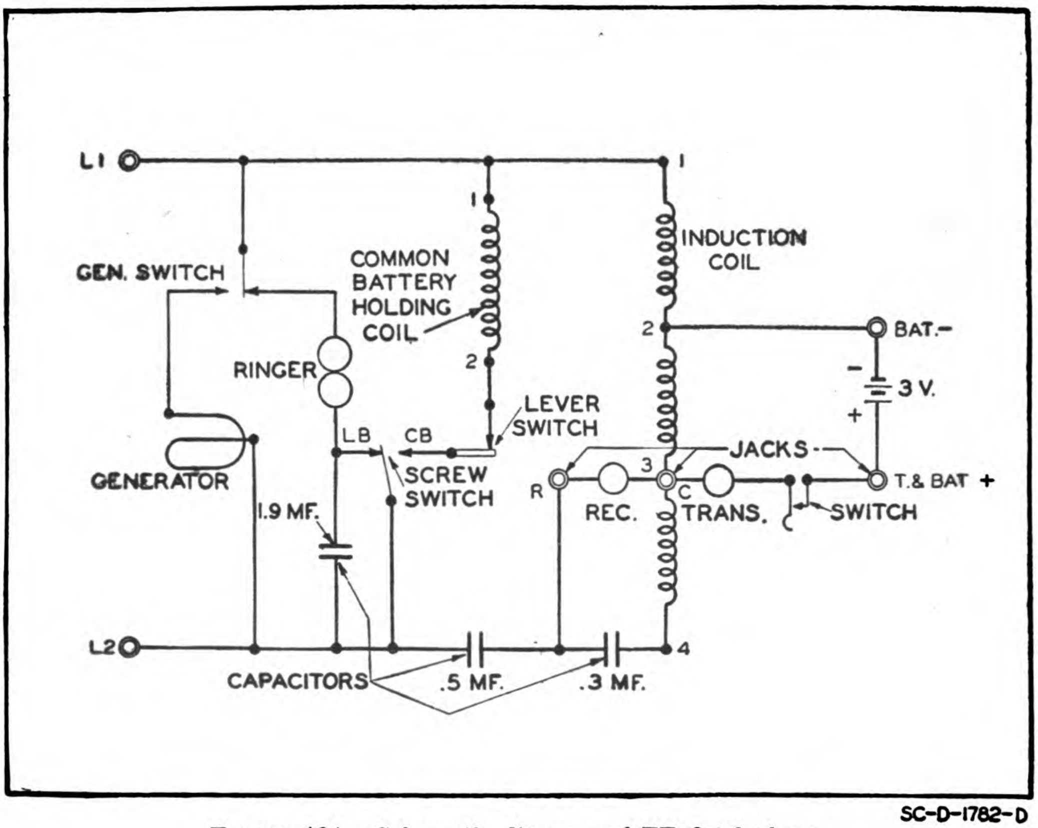


FIGURE 124.—Schematic diagram of EE-8 telephone.

been so improved over older transmitters that it will operate equally well in all positions.

Q. What will happen if the "LB-CB" switch is turned to "CB" and the generator operated with the lever switch up? *A.* The called ringer will not operate properly, due to the fact that a considerable part of the generator current will flow through the holding coil on the calling telephone.

Q. Where may detailed information on the EE-8 telephone be obtained? *A.* In TM 11-333.

125. Switchboards.—*Q.* What type switchboard is used with the battalion and battery telephone system? *A.* Monocord switchboards are normally used. There are 4 types available: BD–9, a 4-drop monocord switchboard without operator's set or night alarm; BD–11, a 12-drop monocord switchboard without operator's set or night alarm; BD–71, a 6-drop monocord switchboard with operator's set, night alarm, and 2 repeating coils; and the BD–72, a 12-drop monocord switchboard with operator's set, night alarm, and 4 repeating coils.

Q. Name the principal parts of the switchboard, type BD–9. *A*. The switchboard frame; the three brass bars; seven binding clips, three on top and four on the bottom of the frame; and the switchboard units.

Q. What is the purpose of the binding clips? *A*. The three upper ones, marked A, A–1, and G, are used to connect the night bell and the ground. Of the four lower ones marked B, B–1, L–1, and L–2, B and B–1 are used to connect the night bell battery, and L–1 and L–2 are connected to the operator's telephone set and plug. By connecting L–1 and L–2 of one switchboard to L–1 and L–2 of another, two switchboards may be used together as one.

Q. What is the purpose of the brass bars? *A*. In addition to providing a mechanical support for the units, the top bars serve as a good ground connection, the center bar as night bell connection, and the bottom bar as battery connection for all units.

Q. Name the principal parts of a type EE–2 switchboard unit. *A*. Mounting screws, line terminals, lightning arrester, fuses, line signal shutter and electromagnet, night bell contact and spring, and jack and line plug.

Q. Explain the operation of a lightning arrester. *A*. It consists of a toothed washer held between the line binding posts by the upper mounting screw and ground through the upper brass bar. If lightning comes in over one of the line wires, the main portion jumps the gap between the binding post and washer and thence to the ground. If the small portion flowing through the switchboard units is at all heavy, the fuses burn out, opening the circuit.

Q. Describe the fuses. *A*. Each unit is provided with two glass-inclosed fuses, which fit into spring contacts to protect each side of the line from excessive currents. The panel is painted white behind the fuses so that a burnt fuse, usually smoked up, can be readily noticed.

Q. Explain briefly the operation and construction of the signal shutter and coils. *A*. The shutter, or drop signal, is normally held in a vertical position by a brass trip latch. The trip latch is attached to the armature of a small electromagnet. The coils of the magnet are connected through the jack to the line. The current from the calling station energizes the electromagnet. The latter attracts and lifts the armature and trip latch. The shutter drops, by its own weight, to a horizontal position.

Q. Explain the operation of the night bell contact. *A*. When the signal shutter drops, the night bell spring and contact are brought together, completing a circuit from a battery to the lower brass bar, through the night bell spring and contacts to the center bar, thence to the night bell. The bell continues to ring until the shutter is raised or battery disconnected.

Q. Describe briefly the switchboard jack and plug. *A*. The jack consists of a cylindrical opening in the panel of the unit, behind which are mounted the tip contact, the sleeve contact, and the signal contact. The tip contact is connected through one of the fuses to one side of the line, and the signal contact to the other through the magnet coils and the other fuse. The plug is cylindrical, having two contacts, one on the tip through the center of the plug and the other on a sleeve on the outside of the plug. These contacts are connected by two wires, inclosed in a single covering, to the tip and sleeve contacts of the jack, respectively.

Q. How do the plug and jack operate? *A*. When the plug of a unit is inserted in the jack of a second unit, the line of the first unit is connected to the line of the second unit. This completes the circuit between the two lines. In addition, the operator may plug into the unit having a vacant jack and listen in. When the plug is inserted, the tip and signal contacts are separated. This opens the circuit to the coils of the shutter magnet.

Q. What care is required in transporting, installing, and using the switchboard? *A*. In transporting and installing the board, all shutters are held closed by the spring lever provided on each unit. When the switchboard is installed, it is necessary that the frame be held in a vertical and level position. In handling switchboard cords, they should be grasped by the plug and not by the cord, in order to prevent breaking the cord.

Q. What is the cause of a short circuit between lightning arrester and line? *A*. Particles of dirt. The small clearance between the arrester and line contacts must be kept clean.

Q. Should the night bell continue to ring after the shutter is raised, how is the trouble remedied? *A*. By adjusting the night bell contact spring so that a small space is left between it and the contact point.

Q. Should the signal shutter fail to drop when the magnet is energized, what remedy is applied? *A*. By removing the unit, the armature and trip catch may be adjusted so that the catch is clear of the shutter when the armature is raised; also be sure the face of the board is vertical.

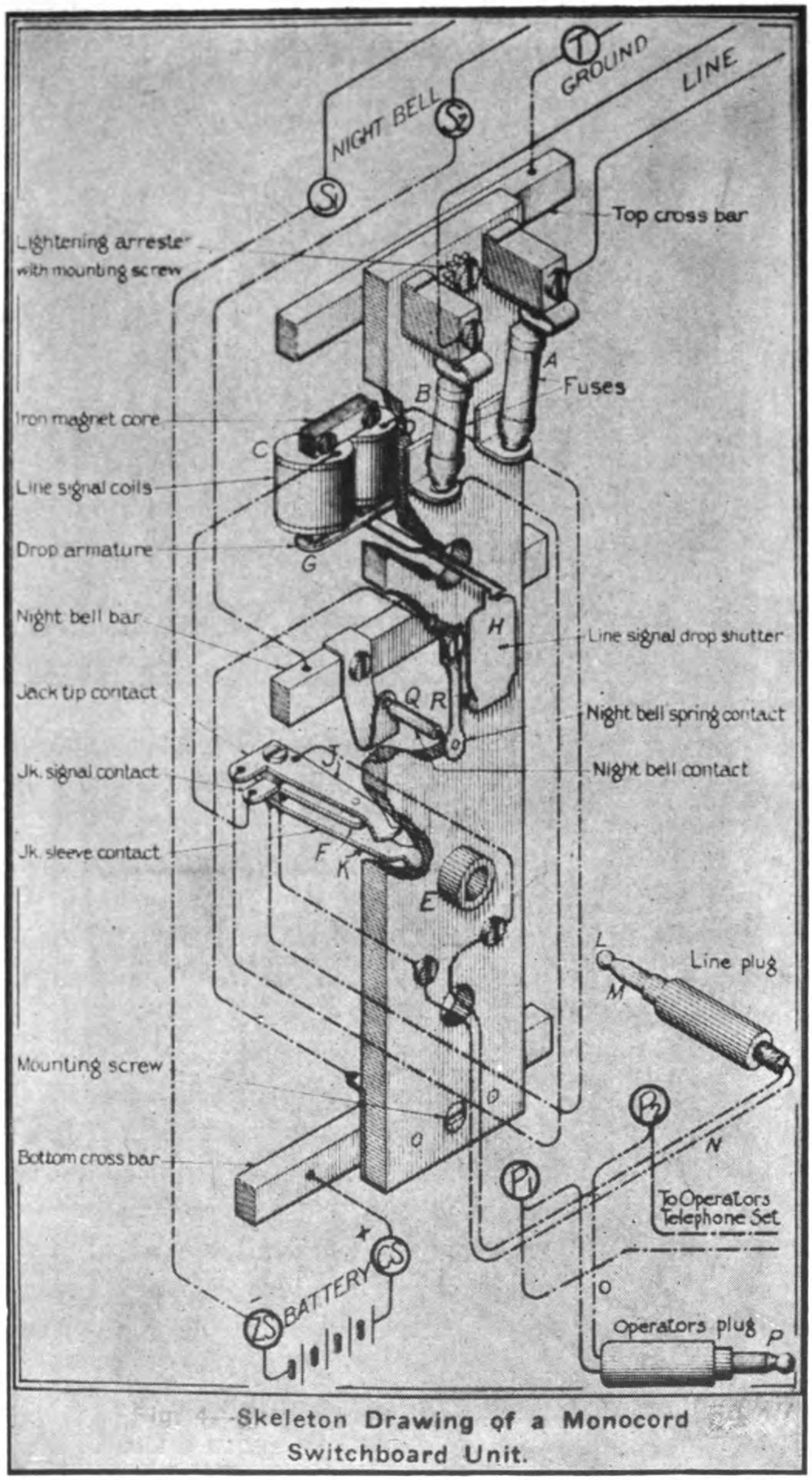


Figure 125.—Diagram of monocord switchboard unit.

Q. What should be done if an open circuit develops in one of the shutter coils? *A*. The switchboard unit should be replaced.

Q. What remedy is applied when the plug fails to make proper connections? *A*. The tip and sleeve contacts on the jack are cleaned and adjusted so that they come into firm contact with the plug when inserted.

Q. How may a switchboard cord be tested to insure that the wires are in operating condition? *A*. Insert the plug of the operator's unit in the jack of the unit to be tested. Ring the operator's set, while holding the tip and sleeve of the cord jack. If the cord is good, the current will be felt by the fingers. If no current is felt, the cord may be open, in which case the magneto crank will turn easily, or it may be shorted, in which case the crank will be hard to turn.

Q. Should the operator's cord be found defective, how can operation of the board be continued? *A*. By three different methods, as follows:

(1) Transfer the wires from L-1 and L-2 to the line terminals of a unit not in use, and use the cord of that unit as the operator's cord while the latter is being replaced.

(2) Connect the terminals of an extra unit directly to the terminal of the operator's set, and use this as a master cord while replacing the defective one.

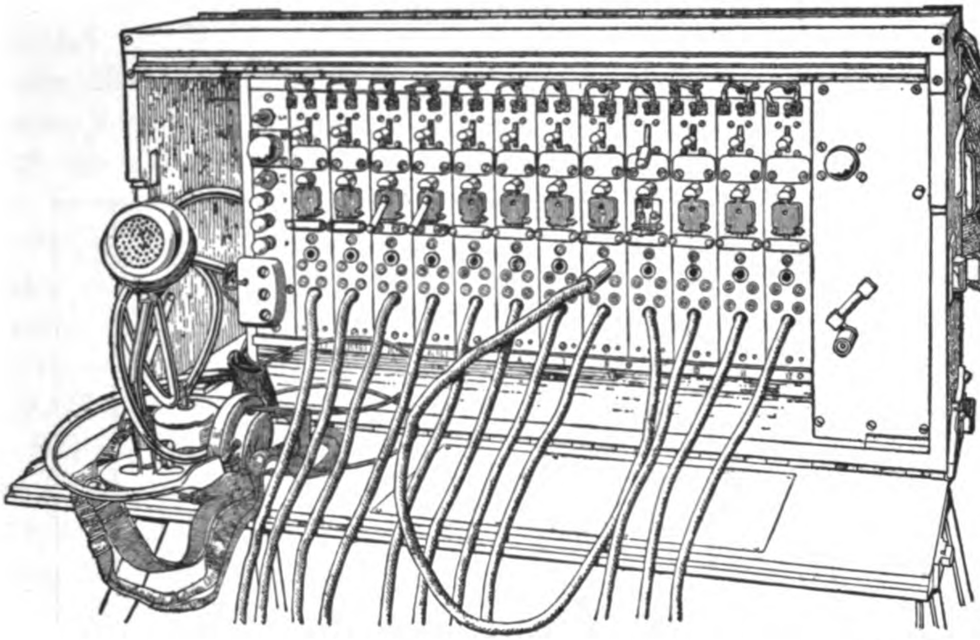
(3) If an extra plug is available but no extra cord, and there are no spare units on the board, remove the paper sleeve from the handle of the plug and transfer the wires from L-1 and L-2 to the terminals of this plug. This plug can then be used as a master plug until repairs are made.

Q. How is the operator's cord replaced? *A*. The cord connections are made accessible by removing two units to the right of the point where the cord goes up through the bottom of the board. The new cord is run up through the bottom of the board and connected. The two units are then replaced.

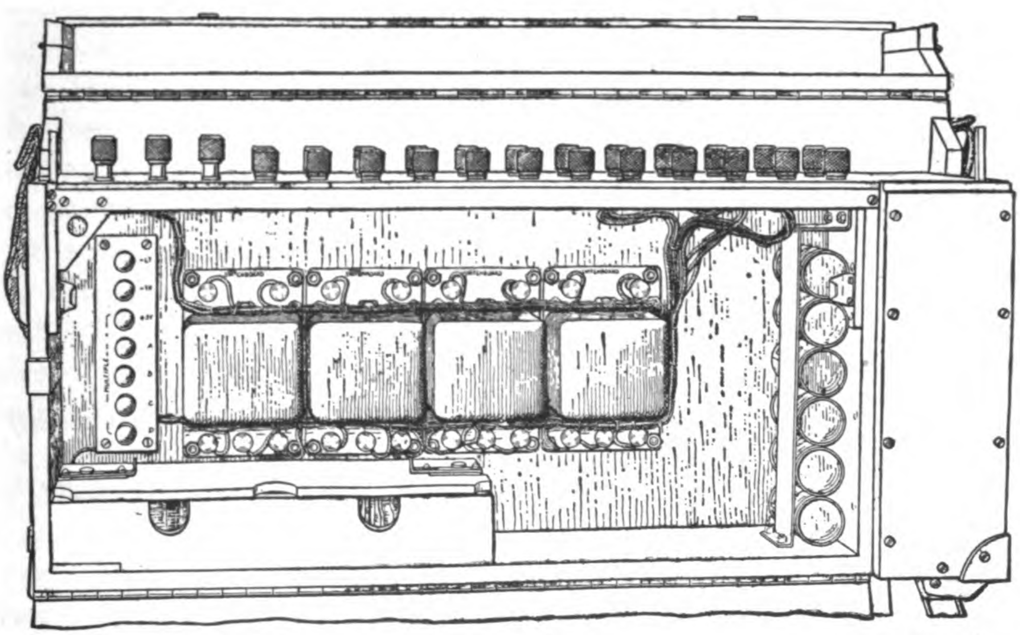
Q. What extra parts should be kept available at all times? *A*. Several extra fuses, extra cords with plugs, extra complete units, and some light, twisted repair wire. In addition, a lineman's repair kit should be available.

Q. What kind of telephone is used as an operator's set? *A*. Any local battery telephone is suitable for use as an operator's set.

Q. How does the EE-2B switchboard unit differ from the EE-2 switchboard unit? *A*. In the EE-2B switchboard unit, the fuses are omitted and a "Talk-Ring" switch substituted. With the "Talk-



① Front view, open.



② Rear view, open.

FIGURE 126.—Switchboard BD-72, showing front and rear views.

Ring" switch, it is possible for the switchboard operator to talk to or ring any telephone connected to the switchboard.

Q. How many dry cells are required for operation of the BD-71 and BD-72 switchboards? *A.* Six type BA-30 cells are required, two in the operator's telephone circuit and four in the night alarm

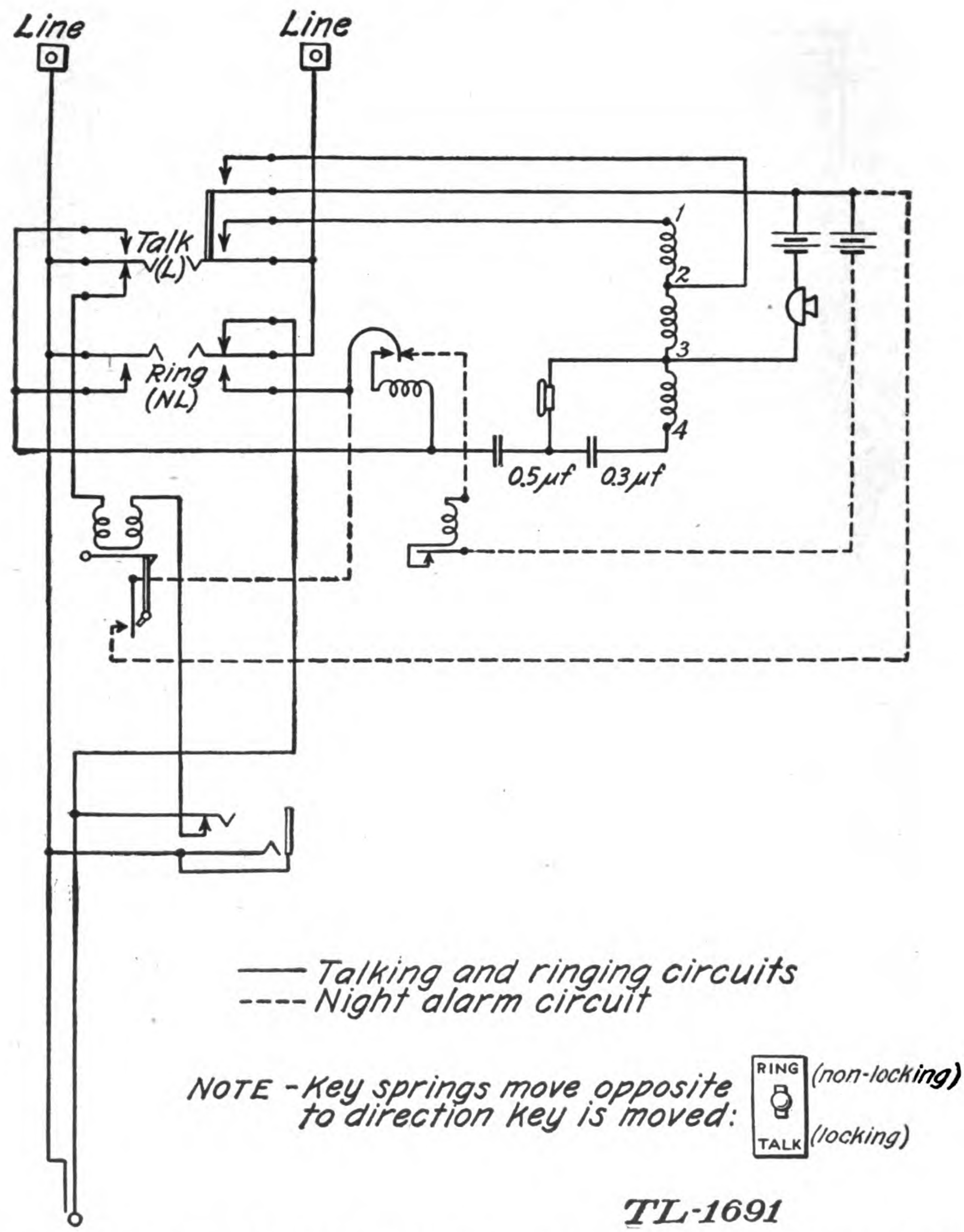


FIGURE 127.—Schematic diagram, EE-2B switchboard unit, with operator's set and night alarm circuits added.

and auxiliary lighting circuit. In an emergency, two cells may be omitted in the night alarm and lighting circuit.

Q. What are the principal circuits of the BD-71 and BD-72 switchboards? *A.*

(1) Switchboard unit circuits (6 in the BD-71 and 12 in the BD-72).

(2) Operator's telephone circuit.

(3) Night alarm and lighting circuit.

Q. What additional equipment is furnished with these switchboards? *A*. Two repeating coils in the BD–71 switchboard and four in the BD–72 switchboard, plus a terminal strip for incoming telephone lines and a terminal strip for paralleling two switchboards.

Q. Should the operator bridge his telephone across two lines which are in use in order to assist in the transmission of information? *A*. No. The additional loss caused by the operator's telephone may make conversation impossible between the two parties connected through the switchboard. The operator should only keep his telephone connected long enough to supervise the connection.

Q. If two separate conversations are taking place through a BD–71 or BD–72 switchboard, what will happen if the operator depresses the "Talk-Ring" switches on two of the switchboard units, one of which is being used on one conversation and the other of which is being used in the second conversation? *A*. All four telephones will be connected to the switchboard operator's telephone and to each other, causing cross talk.

Q. Where may detailed information be obtained covering the BD–71 and BD–72 switchboards? *A*. Detailed information may be obtained in TM 11–330.

Q. Describe the operation of replacing a switchboard unit. *A*. The two line connections on the line terminals at the top of the unit are first disconnected. The two filister-head screws are then removed, one at the top of the switchboard panel and the other at the bottom of the panel. The unit is removed carefully, and when it is clear of the frame the two connections to the bus bars are unscrewed and the unit withdrawn. To replace, reverse the above operations, being careful to make the bus connections exactly the same as on the other units. In both the above operations, care must be taken to protect the shutter drop. It should be locked in the closed position by means of the small locking lever.

Q. What is the use of the repeating coils? *A*. The repeating coils may be used in simplex circuits for telegraphy, or in phantom circuits for telephony. One repeating coil is required on each switchboard for each telegraph circuit with ground return, and two repeating coils are required on each board for a telephone phantom circuit.

Q. With the repeating coils used in a phantom circuit, is it possible to signal the switchboard from one of the telephones connected to the phantom portion of the circuit? *A*. No, because there will be no complete circuit through one of the switchboard shutter magnets.

Q. In case the operator's telephone becomes inoperative, what may be done to permit the use of the switchboard? *A*. An ordinary local battery field telephone may be used by connecting the spare switchboard cord to the line terminals of the telephone and either using the handset of the field telephone or the headset of the switchboard telephone. In this system the switchboard is used in a manner similar to the BD-9 switchboard, and the "Talk-Ring" switches are not used. If a spare switchboard cord is not available, the field telephone may be connected to the line terminals of one of the switchboard units, and the cord of the unit so connected used as the operator's cord.

Q. What will happen if a lightning stroke hits a line connected to the BD-71 or BD-72 switchboard? *A*. Most of the energy of the lightning stroke will pass to ground over the lightning arrester gap from each line terminal to the ground strip in the switchboard.

126. Circuits.—*Q*. What is meant by ground return? *A*. When a single wire line is used, the other terminal of the telephone is connected to a rod or other metallic substance set or buried in the ground or in a tree, thereby using the earth as a conductor for the return circuit.

Q. Why are ground returns seldom used? *A*. Because of interference due to earth currents, cross talk, and the possibility of the enemy "listening in" on such a system.

Q. Describe briefly a phantom circuit. *A*. A phantom circuit utilizes the two line wires connected to the line side of a repeating coil as one conductor of the phantom circuit, and the two lines similarly connected to another repeating coil as the other conductor. The connections from the phantom circuit are made to the center of the line side of the repeating coils. By use of this connection, no currents will be induced in the primaries of the repeating coils, and conversation may be carried on over the phantom circuit without disturbing or interfering with conversations over the normal, or side, circuits.

Q. Describe briefly a simplex circuit. *A*. A simplex circuit utilizes the two line wires connected to the line side of a repeating coil as one conductor of the simplex circuit. The return line is usually through the ground. The connection to the repeating coils is made to the center of the line side of the repeating coil winding. By use of this connection, no currents will be induced in the primaries of the repeating coils due to telegraph impulses in the secondaries, so that there will be no interference with conversation in the normal, or side circuit, due to telegraph impulses in the simplex circuit.

Section II

VISUAL SIGNALING—PANELS

127. Visual signaling—panels.—*Q*. What important visual signals are used in the military service? *A*. Flags, panel signals, pyrotechnics, and signal lamps.

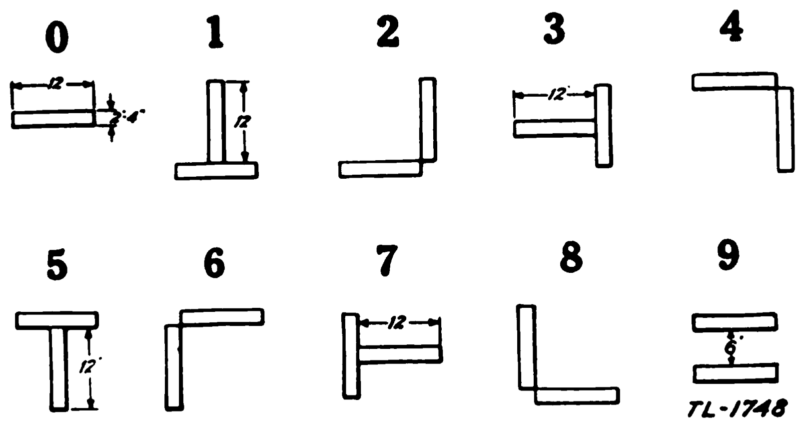


Figure 128.—Panel numerals.

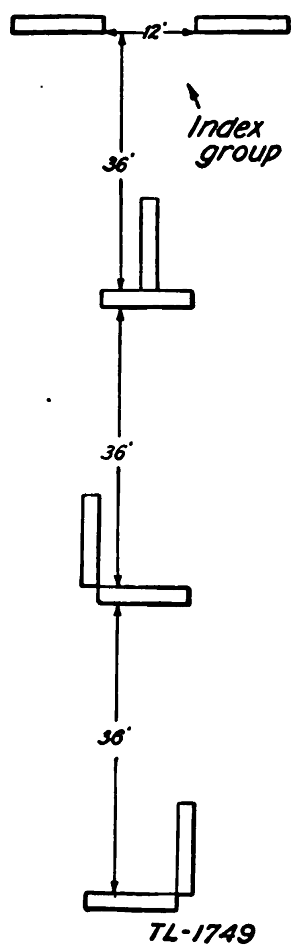
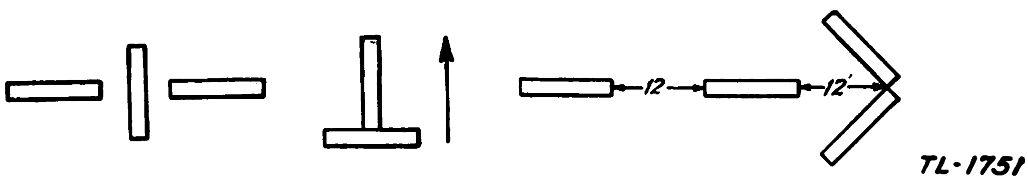


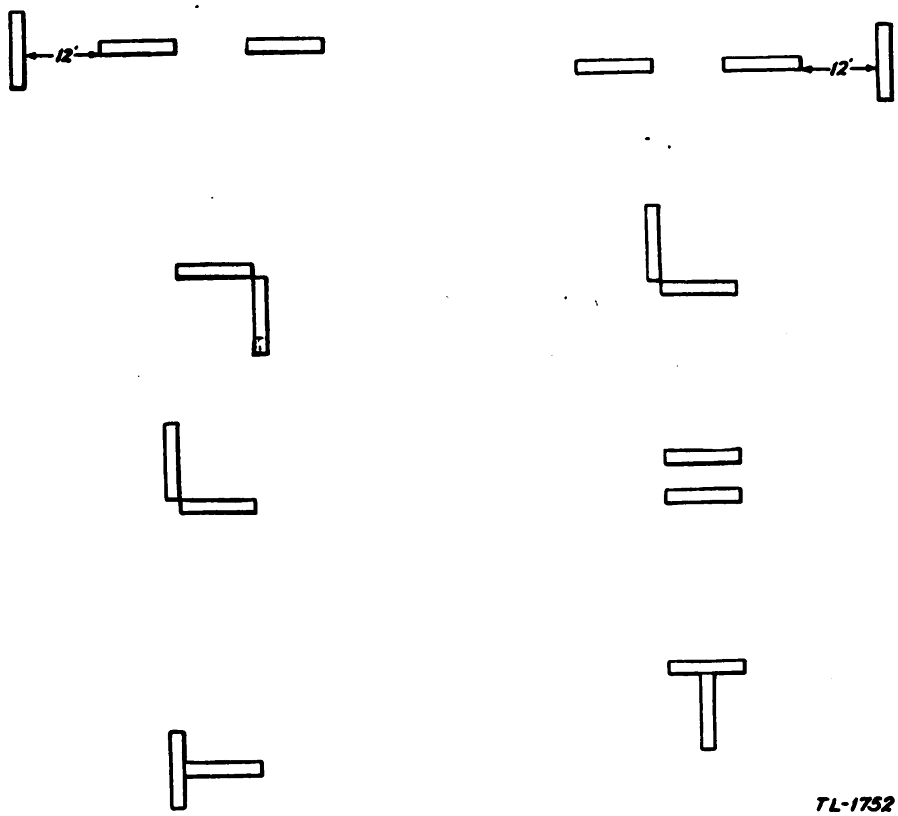
Figure 129.—Example of a code group, 182.

Q. For what are flags used? *A*. For emergency communication between nearby troops.

Q. For what are pyrotechnics and signal lamps commonly used? *A*. For transmission of messages to aircraft and ground troops, especially at night. Signal lamps are also used to challenge aircraft at night.



① Hostile plane near you. ② Wind direction. ③ In this direction.



④ Numerals are being displayed, 487. ⑤ Coordinates are being displayed, 895.

FIGURE 130.—Special panel signals.

Q. For what are panel signals used? *A*. For transmission of messages to friendly aircraft.

Q. How are panels classified? *A*.

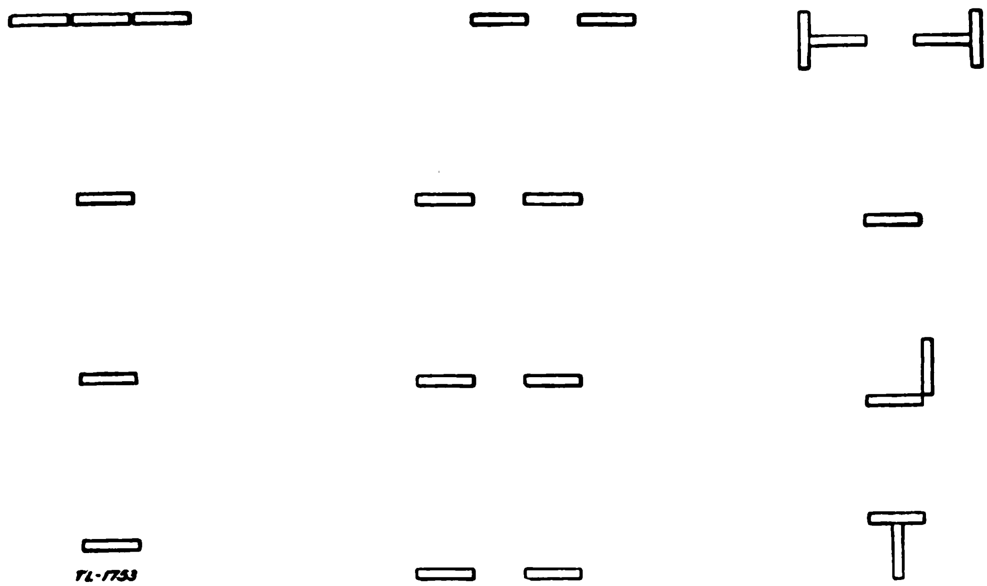
(1) Code panels.

(2) Marking panels.

Q. For what purpose are identification groups used? *A*. To designate or identify military units, and the message dropping grounds and panel display stations of such units.

Q. When are identification groups displayed? *A*. When the ground troops wish to communicate with an approaching friendly plane. When not definitely needed, they are taken in.

Q. What are code panels and what size are they? *A*. Code panels are strips of cloth. For ordinary communication they are 12 feet by 2 feet 4 inches. For high-flying aircraft they are 30 by 6 feet.



⑥ More to follow. ⑦ Error, cancel last display of panels. ⑧ Reconnoiter 25 miles in the direction to be indicated by next display.

FIGURE 130.—Special panel signals—Continued.

Q. What panel codes are used? *A*.

(1) Air-ground liaison code, which is subject to frequent change for purposes of safety.

(2) Fire control code, which is standard. Operators of a panel section must memorize panel numerals in figure 128 for use in codes.

SECTION III

INSTALLATION OF FIELD TELEPHONE SYSTEM

128. General.—*Q*. How are military wire circuits classed according to their use? *A*. As trunk lines or as local lines.

Q. What is a trunk line? *A*. A line which connects two telephone switchboards or centrals.

Q. What is a local line? *A.* A line which connects a switchboard to an individual telephone, or one between two individual telephones.

Q. How are wire circuits classed according to construction? *A.* As metallic or grounded.

Q. What is the difference between the two? *A.* In the metallic circuit two wires are used to provide a complete path for the current; in grounded circuits the earth replaces one wire.

Q. Are grounded circuits satisfactory? Why? *A.* No, because of earth currents, cross talk, and the ease with which the enemy can pick up messages.

Q. What kinds of wire may be used? *A.* Bare wire, insulated single-conductor, insulated twisted-pair, and cables may be used.

Q. What kind of wire is generally used for mobile seacoast artil-

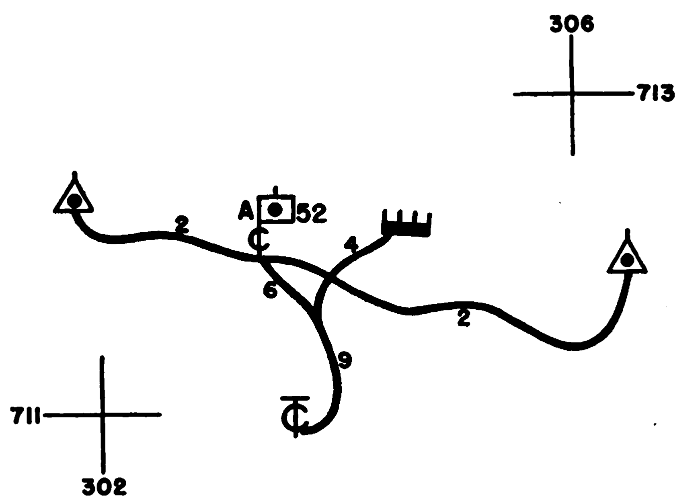


FIGURE 131.—Line-route map.

lery systems? *A.* Twisted-pair, insulated, stranded field wire, Generally W-110 or W-110B wire is used.

129. Installation.—*Q.* What unit installs the field telephone system of a mobile seacoast artillery organization? *A.* The communication platoon, section, or detail.

Q. What noncommissioned officer has charge of the communication unit? *A.* The communication sergeant.

Q. How does the communication sergeant know what lines to lay and where to lay them? *A.* The officer in charge of the unit prepares a line-route map and a circuit diagram which the communication sergeant follows.

Q. What is a line-route map? *A.* A map showing the positions of all switchboards, test stations, and telephones; also the route taken by the line and the number of circuits. This is usually prepared as an overlay on a standard map.

Q. What is a circuit diagram? *A.* An outline sketch showing all the circuits and their connections to each other and to the switchboards. Each circuit is given a number.

Q. In the case of wire lines between higher and lower units, who is responsible for their installation and maintenance? *A.* The higher unit is responsible for wire communications from its command post to the command post of the next lower unit.

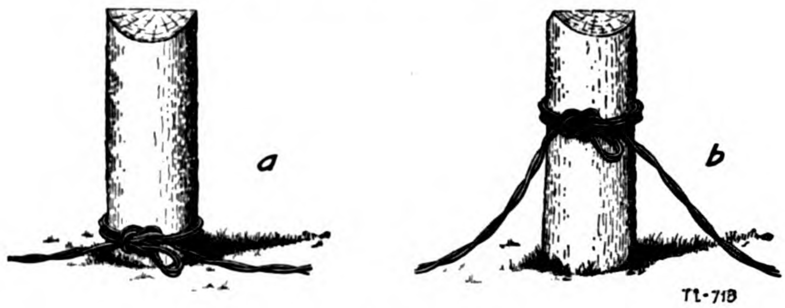


FIGURE 132.—Method of tying wire at ground level; (*a*) correct, (*b*) incorrect.

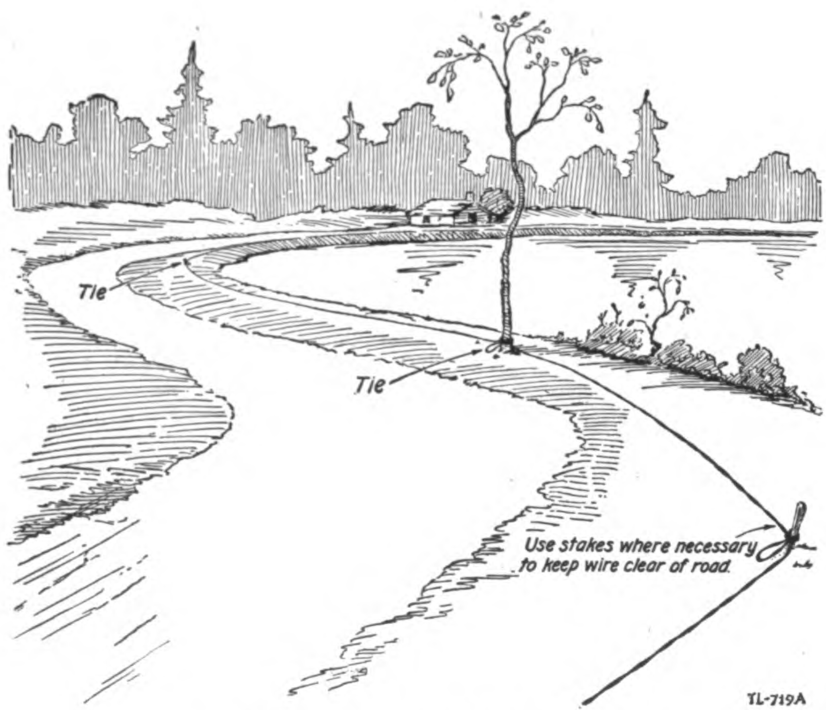


FIGURE 133.—Method of tying wire along curve in road.

Q. What test should be made when laying the line? *A.* Before the reels are taken out for laying wire, the wire should be tested for short and open circuits. For this purpose the wire on each reel should be continuous and have the ends exposed. Then as the lines are paid out they should be tested back to the starting point every quarter mile and at every splice made.

Q. Should there be any slack when wire is laid? Why? *A*. Wire should be laid slack so break can be repaired and small pieces cut out if necessary.

Q. In laying surface lines, what is done to prevent passing troops or vehicles from pulling the wire into traffic lines? *A*. They are laid loosely with plenty of slack and at suitable intervals are tied into objects such as trees or posts.

Q. Indicate the correct method of tying lines to a tree or post. *A*. They are tied at ground level as indicated in figure 132.

Q. On which side of a curved road should surface lines be laid? *A*. Along the inside edge.

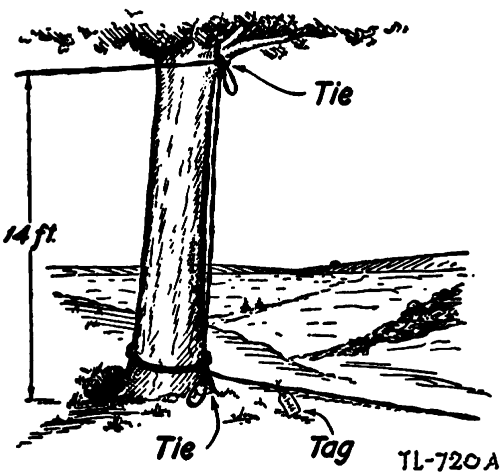


FIGURE 134.—Method of tying wire at junction of surface line with overhead construction.

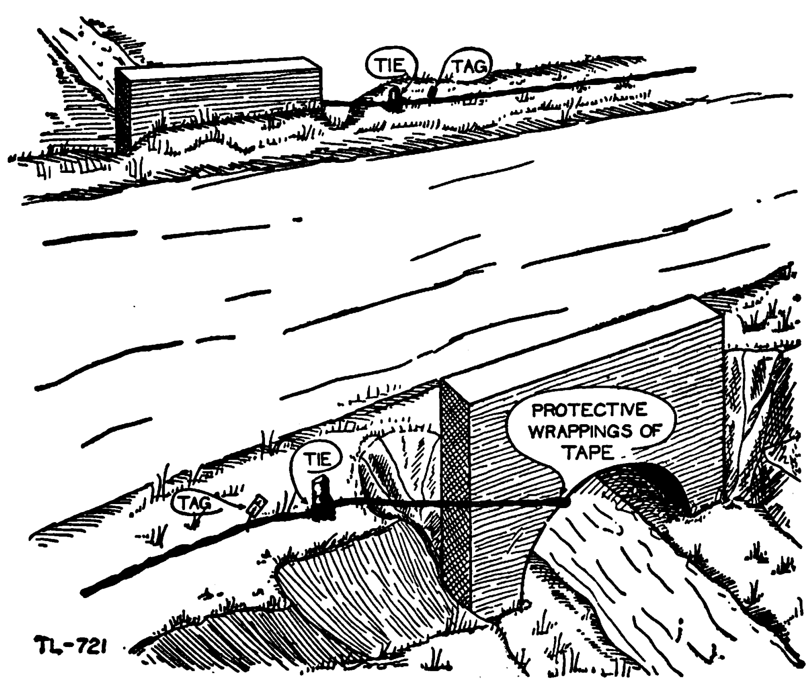


FIGURE 135.—Wire crossing road through culvert.

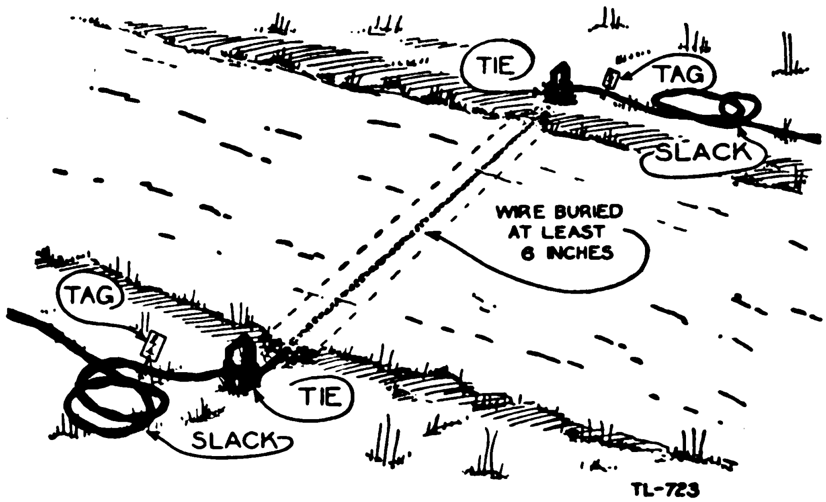


FIGURE 136.—Wire crossing under road in trench.

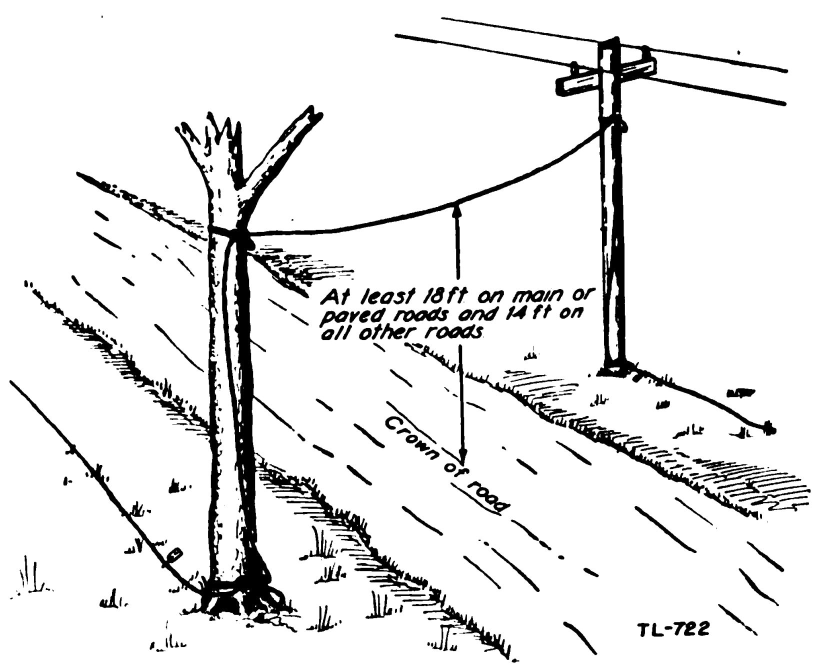


FIGURE 137.—Wire crossing road overhead.

Q. How are the lines kept out of traffic lines on the curve? *A*. By tying to trees or posts as shown in figure 133.

Q. How should surface lines be connected with overhead construction? *A*. The surface line should be securely tied and tagged at the base of the pole at which the connection is made, and tied again just above the cross arm or terminal where the connection is to be made. (See fig. 134.)

Q. How should lines cross a road? *A*. Through a culvert, in a trench, or high enough to be clear of all traffic. (See figs. 135, 136, and 137.)

Q. How are lines laid across water? *A.* A single section of weatherproof wire in good condition is used and is weighted sufficiently to hold it against the movement of the current.

Q. What provision is made to maintain communication should a line be broken by shell fire or other causes? *A.* Duplicate lines are run, whenever possible, by different routes, to distant and important OP's or CP's which are connected to the switchboard and thus readily substituted for defective lines.

Q. What is short-stake construction? *A.* Short stakes about 4½ feet in length are driven into the ground at intervals of about 15 to

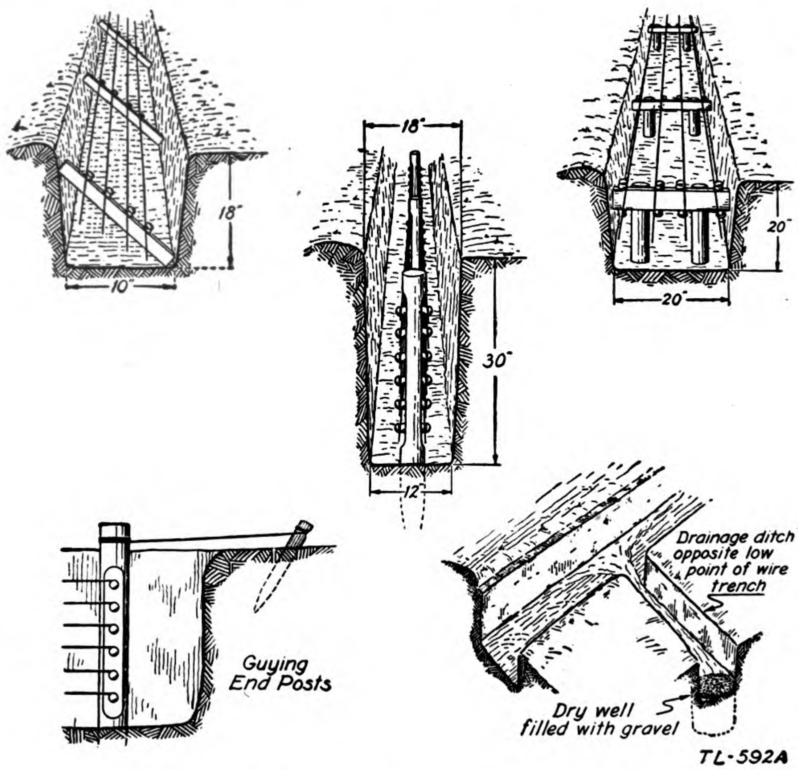


FIGURE 138.—Wire trench construction.

20 feet. Small insulated knobs, usually of wood or porcelain, are fastened to the stakes. Wires are attached to these knobs.

Q. What is wire trench construction? *A.* Short stakes are driven into the bottom of a small wire trench at intervals of about 8 to 10 feet and wire attached as in the preceding case.

NOTE.—The candidate should be required to demonstrate, practically as far as possible, his ability to set up the telephone net required by his unit.

130. Protection and concealment.—*Q.* What would be a good telephone position? *A.* One free from enemy observation and protected from shell fire. It should not be necessary for the operator to lie down, nor should he be in a position where he is subject to repeated interruption because of the physical movement and conversation of others.

Q. Where should the switchboard be placed? *A*. At some quiet spot, centrally located and well protected from shell fire.

Q. Give some points to be observed in selecting a route for a telephone line. *A*. It should—

(1) Be as short as possible.
(2) Avoid main lines of travel.
(3) Avoid road junctions.
(4) Follow some natural line of concealment.
(5) Be camouflaged, if in view of the enemy.
(6) Avoid areas within range of hostile light artillery, where possible.

Q. What natural features can be utilized in laying a line? *A*. Reverse slopes of hills, trenches, ditches, and woods.

Q. How are telephones and operators protected? *A*. OP's are normally carefully concealed by camouflage and, if time permits, provided with some cover.

SECTION IV

LOCATION OF FAULTS AND TESTS FOR GROUNDS AND SHORT CIRCUITS

131. Location of faults and tests for grounds and short circuits.—*Q*. How does one test a telephone to determine if it is in serviceable condition? *A*.

(1) *Ringing circuit*.—Crank the magneto and note the amount of effort required. Short-circuit the line terminals with a wire and again crank the magneto. If the ringing circuit is in order, the effort required in the latter case will be much greater.

(2) *Transmitting and receiving circuits, and strength of battery*.—Place the receiver to the ear and short-circuit the terminals with a short piece of wire or other metal. Press the button several times; if there is a strong click in the receiver each time the button is released, the circuit and the battery are in good order. A weak click indicates a poor battery. Another test is to short-circuit the line terminals and blow in the transmitter. The blowing sound should be plainly heard in the receiver if the battery and circuits are in good order.

Q. What test may be made for a broken cord? *A*. One method is to short-circuit the line terminals and work the cord up and down, while holding the transmitter button closed. A clicking sound indicates a broken cord. In case the cord has been broken by pulling on it, or if both wires in the cord are broken, the above test may not work, in which case it would be necessary to remove the cord and connect each wire separately between L-1 and L-2 on the test set. If the voltmeter shows a deflection when key No. 3 is moved to the lower position, the cord is good. While this test is being made, it is advisable to move the cord to be sure the wire is not making a momentary contact.

Q. What may be the trouble if it is impossible to ring a distant station? *A*.

(1) Broken wire or a loose connection in the ringing circuit of the telephone or distant telephone.

(2) Unserviceable magneto in user's telephone.

(3) Unserviceable buzzer in the distant telephone.

(4) Open, shorted, or grounded wires in the line between telephones.

Q. What may be the trouble if it is possible to receive but not to transmit? *A*.

(1) Transmitter may be unserviceable.

(2) Receiver in distant telephone may be unserviceable.

(3) Transmitter cord in telephone may be unserviceable.

(4) Distant receiver cord may be broken.

(5) Thumb switch button on handset may be out of order and not making proper contact.

(6) Battery may be deteriorated.

Q. What may be the trouble if it is possible to transmit but not to receive? *A*.

(1) Receiver may be unserviceable.

(2) Transmitter in distant telephone may be unserviceable.

(3) Receiver cord may be broken.

Q. What is the purpose of the universal test set? *A*. To test field wire circuits and locate troubles.

Q. Explain the tests indicated by figure 139. *A*. Test No. 1 shows how an open line is located. At positions A and B the tester can talk to telephone No. 1. At position C the tester cannot talk to telephone No. 1, but can talk to telephone No. 2, therefore the open line must lie between positions B and C. Test No. 2 shows how the approximate location of a short circuit may be obtained. As the tester moves from position A toward the short circuit, conversation with telephone No. 1 becomes more and more difficult. Depending on the type of line and the character of the short circuit, this test may or may not be possible of satisfactory accomplishment.

Q. What tests can be made with this set? *A*.

(1) Ringing substation or party.
(2) Talking to substation or party.
(3) Test for short circuits.
(4) Test for grounds.
(5) Test for crosses on lines carrying current.
(6) Test for crosses on other lines.
(7) Measuring voltage of auxiliary batteries.

Q. What batteries are required for this set? *A*. One type BA-1 for energizing the transmitter, and two type BA-2 in series for the voltmeter.

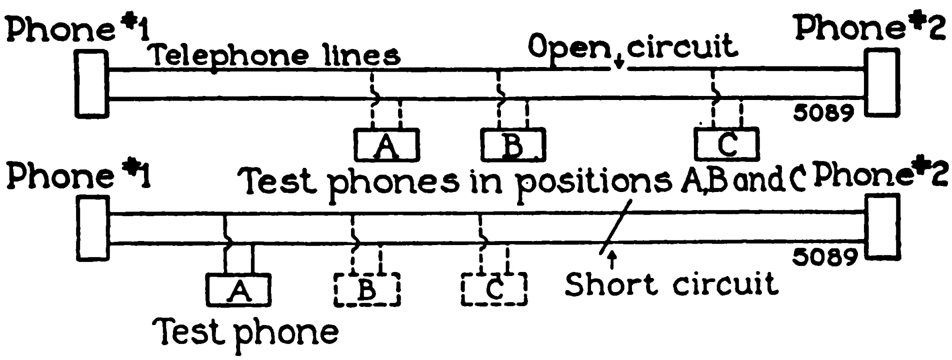


FIGURE 139.—Above: Test for open circuit. Below: Test for short circuit.

Q. How should the keys be set to ring? *A*. Key No. 1 set to "ring," all others neutral.

Q. How should the keys be set to test for shorts? *A*. Key No. 3 should be thrown to the lower position "VMB," and the reading on the voltmeter noted. If a reading appears, it shows a short. The full battery voltage indicates a dead short.

Q. How should the keys be set for talking or listening? *A*. Key No. 1 set to "Listen."

Q. How should the keys be set for ground tests? *A*. Key No. 3 should be thrown to upper position "VMG"; this tests one side of the line for grounds. Leaving No. 3 in that position, throw key No. 2 to "LR" position, which reverses the line and tests the other side for grounds. Any reading on voltmeter shows a ground. Full battery voltage shows a direct ground.

Section V

INSTALLATION AND OPERATION OF MESSAGE CENTERS; ENCODING AND DECODING

132. Message centers.—*Q*. What is the purpose of a message center? *A*. To receive, transmit, or deliver all messages except the following:

(1) Messages transmitted directly from the originator to addressee by telephone or messenger.

(2) Messages handled by postal service.

(3) Messages passing directly from the originator to a signal communication agency (such as a radio station) for immediate transmission, in cases authorized by the commander.

Q. Where is the message center located? *A*. At or near the command post of the unit it serves.

Q. What signal agencies are available to a message center? *A*. All established agencies; radio, telephone, messenger, and visual signal agencies are usually established.

Q. With respect to priority, how are messages classified? *A*.

(1) Urgent messages (O).

(2) Priority messages (P).

(3) Routine messages (no symbol).

Q. What is an urgent message? *A*. One where delay may result in unnecessary casualties or serious tactical disadvantages. This type of message is sent immediately upon receipt.

Q. What is a priority message? *A*. One of such importance or urgency that it is given precedence over routine messages.

Q. What is a routine message? *A*. One which requires no priority. Such messages are generally sent in the order in which filed.

Q. Who designates the means to be used for transmitting any message? *A*. The message center chief selects the most suitable means available for the transmission of any message.

Q. May the originator make this designation? *A*. The originator does not ordinarily designate the means used; but if he desires it to go by messenger, he may so mark it and it will be delivered that way.

Q. What records are kept at a message center? *A*. A register showing times of receipt, dispatch, and delivery of every message. This record also shows the routing, to whom sent, and the means of transmission.

Q. If a messenger service is established, who operates it and how is it coordinated with those of other units? *A*. The messenger service is operated by the message center. Subordinate units time their service to agree with that of higher units.

133. Encoding and decoding.—*Q*. What is a code? *A*. A method of secret writing in which groups of symbols are substituted for sentences, phrases, words, letters, or numbers. To use a code, a complete list of groups of symbols and their meanings must first be prepared.

Q. What is a cipher? *A*. A method of secret writing in which the letters in a message are transposed, or other letters or numbers are substituted for the letters in a message, according to a prearranged key. A mechanical device is often used for enciphering and deciphering messages.

Q. When are messages put in cipher or code? *A*. All messages transmitted by radio or other means which might be intercepted by the enemy are put in code or cipher, except when, in the opinion of the commander, the information contained therein is of no value to the enemy or when its urgency outweighs its value to the enemy. Such messages are marked "Send in clear" over the commander's signature.

Q. Give some rules to be observed in the use of codes and ciphers. *A*.

(1) Never encode a message unless it is necessary.

(2) Never encode a message that has already been sent in the clear.

(3) Make coded message short.

(4) Never use coded and uncoded words in the same message.

Q. Describe the cipher device, type M-94. *A*. This device consists of a shaft upon which are placed 26 aluminum disks, each of which has a series of slots and projections for engaging the adjacent disks. Twenty-five of the disks show upon their rims the alphabet differently arranged, while the twenty-sixth carries a guide rule which may be revolved about the assembled cylinder and brought under any one of the 26 horizontal lines of letters. The disks are assembled on the shaft and held in place by a thumb nut.

Q. Is it necessary to place the disks on the shafts in any particular order? *A*. Yes. This is the way in which the key is employed.

Q. How is this order determined? *A*. Assume that the key phrase "United States of America" has been designated.

(1) Write the numbers from 1 to 25, inclusive, on a horizontal line.

(2) Under these numbers, write the letters of the key word or phrase, repeating if necessary, until a letter is beneath each number.

(1)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
(2)	U	N	I	T	E	D	S	T	A	T	E	S	O	F	A	M	E	R	I	C	A	U	N	I	T
(3)	24	14	10	20	6	5	18	21	1	22	7	19	16	9	2	13	8	17	11	4	3	25	15	12	23

(3) Place numbers under the letters, from left to right, in accordance with their relative position in the alphabet. Thus, under the first A, place 1; under the second A, 2; and under the third A, 3. Since B does not appear in the key phrase, C is the next letter considered, the number 4 being placed beneath it. Continue in a like manner until a number is written beneath each of the 25 letters of the key phrase. The last number should be 25; if not, an error has been made.

(4) The numbers in the bottom line determine the order in which the disks are assembled on the shaft. Thus, with the key phrase used in this example, disk No. 24 is placed on the shaft first, then No. 14, and so on, in order, with the last disk being No. 23.

Q. How is a message enciphered? *A*. After placing the disks on the shaft in the correct order as determined by the key word or phrase, revolve the disks one by one until the first 25 letters of the message are arranged in order from left to right on a horizontal line just above the guide rule. Disengage the guide rule disk so that it may revolve and set it under any one of the other 25 horizontal lines of letters. Write, in groups of 5 letters each, the letters appearing immediately above the rule. This will be the cipher equivalent of the first 25 letters of the message. The remainder of the message is enciphered in the same manner.

Q. Where is the cipher device used? *A*. At the message center.

Q. How is a message deciphered? *A*. Knowing the key word or phrase and having arranged the disks in their proper order, set up the first 25 letters of the cipher message in order from left to right on a horizontal line just above the guide rule. Revolve the guide rule slowly, looking for a line with an intelligible text of the first 25 letters of the message. The remainder of the message is deciphered in the same manner.

Section VI

INSTRUCTION OF LINEMEN AND TELEPHONE AND SWITCHBOARD OPERATORS

134. Instruction of linemen and telephone and switchboard operators.—The candidate should be required to demonstrate practically his ability to instruct telephone linemen, telephone operators, and switchboard operators. Duties of linemen and of telephone and switchboard operators are described in TM 4-315 and in TM 4-330.

Section VII

TIME-INTERVAL SYSTEM, MOBILE SEACOAST ARTILLERY

135. General.—*Q*. What features do all portable time-interval systems have in common? *A*. Some method of furnishing an impulse of electric current at regular intervals and of using this impulse to operate a hummer and a howler. The tone from the hummer is superimposed on the telephone lines to give a buzz in the observers' headsets. The howler is placed at the gun position as a firing signal.

Q. How is the current impulse at regular intervals furnished? *A*. Some systems use a manually operated key, the operator having a stop watch to determine the intervals at which to press the key. Other systems use a time-interval clock or an electric motor to operate a contact-breaking disk.

Q. What is a howler? *A*. A vibrator operating on a diaphragm and resonator. The electric impulses from the time-interval device actuate a relay which closes a local battery circuit and operates the vibrator. The howler is placed at the gun position.

136. Time-interval apparatus, EE-85.—*Q*. Name the three principal parts of the standard time-interval apparatus for mobile seacoast artillery. *A*. The time-interval apparatus EE-85, with the line connector unit EE-87, and the firing signal EE-65.

Q. What are the different time intervals that may be provided with the time-interval apparatus EE-85? *A*. They are 1, 5, 10, 15, 20, 30, and 45 seconds. Each of these intervals, except the 1- and

5-second intervals, is preceded by two 1-second intervals. Also, a preliminary warning interval is provided for the 20-, 30-, and 45-second series, occurring 3 seconds ahead of the series of intervals.

Q. On the 20-second interval, at what times are the contacts closed? *A.* At 15, 18, 19, 20; 35, 38, 39, 40; etc., seconds.

Q. How many telephone lines may be served by the line connector EE-87? *A.* From one to six.

Q. How is the time-interval apparatus and its associated equipment installed? *A.*

(1) Be sure that the storage battery is fully charged.

(2) Connect the time-interval apparatus to the storage battery.

(3) Connect one marked binding post of the time interval desired and one "common" binding post to the "relay" binding posts of the line connector unit.

(4) Similarly connect the firing signals at each gun position directly to the desired time-interval and "common" binding posts of the time-interval apparatus. The firing signals at each gun may be connected to the same or different time intervals as desired. Several firing signals on the same time interval may be bridged together or individual lines may be run to the time-interval apparatus, whichever is shorter.

(5) Connect the line connector unit to the storage battery.

(6) Bridge the telephone lines to the pairs of binding posts marked L-1 to L-6, inclusive, on the line connector unit.

Q. How is the time-interval apparatus put in operation? *A.* By pushing the switch to the "on" position.

Q. How is the line connector unit put in operation? *A.* By pushing the operating key to the position for INT. 1 or INT. 2.

Q. How is the volume controlled? *A.* By pushing the tone key to one of the positions "LOUD," "MED.," or "LOW" to give the desired volume.

Q. How is the relay of a firing signal adjusted for best operation? *A.* With the time-interval apparatus in operation (5-second interval suggested), adjust the "spring" and "gap" levers as follows:

(1) With the "spring" lever at position 5, move the "gap" lever out until signals stop and then return it about half way on the graduated "gap" scale.

(2) Make minor adjustments with the "spring" lever to obtain the best signals.

(3) By means of the vibrator adjusting screw, adjust the vibrator contacts for best tone and operation, and keep the locknuts tight. (The loudness of the tone cannot be materially changed by this adjustment.)

Q. How are the time-interval contacts adjusted? *A*. By removing the large panel from the time-interval case and making the adjustment by means of the setscrews which control the spring adjustment. *Extreme care should be used.*

Q. What should be used to clean the contacts? *A*. Only rough paper (*not sandpaper*) or a burnishing tool.

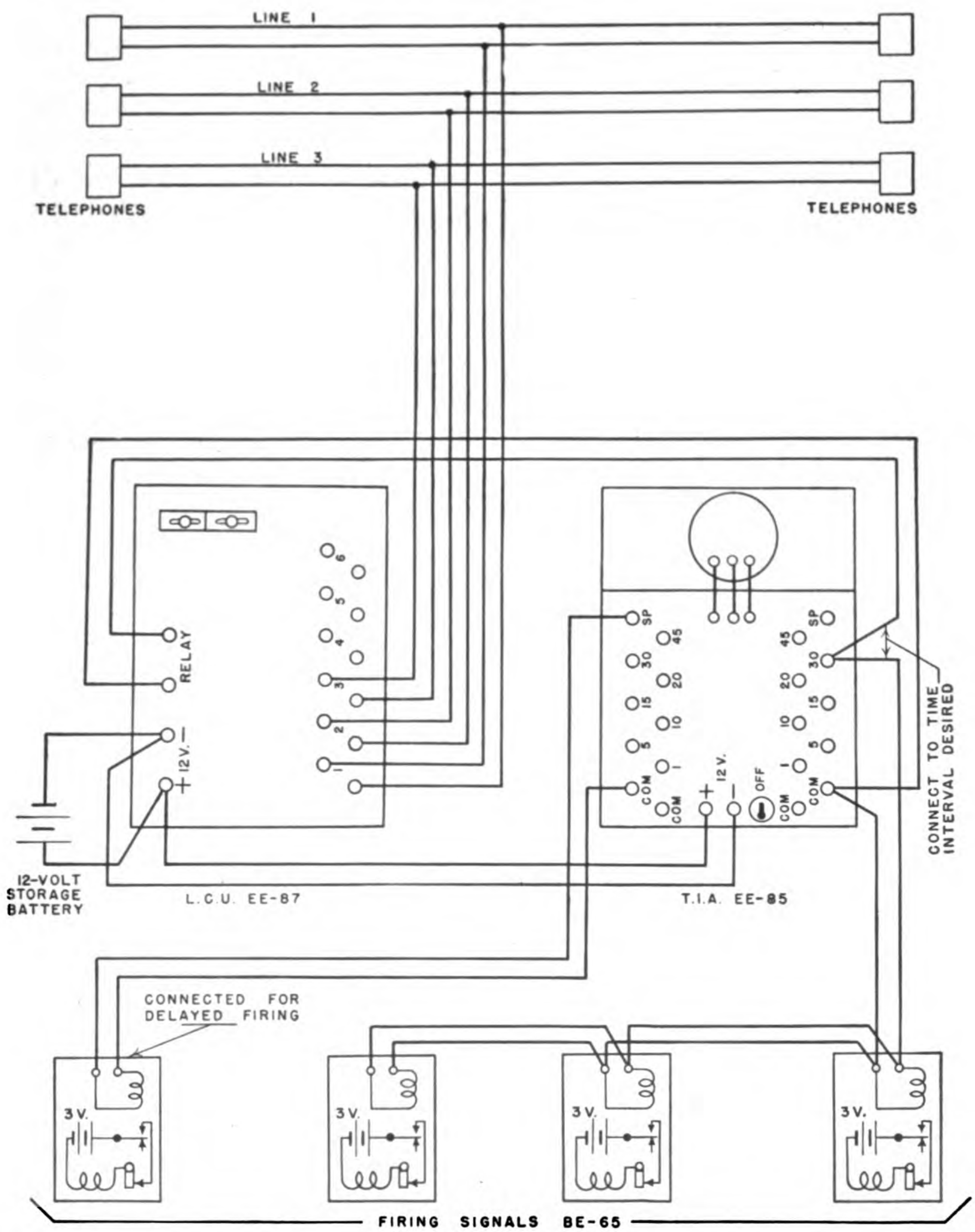


FIGURE 140.—Example of installation, time-interval apparatus EE-85 with line connector unit and firing signals.

Q. In case the clock mechanism needs repairs, what action should be taken? *A*. The clock mechanism should *not* be opened but should be removed and sent to the manufacturer for repairs.

Q. What maintenance of the line connector unit is required? *A*. The keys and relay should be cleaned and adjusted when required.

Q. How are the contact springs of the line connector unit adjusted? *A*. By bending the top springs up or down with a pair of long-nose pliers.

Q. What maintenance of the firing signals is required? *A*.

(1) The firing signal relays should be kept clean and in adjustment.

(2) To prevent corrosion, batteries should be removed from the lower compartment when not in use.

Q. What precaution should be taken when handling the firing signals with the batteries in place? *A*. The spring tension should be increased to the maximum to prevent the contact closing due to vibration in handling.

NOTE.—For an organization equipped with time-interval apparatus other than that described, questions of a similar scope, pertaining to the equipment on hand, should be substituted.

CHAPTER 18

RAILWAY CONSTRUCTION, EQUIPMENT, AND MOVEMENT

137. Track construction.—*Q*. What is the standard length of rail, and how many ties are required per rail length? *A*. 39 feet. Eighteen ties per rail length are standard but it is possible to oper- with only 10 ties per rail length.

Q. How is the size of rail designated? *A*. By the weight in pounds per yard.

Q. How are rails held together? *A*. By splice bars, one on each side of the rail. The rail is drilled at the end so that bolts may be passed through and the splice bars are bolted together.

Q. What is the gage of the track? *A*. The distance from inside of the rail to inside of the rail. Standard gage is 4 feet 8½ inches, measured on a plane ⅝ inch below top of rail.

Q. Should the standard gage for track be maintained on curved track? *A*. Curves of 8° and less have standard gage. The gage should be widened ⅛ inch for each 2° or fraction thereof over 8°, to a maximum of 4 feet 9¼ inches when laid. Gage, including widening due to wear, should never exceed 4 feet 9½ inches.

Q. What is the usual size of tie? *A*. 7 by 9 inches by 8 feet 6 inches long.

Q. What is a tie plate? *A*. A metal plate placed between the rail and the tie to give the rail a better bearing and to prevent the rail from cutting into the tie.

Q. What is a turn-out? *A*. A track arrangement consisting of switch and frog with connecting and operating parts, and extending from the point of the switch to the heel of the frog, by means of which engines and cars may pass from one track to another.

Q. What is meant by throw? *A*. Throw is the distance that the switch point not in contact with the rail is from the rail.

Q. How much throw is desired in the switch points? *A*. Four and three-fourths inches.

Q. What is a frog? *A.* A frog is a device used where two running rails intersect, and providing flangeways to permit wheels and wheel flanges on either rail to cross the other.

Q. What type switch is standard on American railroads. *A.* Split switch.

Q. What is the function of the switch points? *A.* To cause the train to turn from the main track by guiding the flanges on the wheels.

Q. What track material peculiar to a turn-out is included in the construction? *A.* Switch points, frogs, and guard rails.

Q. What is the function of the guard rail? *A.* To prevent the flanges of the wheels from riding on the frog point and causing a derailment.

Q. How are turn-outs designated? *A.* By number.

Q. What determines this number? *A.* The number of the frog to be used in the turn-out.

Q. What is the meaning of a frog number? *A.* The opening of the angle for a certain length. A No. 7 frog opens 1 foot for 7 feet of length, a No. 8 frog opens 1 foot for 8 feet of length, and so on.

Q. With what number of turn-out will those in railway artillery usually be concerned? *A.* No. 8.

Q. What is the standard length of switch points for a No. 8 turn-out? *A.* 16 feet 6 inches.

Q. What is the standard length guard rail for a No. 8 turn-out? *A.* 11 feet.

Q. How much clearance is allowed between the guard rail and the lead rail? *A.* 1¾ inches.

Q. What is a switch stand? *A.* The device used to position the switch points.

Q. What is the length of the lead of a No. 8 turn-out? *A.* 68 feet.

Q. What is meant by lead? *A.* The length between the actual point of the switch and the ½-inch point of the frog (actual point of frog as distinguished from theoretical point of frog) measured on the line of the parent track.

Q. What is the safe speed for train operation through a No. 8 turn-out, assuming that same is properly installed? *A.* 20 miles per hour.

Q. Where should a frog be placed, if possible? Why? *A.* A frog should be placed so that the heel of the frog is located at an existing joint in the rail. This permits placing the frog with the minimum amount of rail cutting to match out odd lengths.

Q. Should joints in rails be directly opposite each other or should they be staggered? *A.* They should be staggered as the joints are the weakest points in a line of rail. If there is a joint in the rail on both sides of the track at one point, this point will tend to settle and cause a low point in the track.

Q. Should rails be joined tightly with no gap between the two rails? *A.* No. A space should be left to allow for expansion of the steel due to increase in temperature.

Q. How much space should be left between the ends of rails when installing? *A.* The gap left between rails when installing depends on the temperature when the rail is laid. (See table III.)

TABLE III.—*Temperature expansion for laying rails*

Temperature (°F.)	Allowance (inch)
−20 to 0	5/16.
0 to 25	1/4.
25 to 50	3/16.
50 to 75	1/8.
75 to 100	1/16.
Over 100	Rails should be laid close without bumping.

Q. Name the essential track tools for laying track. *A.* Track wrenches, claw and lining bars, spike mauls, gages, rail bender, rail tongs, and tie tongs.

Q. Name the essential track tools for surfacing track. *A.* Track jacks, level boards, picks, shovels, and lining bars.

Q. How is the location of proposed track designated on the ground? *A.* By means of stakes bearing tacks for line.

Q. What stakes may be expected to be found when the track-laying crew starts work? *A.* Stakes marking the center line of the track, stakes showing the point of frog for turn-outs, and stakes showing the point of switch for turn-outs.

Q. If a turn-out is to be constructed and the only stakes found are for the centerline of the main track and spur track or siding, the point of frog, and point of switch, how does the man in charge of the crew know what length tie to use and what length rails to place? *A.* These data are all contained in a standard lay-out sheet for the turn-out of the number used.

Q. How does the track crew know how high to raise the track when surfacing? *A.* Elevation stakes are placed at the side of the track, clear of traffic and construction, showing the elevation of the top of rail.

Q. A stake is encountered bearing the letters S. T. What does this mean? *A.* The stake marked S. T. indicates the location of the point of change from spiral (curve) to tangent (straight) track.

Q. What does a stake marked T. S. mean? *A.* The point at which the track changes from tangent (straight) to spiral (curve) track.

Q. Describe briefly the operation of surfacing track on a 600-foot spur. *A.*

(1) Place a jack under the joint or center of the rail on the line side of the spur adjacent to the frog. (It is assumed that the turnout has been surfaced.)

(2) Sight along the inside top edge of the rail and cause the rail to be raised at the point where the jack is to this level.

(3) By either shovels or picks, cause ballast to be placed under ties from the end of the tie to about 18 inches inside of the rail and tamped to hold the track at this elevation.

(4) Move jacks ahead to successive positions so that the surface of the rail presents a smooth profile.

(5) Spot jacks in corresponding positions on the gage side at the same time and raise the gage side so as to make the track level, using a level board reaching from the line rail to the gage rail.

(6) Place ballast under every tie, in the center of the track.

(7) When the operation is completed, by use of shovels, dress the track by smoothing the ballast and placing some between each tie to keep the ties from bunching together during operation over the track.

(8) When this is completed, line to center stakes.

Q. Assuming that the materials are on hand, describe the construction of track. (Assume also that whatever clearing and grading was necessary, has been done.) *A.*

(1) Locate the centerline stakes and measure over from this line one-half the length of a tie (4 feet 3 inches). Establish a line for this half-tie length distance from center line, so that ties may be placed with their ends along the line. Mark the ties with a piece of crayon at the point where the outer web of the rail will be with respect to the tie.

(2) Place a rail on the ties in its approximate position. Loosen the splice bars on the rail to which the new rail is to be connected. Move the new rail back against the rail to which it is to be joined, guiding it in the splice bars as it is moved to the rear. (A gap must be left between the rails to allow for expansion. Use a gage for proper distance.) While another rail is being obtained, put a set of splice bars on the bald end of the rail.

(3) Spike the rail as soon as it is in proper position. The end of the tie must be prized up firmly against the rail when spiking.

(4) After the line side rail has been spiked, establish the gage rail location by using the standard gage. Splice the gage rail to the last gage rail in place and after establishing the proper gap, spike it in place.

(5) Tighten all the splice bar bolts and after approximately five rails are in place on each line of rail, line the track with the center stakes by prying against the rail with lining bars. If no stakes are available, alinement by eye may be resorted to.

(6) Place ballast along the track by opening the hoppers on the hopper cars a small amount, and move the hopper car along the track. Place a tie in front of the rear wheels of the car to level the ballast along the track as it slides in front of the wheels.

(7) Remove the ballast train. Jack the line rail up to the desired height and cut the ballast under the ties with shovels or picks. Jack the gage rail up to the desired height and place ballast under the ties on the gage rail side.

(8) Dress ballast along center of track and cut ballast under ties by shovels or picks. Dress up all ballast for the complete track.

(9) Line the track for any irregularities of line or grade that may have been introduced in the ballasting operation. The track is now ready for operation.

Q. Explain briefly the steps in the installation of a turn-out in an existing line. *A*. After the route of the spur track has been determined and the location of the frog selected, proceed as follows:

(1) Pull all spikes from every other cross tie throughout the length to be occupied by switch ties and remove the ballast from around these unspiked cross ties.

(2) Set track jacks under the rail and loosen the track by jacking it up very slightly.

(3) Withdraw the loose ties and substitute switch ties of the proper lengths.

(4) Remove the remainder of the cross ties and substitute switch ties in a similar manner.

(5) Set the frog. This can be done in 15 minutes by a detail of 12 experienced men and consists merely of taking out the rail where the frog is to be located, setting the frog in place, spiking it up to gage and making the connection with the proper length of cut rail, and installing a guard rail opposite the frog.

(6) Assemble the inside lead rail, join it to the frog and the switch point, and spike it up so as to allow 6¼ inches clearance between the heads of the rail at the heel of the switch, leaving the rail to be shifted back and forth between the heel of the switch and the frog.

(7) Line the lead rail by eye and spike it.

(8) Unspike and line out the main line rail on the turn-out side.

(9) Fit the slide plates beneath it and place the switch point against it. When the main line rail (stock rail) is lined to the proper point, the gage will just fit from the opposite main line rail to the gage line of the switch point. Both the switch point and the stock rail should be spiked at this time and a rail bender should be applied so as to produce a slight kink in the stock rail 8¼ inches ahead of the switch point so that the switch point may fit against the stock rail without creating a line kink.

(10) Lay the outside lead rail to connect with the stock rail at the proper gage distance from the inside lead rail.

(11) Install the guard rail opposite the frog on the outside lead rail. It is important that the gage fit exactly from the point of frog to the outside lead rail and that the guard rail provide a flangeway of 1¾ inches.

(12) The main line side switch point may now be installed, the head and back rods applied, switch stand set up on the turn-out side of the main line, and the connecting rod installed. It will always be necessary to adjust the head and back rods in such a manner that each switch point will fit snugly when thrown against the stock rails.

Q. What length of time is required to install a turn-out in an existing track? *A.* An experienced noncommissioned officer and 12 men can install a turn-out in an existing track in 2 working days of 8 hours each, provided material is assembled and ready for installation. Where a new switch is installed, incident to the construction of the main line itself, a turn-out can be completely installed and ballasted in 8 hours.

138. Railway cars—basic.—*Q.* Point out the following parts and explain the purpose of each. *A.*

(1) *Draft gear.*—The whole combination of draft and coupler attachments for transmitting drawbar pull to car sills.

(2) *Grab handle.*—More commonly called grab irons, are required safety appliances and are the separate rungs making up the ladders on the cars used by trainmen in going over the train.

(3) *Journal.*—That part of the axle on which the journal bearing rests. The journal bearing carries the weight of car and contents.

(4) *Auxiliary reservoir.*—A cast iron cylinder of such volume that with an initial air pressure of 70 pounds and standard travel of 8 inches in the brake cylinder, the air pressure in the brake and reservoir cylinders will equalize at 50 pounds.

(5) *Brake shoe.*—That part of the brake mechanism which makes contact with the wheels and by pressure against them tends to retard the motion of the wheels.

(6) *Brake hanger.*—Hooks or straps rigidly attached to some part of the truck on which is hung the brake rigging.

(7) *Coupler.*—The mechanical device used to transmit force from adjacent car to the spring or friction device of the draft gear.

(8) *Train line pipe.*—Air line going straight through the train.

(9) *Journal box.*—Steel housing or box around the journal, containing the journal, the journal bearing, wedge, and greased packing for lubricating purposes.

(10) *Triple valve.*—Valve in each individual car line worked by a variation in train line pressure so as to allow the charging of the auxiliary reservoir, the application of brakes by allowing air in the reservoir to enter the brake cylinder, and the release of brakes by allowing air in the brake cylinder to escape to atmosphere.

(11) *Brake beam.*—Steel beam that carries brake shoes on each end and transmits pressure to shoes for braking action.

(12) *Release valve.*—Small spring valve mounted on top of the auxiliary reservoir by which pressure in the reservoir can be reduced, thus releasing brakes.

(13) *Angle cock.*—Valve at each end of the car used for turning on and off the train line, when coupling and uncoupling the air hoses between adjacent cars.

(14) *Cut-out cock.*—Valve in the individual car line to be used to turn that line off from the train line thus making the brakes inoperative on the particular car.

(15) *Retaining valve.*—The purpose of the retaining valve is to retard the rate of brake release through the brake cylinder exhaust valve while auxiliary reservoirs are being recharged and when the brake cylinder pressure has been reduced to a certain predetermined amount to retain that pressure in the cylinder.

(16) *Brake cylinder.*—The cylinder where, by use of air pressure against a piston, a force is transmitted through the brake rigging to the shoes, which, acting against the wheels of the car, retard its motion.

(17) *Kingbolt or center pins.*—Large steel pins passing through the center of the body bolster and truck bolster, thus holding the car body and trucks in their proper relation to each other.

(18) *Centrifugal dirt collector.*—A device located near the triple valve in the air line for the purpose of preventing pipe scale, sand, cinders, or other foreign particles of any kind from reaching the triple valve.

(19) *Truck bolsters.*—The cross beams or members which transfer the load of the car body and contents to the springs.

(20) *Center plates.*—The plates attached to the bolsters to carry the weight of the body and contents from the body bolster to the truck bolster. The center plates provide a means to transfer stress and permit turning of the trucks at the same time around the center pin or kingbolt.

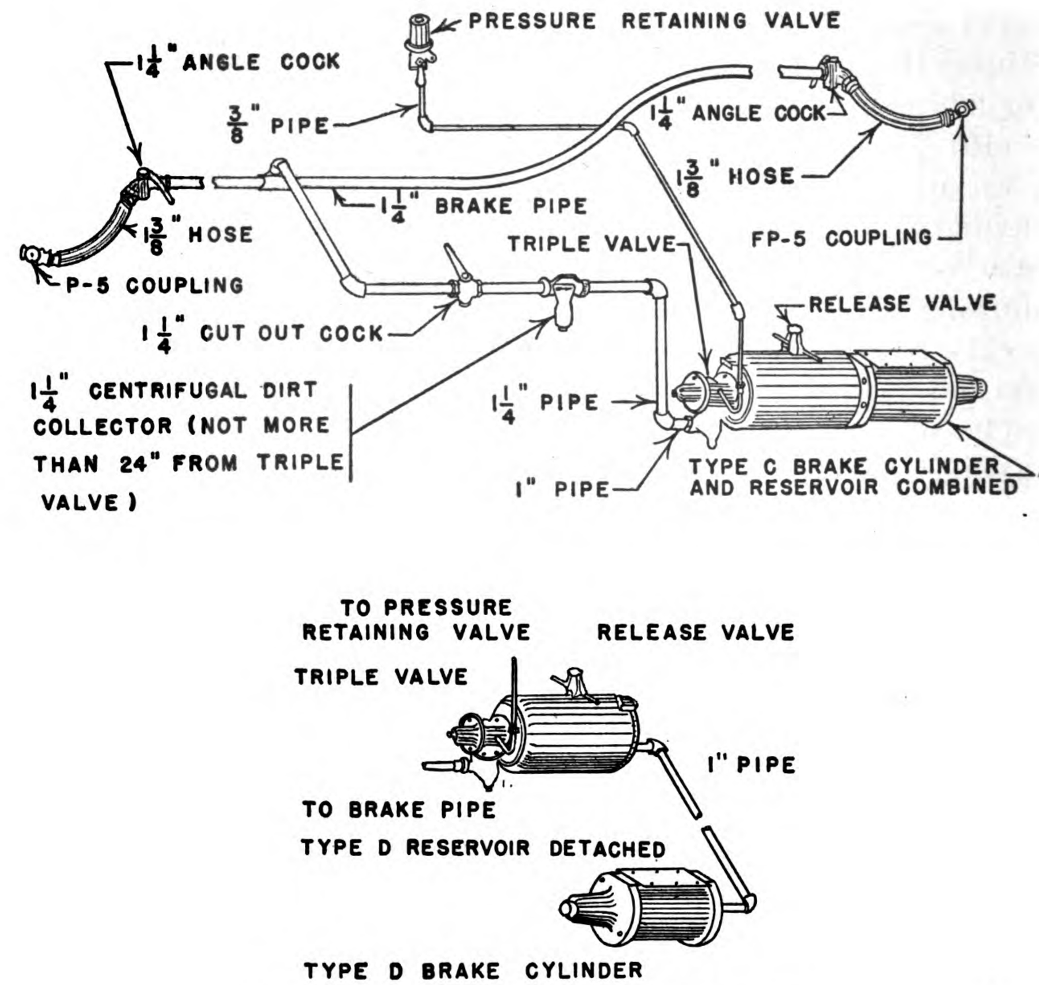


FIGURE 141.—Air brake equipment, railway car.

(21) *Uncoupling lever.*—The lever used to remove the locking pin from the coupler head when uncoupling cars.

Q. What are the two classes of draft gears? *A.* Spring draft gear and friction draft gear.

Q. What type draft gear is used for military railway cars? *A.* Friction draft gears.

Q. Should the hand brake ever be applied at the same time that the air brakes are in action? *A.* No. The action of both brakes at the same time will be equal to the sum of the power of both brakes, resulting in excessive force being applied to the brake gearing.

Q. If the air brake on a car in a train becomes defective, can the car still be operated in the train? How? *A.* If the defect is not in the train line, it can be operated. Cut out the air brake equipment on that car by turning the cut-out cock so that the handle is parallel to the branch pipe, and release the brakes, if they are set, by opening the release valve.

Q. What is the purpose of the retainer valve? *A.* If the retainer valve is turned up, the air cannot escape from the brake cylinder and the brakes on the car will not release with those on the remainder of the train. In order to hold a train when descending long grades, the retainer valves are set on a number of cars to permit pressure to be pumped up again in the train line.

Q. What is the purpose of the release valve? *A.* It permits the release of air from the auxiliary cylinder, releasing the brakes on the particular car.

Q. How is a car uncoupled or "set out" of a train? *A.* Close the angle cock on the adjacent end of the car next in rear of the one being uncoupled and the angle cock on the one being uncoupled. Raise the air hoses and uncouple them. Uncouple the cars by means of the uncoupling lever. Proceed to the other end of the car being uncoupled and repeat the operation, being careful to cut off the angle cock nearest the locomotive first.

Q. Should a triple valve be dismantled by battery personnel? *A.* No. It should be taken apart only by personnel trained to repair and test it.

Q. What precautions must be taken when a car is "set out" of a train? *A.* The hand brakes must be set or the wheels blocked with pieces of board.

Q. How do air brakes function? *A.* When a car is connected to a locomotive or train line, the air is pumped up to operating pressure, which causes the triple valve to let air into the auxiliary reservoir. Reduction of air pressure in the train line causes the triple valve to operate and let part of the compressed air stored in the auxiliary reservoir into the brake cylinder, moving the brake piston and in turn applying the brakes. The greater the air reduction the greater is the braking effect. When the air in the train line is again up to operating pressure, the triple valve operates to allow the auxiliary reservoir to be filled, at the same time opening a port from the brake cylinder to the retainer valve pipe and thence to the atmosphere, thus releasing the brakes.

Q. How many sets of air brake equipment has an ammunition car? A kitchen car? A gun car. *A.* They have, respectively:

(1) One.

(2) One.

(3) Two.

Q. Why are there no retainer valves on most gun cars? *A.* Since there are two sets of brake equipment on a gun car, were one retainer valve set and the other not while the train is in motion, an undue strain would be placed on the kingbolts of the gun car. For this reason the retainer valves are omitted from a gun car.

Q. How often should railway artillery matériel be exercised? *A.* Railway artillery matériel should be exercised once each month and at least once in 3 months to keep the journals oiled on top and prevent them from rusting. The air should be connected and the air brakes operated at the same time to keep the air brakes uniformly lubricated and prevent undue collection of dust in them.

Q. Are the railroad cars in the battery standard or narrow gage? *A.* Standard gage.

Q. Is narrow-gage equipment ever used in railway artillery? *A.* The 8-inch guns and 12-inch mortars were originally designed to be moved in several loads over narrow-gage tracks when necessary. None of this narrow-gage equipment is issued to troops at present.

139. Railway cars—advanced.—This topic will include the subject matter contained in paragraph 138 and in addition the following:

Q. What is the allowable travel for an air brake piston? *A.* Seven to nine inches. A travel beyond these limits necessitates adjustment.

Q. What type air brake equipment is used on railway cars? *A.* Westinghouse air brake with type K–1 triple valve.

Q. Is this similar to commercial freight equipment? *A.* Yes.

Q. Trace the passage of air through an airbrake system from atmospheric pressure to atmospheric pressure. *A.* Air is pumped from the atmosphere at the locomotive into a main reservoir to a pressure 20 pounds greater than the train line pressure (on freight trains to 90 pounds). From the main reservoir it passes through equalizing valves to the engineer's valve. When this valve is placed in "release" position, the air flows through the train line on each car and on any particular car through the branch pipe, cut-out cock, centrifugal dirt collector, and triple valve into the auxiliary reservoir, until a pressure of 70 pounds is established. When the engineer's valve is turned to the position of "service application," a part of the air in the train line flows out to atmosphere, reducing the pressure in the train line. This pressure reduction causes the triple valve to move, opening a port, so that air flows from the auxiliary reservoir into the brake cylinder. When the engineer's valve is moved to "lap" position, all flow of air stops. When it is again moved to "release" or "full release" position, air flows from the main reservoir through the train line and actuates the triple valve, allowing the pressure again to build up in the auxiliary reservoir, at the same time opening a port which allows the air to flow out of the brake cylinder to atmosphere through the retainer valve pipe and valve. The "emergency" position of the engineer's valves causes, in general, the same action as "service application," except that a greater reduction of air pressure takes place in the train line and more air is allowed to flow from the auxiliary reservoir into the brake cylinder until pressure is equalized between them and the brakes are firmly set. A break in the train line causes the same action as emergency application by the engineer, setting all brakes on the train.

Q. What is a "terminal test" and when and why is it made? *A*. An application and release of brakes on the entire train. It is made when a train is first made up, and thereafter whenever the train line has been broken during switching or for any other purpose. It permits an inspection of the operation of all air brakes, and shows whether there is abnormal leakage of air in the train line. While the brakes are applied, the leakage as indicated on a gage in the engine cab should not exceed a 4-pound drop in pressure in 3 minutes.

Q. How often should triple valves be tested? *A*. Within a year of the date at which commercial shipment is to take place.

Q. What constitutes a standard air hose? *A*. One which is intact, 1⅜ inches in diameter, 22 inches in length, and has label vulcanized to it showing name of manufacturer, date made, and serial number.

Q. How is waste prepared for packing a journal? *A*. The waste must be loosened thoroughly, placed in a saturating vat, and kept completely submerged in new or renovated car oil, at a temperature of not less than 70° F., for a period of not less than 48 hours, to insure saturation. Then it is drained, for the purpose of removing the excess oil, until the packing is in an elastic condition. Oil should not drip from the waste when lifted from the drain rack, but oil should flow from it when it is squeezed by hand. Packing in storage should be turned over at least once each 24 hours, or the oil which has accumulated in the bottom of the container should be drawn off and poured over the top of the prepared packing.

Q. Describe briefly how a journal bearing or brass is changed. *A*. The car is spotted so that the journal box is over a tie. A short hydraulic jack is placed under the journal box so that when jacked up all of the strain is placed on the arch bar. As the jack goes up, the arch bar goes up and the wedge and the brass have all of the weight taken off and become loose so that they can be easily removed. The damaged brass is taken out, a new one inserted, and the jack let down. This completes the operation.

Q. What causes most of the leaks in the train line? *A*. Damaged gaskets in the air hose connections.

Q. What is the remedy for this condition? *A*. Change gaskets; it takes only a few seconds. The gaskets are made of rubber and can be easily removed and replaced.

Q. What standard markings are required to be placed on railway cars to be acceptable on commercial railroads? *A*. The standard markings are listed in the standards of the Master Car Builders Association.

Q. Why is train inspection necessary? *A*. To find and remedy, before trying to handle the train on a grade, any defects that would render its handling unsafe; part of the pistons may be out against the cylinder heads when the brakes are applied, the retaining valves may be poor, some brakes may not apply, auxiliaries may not charge, leaks may exist, the brakes may go into emergency when trying to make a service application, and many other defects may exist.

Q. Name some points of inspection of railway cars. *A*. Inspect for cracked wheels, flanges chipped or worn sharp, sill steps loose or missing, grab handles loose or missing, loose ladders, running boards broken or rotten, unauthorized articles attached to running boards, bent or missing hand brake masts, missing pawls, worn or broken brake shoes, packing of journal boxes, greasing of kingpins, condition of air hose, functioning of air brakes, and lashing of equipment on open cars.

Q. How may air brakes be tested? *A*. Couple a locomotive to the car and connect and pump up the train line. Apply and release the brakes. Watch the brakes while application and release are being made. Blow out the dirt collectors while the air is connected.

Q. What inspection should be given journal boxes? *A*. See that the lids fit tightly; that dust guards are in place and in good condition; that waste is sufficient in quantity, and oily enough to provide lubrication to the axle; and that the hinge pin in the box lid is in good condition.

Q. What inspection should be made of couplings? *A*. See that knuckles and lockpins are intact; that uncoupling chains and levers are in working order; and that draft gear is undamaged.

Q. What inspection is made of the brake system before a car is permitted to leave the yards? *A*. Check that the angle cocks, cut-out cocks, and retainer handles are in their proper position; that the hand brakes are released; and the hoses are properly coupled.

Q. If a brake shoe is noticed wearing unevenly, what is probably the reason? *A*. Improperly hung brake beams.

Q. What imperfections should be looked for when inspecting wheels? *A*. Broken flanges, flat wheels, cracked wheels, wheels loose on axle, chipped rims, worn treads, brake burns, and shell-outs.

Q. How is the travel of the piston in the air brake cylinder regulated? *A*. By the automatic slack adjuster.

Q. The slack adjuster regulates the piston travel at about 8 inches. If a test of piston travel while the train was standing should show a travel of only 6½ inches, would it be an indication of improper functioning of the automatic slack adjuster? *A*. No. The automatic slack adjuster adjusts the travel when the car is traveling. The motion of the wheels with respect to the brake beams will cause a different amount of slack to be adjusted for when traveling than when the car is stopped.

Q. Is any adjustment necessary for the brake system of a car, if new brake shoes are installed? *A*. Yes. The automatic slack adjuster must be adjusted by turning the ratchet adjuster nut at the end of the cylinder of the slack adjuster.

Q. What care must be given the automatic slack adjuster? *A*. The cylinder of the slack adjuster should be cleaned and lubricated every 6 months.

140. Loading and unloading cars.—*Q*. What equipment is carried on a gun car? *A*. All parts of the ground platform (H-beams, fishplates, bolts, and cross ties), jack beams, outriggers, floats, footplates, and chests containing necessary tools for the gun or mortar.

Q. How is ammunition carried? *A*. In ammunition cars, equipped with shell and powder racks, held in place by stanchions and supports fastened to the walls of the cars.

Q. Explain how the equipment of an ammunition car assigned to the (candidate's) battery is placed in position for loading of projectiles and powder. *A*. ———.

Q. How many projectiles and how many powder charges are carried in an ammunition car of the (candidate's) battery? *A*. ———.

Q. Where are track tools and supplies for the guns carried? *A*. In the store car.

Q. How are kerosene and oil carried? *A*. In drums, in the store car. Kerosene and lubricants are *not* to be placed in ammunition cars.

Q. What placarding should be placed on loaded ammunition cars? *A.* They should have a card with the word "explosives" in red on each side and each end of the car.

Q. What are some of the precautions to be observed in preparing guns or mortars for movement? *A.* All platforms should be swung inboard and lashed or secured. The gun or mortar must be securely fixed in traveling position. The parts of the ground platform and outriggers, floats, and footplates must be firmly lashed in place and, in general, nothing should be left movable.

Q. Are cars issued for moving motor transportation? *A.* No. If it is to be moved by rail, flatcars must be provided.

Q. Explain how to load motor transportation on flatcars. *A.* If a loading platform is not available, either of the following methods may be used:

(1) Use railway jacks to remove the rear truck from the end car, letting the end of the car down to the ground and bridging with a short, low ramp. Remove the brake masts from the flatcars and bridge the gaps between cars with heavy planking or sheet metal (pieces of boiler plate). Vehicles can be loaded under their own power. They should be run up onto the end car and then over each flatcar in turn to the farther end of the train. Motorcycles may be loaded crosswise between large vehicles. All vehicles must be securely fastened to the cars. With lighter vehicles the wheels are chocked and cleats are spiked to the floor of the car on each side of each wheel. Lashings may also be used. One method of securing heavier trucks to the flatcar is to bore holes through the floor of the car and insert large iron bolts to which the lashings are fastened. In the case of heavy trucks on pneumatic tires, the lashings can be drawn tight by deflating the tires, taking up on the lashings, and again inflating the tires. When all cars are loaded, including the car which served as a ramp, the lowered end of that car can be jacked up onto its truck. All gasoline and water should be drawn from each vehicle before shipment.

(2) A simple type of end ramp can be constructed by building up a crib near the end of the last car, using railway ties or similar timber. Four end-beveled planks, 2 inches by 12 inches by 12 feet, held together by cross members are then placed in such manner that they are supported by the end of the car, the crib, and the ground, and are then secured by nailing and staking. The disadvantage of this ramp and all others of similar nature is in the steepness of its slope which requires that vehicles be hauled up by block and tackle; furthermore, the angle between the ramp and the level surface of the car is so great that some vehicles may have insufficient road clear-

ance to clear the top of the ramp. The gaps between cars are bridged and the vehicles are run to the farther end of the train and are secured in the manner described in (1) above.

Q. What precautions must be taken as to height of loads? *A*. Loaded cars must be able to clear all obstructions, such as tunnels and bridges, along the line.

Q. What precautions must be taken to distribute the load? *A*. The load must not be placed so that more weight falls on one side of the car than on the other. Loads must be so placed as to allow room for access to and operation of the hand brakes on the flatcars.

Q. Explain how the extra equipment is loaded on the gun mount or mortar carriage assigned to the (candidate's) battery. *A*. ———.

141. **Make-up of trains.**—*Q*. Mention some points to be covered in making up an armament train for commercial shipment. *A*. Place the battalion locomotive (to be shipped "deadheaded") at the head of the train (that is, it will be immedately in rear of the commercial locomotive). Place one or more ammunition cars between each two gun cars to distribute the load of the train. In case the gun overhangs the end of its car, place a gondola in rear of the gun car. Place store and kitchen cars near the rear of the train. The kitchen car to be used by train guards during the trip should be placed next to the car in which they will ride when not on duty as guards.

Q. How is a train made up to avoid unnecessary switching? *A*. If the movement is for a short distance and a complete diagram of trackage can be laid out, before the train is made up, the guns are faced in the proper direction to enter the firing spurs, and placed in the train in the order in which they will enter the spurs, and a loaded ammunition car is placed in rear of each. The battalion locomotive is placed so that the guns may be pushed into position. The kitchen, tank, gondola, fire-control car, and extra ammunition cars are placed near the rear of the train where they may be dropped off on the proper sidings. When the railway movement is a long one and all trackage cannot be laid out in advance, the train should be made up as for a commercial shipment, and switching done at the terminal after the exact trackage arrangements have been determined by reconnaissance.

Q. Why should a battalion train normally be moved as a unit? *A*. Because the battalion is the normal fire unit; because the size of the train renders it easy to move with a light switch engine; because it is of a size which will enter most sidings without being broken up, and can be moved on many commercial car ferries as a unit; and because it is nearly the same length as the type military trains authorized for rail movements of divisional troops.

Q. In addition to distributing the weight along the train, give another reason why ammunition cars should be placed between gun cars. *A*. Because most gun cars have no retaining valves. Placing ammunition cars throughout the train enables them to be used to brake the train more uniformly.

Q. How may a car be turned around? *A*. By means of a turntable or a "wye" in the track.

Q. What precautions must be taken to avoid fouling switches and main lines? *A*. Cars placed on sidings must be moved well clear of switches. All hand brakes must be set and wheels blocked. Push cars must have their wheels blocked or one end must be set off the rails when they are not in use.

Q. Which way should the muzzle of the gun point, toward the front or toward the rear of the train? *A*. The muzzle should always point toward the rear.

142. Railway movements.—*Q*. What is the commercial definition of a train? *A*. One or more locomotives with or without cars displaying markers.

Q. Explain color, lamp, flag, hand, and whistle signals. *A*.

(1) *Color signals*.—Red indicates stop; yellow, proceed with caution; green, proceed; blue, displayed at one or both ends of a car or group of cars indicates that workmen are around or under the car or cars and that cars must not be coupled or moved. Only the workman who places the blue signal is authorized to remove it.

(2) *Hand, flag, or lamp signals*.—Swung across the track—stop. Held horizontally at arm's length when train is moving—reduced speed. Raised and lowered vertically—proceed. Swung vertically at half arm's length across the track, when the train is standing—back. Swung vertically in a circle at arm's length across the track when train is running—train has parted. Swung horizontally above the head when train is standing—apply air brakes. Held at arm's length above the head when train is standing—release air brakes.

(3) *Whistle signals* (O indicates short blast; — indicates long blast).

Sound	*Indication*
O	Stop.
OO	When standing, start.
OO	When running, stop at once.
OOO	When standing, back.
OOOO	When standing, apply or release brakes.
—OOO	Flagman protect rear of train.
— — — —	Flagman may return from west. (South.)
— — — — —	Flagman may return from east. (North.)
	When running, train parted.

Q. When are fusees and torpedoes used? *A.* A fusee is lighted on or near a track to notify trains in rear to proceed with caution. The explosion of two torpedoes is a signal to reduce speed and look out for a train or obstruction ahead.

Q. What are American Railway Association rules? *A.* Rules agreed to by all American railroads and by the Quartermaster Corps on behalf of the Army, which standardize railway equipment, repairs, and charges for repair work and parts.

Q. What authority has a troop commander over a military train which is operating on a commercial railroad? *A.* He commands Army troops on the train and cooperates with the railway officials in furnishing information relative to speeds, stops to be made, and switching to be done. The train is inspected by railway officials before the journey is commenced and the itinerary is determined. When the commercial train crew takes over the train the responsibility for its operation by military personnel ceases until its destination is reached.

Q. What are authorized speeds for railway artillery matériel? *A.* On first-class railroads, 8-inch guns and 12-inch mortars may proceed at speeds as high as 50 miles per hour. On sidings and firing spurs they can be operated as fast as a locomotive can be safely operated, usually at about 5 miles per hour. Heavier types of railway guns must be operated more slowly, usually at speeds of not more than 15 to 20 miles per hour even on the first-class railroads. This is due to their excessive weight and the danger of overheating the journals.

Q. How will military locomotives usually be shipped on a commercial railroad? *A.* As "live" locomotives, that is, with a crew and under sufficient steam so that the cylinders may be kept lubricated while they are in motion, but they will not furnish any power in moving the train of which they are a part.

Q. In case a car of a railway artillery train is damaged while moving over a commercial railway, what is done? *A.* If the car can be securely locked, it may be left without guard and moved to destination later by the railroad company. If it cannot be secured, a guard should be left with it with necessary provisions for messing and sleeping.

Q. In case of a wreck, what action is taken? *A.* Insure safety of personnel aboard, care for any injured, and arrange to guard Government property.

Q. What train guards should be provided for armament trains? *A.* Two guards for each gun and for each loaded open car, as a gondola, the contents of which cannot be placed under lock.

Q. Where do train guards ride? *A*. When on duty, on the car which they guard. When off duty, in a car provided for them. This may be an extra boxcar, empty ammunition car, day coach, or commercial sleeper.

Q. How are personnel transported? *A*. Personnel, other than train guards, usually ride on troop trains on a long move. On a short move, they may ride in empty ammunition or fire-control cars.

Q. What guards are provided for personnel cars? *A*. Subject to any special instructions of the train commander, a guard is placed at each exit of a car carrying personnel, to prevent troops from getting off the train without authority.

Q. What data are given the railroad company with reference to clearances, weights of matériel, and numbers of cars to be shipped? *A*. All necessary data of this kind are furnished the railroad company by the railway officer before the move, so that routing over tracks which will carry the necessary weights and give the proper clearances may be determined in advance.

CHAPTER 19

GENERAL SUBJECTS

SECTION I

DEFINITIONS AND ELEMENTARY PRINCIPLES FOR SEACOAST ARTLLERY

143. Definitions and elementary principles.—Definitions applying especially to nomenclature matériel should be covered in connection with the appropriate topics in the text. The following terms are more general in their nature.

Absolute deviation.—*See* Deviation.

Accidental errors.—Those errors which are nonsystematic in nature and which, in artillery fire, cause the dispersion of shots about the center of impact. They may arise from such sources as the variation from round to round in the operation of instruments, in muzzle velocity, in the weight and shape of projectiles, and in the action of the gun and carriage.

Accuracy of fire.—Accuracy of fire is determined by dispersion and is measured by the closeness of the grouping of the points of impact or burst about their center of impact.

Accuracy of practice.—Accuracy of practice is measured by the distance of the center of impact from the center of the target; also known as accuracy of the shoot.

Adjusted range or adjusted range correction.—That range or range correction obtained or proved by actual firing which places the center of impact at or near the target.

Adjusting point.—The particular point on which fire is adjusted.

Adjustment corrections.—*See* Arbitrary corrections; Spot.

Adjustment of fire.—The process of determining and applying corrections to firing data to bring the center of impact or of burst to the adjusting point and to keep it there.

Aerial observation.—Observation of fire from aircraft.

Aiming.—The operation of pointing the gun in range or direction by means of the sight.

Aiming point.—The point on which the gun pointer sights in pointing the gun.

Altitude.—The vertical distance above or below sea level (mean low water) or other datum level. Also called height of site.

Angle of approach.—The acute horizontal angle between the plane of position and the vertical plane containing the course of the target.

Angle of departure.—The vertical angle between the line of departure and the line of position.

Angle of depression.—The angular depression of the line of position below the horizontal plane.

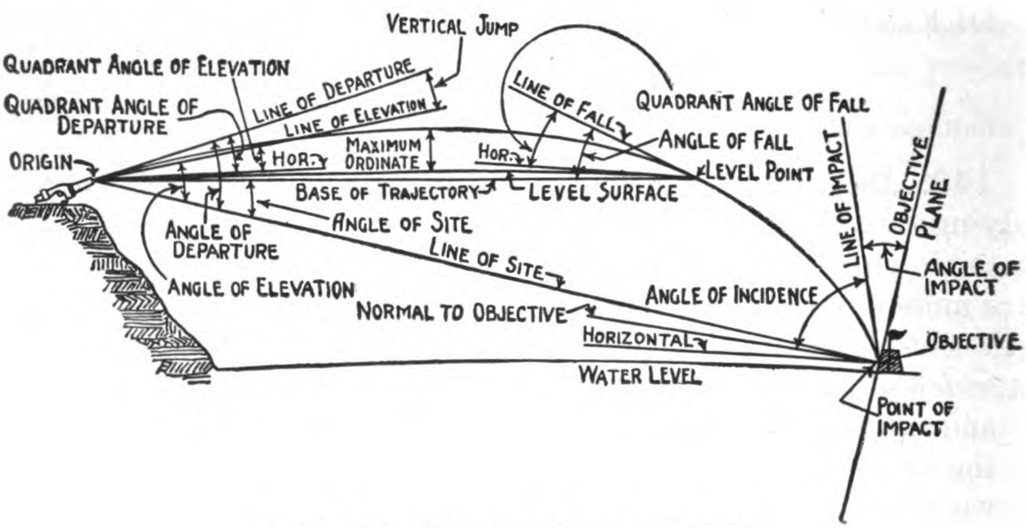


FIGURE 142.—Elements of trajectory in air.

Angle of elevation (*or elevation*).—The vertical angle between the line of elevation and the line of position.

Angle of fall.—The angle between the line of fall and the base of the trajectory.

Angle of impact.—The acute angle between the line of impact and the plane tangent to the surface of the ground (or other object) at the point of impact.

Angle of incidence.—The acute angle between the line of impact and the normal to the surface of the ground (or other object) at the point of impact. It is the complement of the angle of impact.

Angle of jump.—The angle between the line of departure and the line of elevation. Its component in the vertical plane is called the vertical jump, and its component in the horizontal plane is called the lateral jump.

Angle of site.—The angle between the line of site (position) and the base of the trajectory.

Angular height.—The vertical angle between the line of position and the horizontal.

Angular travel error.—The error which is introduced into a predicted angle obtained by multiplying an instantaneous angular velocity by a time of flight.

Angular velocity.—The rate of change of direction expressed in angular measure.

Arbitrary corrections.—Corrections to firing data which are applied to correct for conditions or observed deviations after all known deviating causes have been corrected for.

Armament errors.—The divergence, stripped of all personnel errors and adjustment corrections, of an impact or burst from the center of impact of a series similarly stripped.

Ascending branch.—That portion of the trajectory between the origin and the summit.

Automatic weapon defense.—The particular class of defense provided by antiaircraft artillery automatic weapons.

Axial observation.—Observation of fire from a point on or near the gun-target line. Observation is said to be axial when the observing angle is 5° or less.

Axis of bore.—The center line of the bore of the gun.

Axis of trunnions.—The axis about which a gun is rotated in elevation.

Azimuth.—The horizontal angle, measured in a clockwise direction from a selected reference line, usually grid south, passing through the position of the observer to the horizontal projection of the line of sight from the observer to the objective.

Azimuth difference.—The difference between the two azimuths of a point as measured from two other points. Also called parallax.

Backlash.—The lost motion or play in a mechanical system.

Ballistic coefficient.—The numerical measure of the ability of a projectile to overcome air resistance and maintain its velocity.

Ballistic density.—A fictitious constant density of the atmosphere which would have the same total effect on the projectile during its flight as the varying densities actually encountered.

Ballistic wind.—A fictitious wind, constant in velocity and direction, which would have the same total effect on a projectile during the flight as the true winds actually encountered.

Ballistics.—That branch of applied mechanics which treats of the motion of projectiles. It is divided into two main branches: interior ballistics and exterior ballistics. The former is concerned with the motion of the projectile while in the gun; the latter treats of the motion of the projectile after it has left the gun.

Barrage fire.—Fire having for its purpose the placing of a curtain or barrier of fire, executed on predetermined firing data, across the probable course of the enemy.

Base line.—A line of known length and direction between two observation or spotting stations, the positions of which with respect to the battery are known. The base line is called right-handed or left-handed, depending on whether the secondary station is to the right or left of the primary from the point of view of a person facing the field of fire.

Base of trajectory.—The straight line joining the origin and the level point.

Base piece.—The gun selected after calibration fire, the center of burst or impact of which is taken as the reference point in determining calibration corrections for the remaining guns of the battery. No calibration corrections are applied to the base piece.

Base ring.—The metal ring which is bolted to the concrete of an emplacement and which supports the weight of the cannon and carriage.

Battle chart.—A chart used in group or higher commands showing the water area covered by the armament of their respective commands.

Bilateral observation.—Observation of fire from two observation stations.

Biting angle.—The maximum angle of obliquity at which penetration of armor is secured.

Bore rest.—*See* Clinometer rest.

Bore sighting.—The process by which the axis of the bore and the line of sight are made parallel or are made to converge on a point.

Bracket.—The difference between two ranges or two adjustment corrections, one of which indicates a center of impact which is over the target and the other a center of impact which is short of the target. The term is also used in a similar manner with reference to direction.

Bracketing correction.—An adjustment correction which gives an equal number of overs and shorts.

Bracketing elevation.—An elevation which gives an equal number of overs and shorts.

Bracketing method of adjustment.—The method of fire adjustment used when the sense only and not the magnitude of the deviation is known.

Bracketing salvo.—A salvo in which the number of impacts sensed short is equal to the number of impacts sensed over.

Calibration.—*See* Calibration fire.

Calibration corrections.—Corrections which are applied on the guns as a result of calibration fire.

Calibration fire.—Preparatory fire having for its purpose the determination of the separate corrections to be applied to the individual guns of a battery in order to cause all the guns to hit the same point or the bursts or impacts to assume a desired pattern.

Calibration point.—A point at which the calibration fire is conducted.

Cant.—The angle made with the horizontal by the axis of the trunnions.

Cases I, II, and III pointing.—*See* Pointing.

Center of dispersion.—*See* Dispersion.

Center of impact.—The mean position of the points of impact of a particular series of shots fired with the same elevation (or with the same adjustment correction).

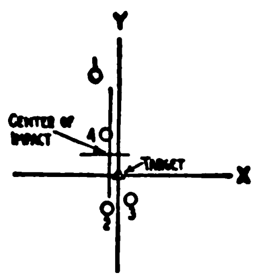


FIGURE 143.—Center of impact.

Chronograph.—An instrument for measuring and recording graphically short intervals of time. More specifically, an instrument for determining the velocity of projectiles.

Clinometer.—An instrument for measuring accurately vertical angles; for example, the inclination of the axis of the bore to the horizontal.

Clinometering.—The process of adjusting the elevation-indicating device on a gun, using a clinometer, so that it indicates accurately the quadrant elevation of the gun when elevated to any position.

Clinometer rest.—A device inserted in the bore of the gun for supporting a clinometer. It is also called a bore rest.

Coefficient of form.—A factor introduced into the ballistic coefficient to make its value conform to results obtained by firing.

Conduct of fire.—The employment of technical means to place accurate fire on a target.

Continuous fire.—Fire conducted at the normal rate without interruption for the application of adjustment corrections or for other causes.

Continuously pointed fire.—Fire in which the fire-control devices are directed on the target and the data vary continuously with the position of the target.

Contradiction.—A contradiction is obtained when two shots fired with the same elevation or with the same adjustment correction give impacts of opposite sense. A contradiction may also be obtained in direction.

Control station.—A device which permits a searchlight to be pointed in elevation and azimuth from a distant point. The station consists of a distant electric controller and a comparator or zero reader.

Controller.—See Distant electric control.

Corrected azimuth.—The azimuth from the directing point to the target corrected for all known variations from those conditions assumed as standard in the construction of firing tables.

Corrected deflection.—The deflection corrected for all known variations from those conditions assumed as standard in the construction of firing tables.

Corrected elevation.—The firing table elevation corresponding to the corrected range.

Corrected range.—The range corrected for all known variations in conditions from those assumed as standard in the construction of firing tables. It is the computed range at which the piece should be set.

Danger space.—That portion of the range within which a target of given dimensions would be hit by a projectile with a given angle of fall. It is the area indicated by projecting the target on the surface of the earth or water along lines parallel to the line of fall of the projectile.

Datum or datum level.—A spherical surface which represents mean sea level or other established reference level from which altitudes are measured.

Datum point.— A fixed point, the azimuth and range of which have been accurately determined from one or more observation stations or other positions.

Dead areas.—Areas that cannot be reached by fire. These may be caused by masks in front of the battery as well as by obstructions in the descending path of the projectile.

Dead time.—The time interval represented by the travel of the target from its position at observation to its present position. It is the time necessary to compute and utilize an element of the firing data.

Defilade.—The vertical distance by which a position is concealed from enemy observation. If the smoke and flash of firing are also concealed, the battery is said to have smoke and flash defilade.

Deflection.—The horizontal angle between the line of sight to the target and the axis of the bore when the piece is pointed in direction. It is usually expressed in reference numbers and is set on the sight. The deflection due to travel alone is called the uncorrected deflection.

Deliberate fire.—Fire which is conducted at a rate intentionally less than the normal rate of fire of the battery in order that adjustment corrections may be applied between series or for tactical reasons.

Density.—Density of the air measures the mass that must be displaced by the projectile. It varies with the altitude, decreasing as the altitude increases. In practice, the density used is the ballistic density.

Density of loading.—The term employed to represent the density of the contents of the powder chamber. It is the ratio of the weight

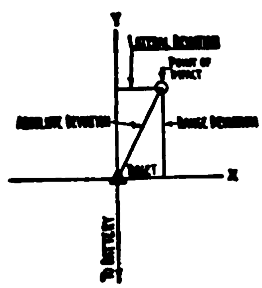


FIGURE 144.—Deviations.

of the powder charge to the weight of a volume of distilled water at 39.2° F. which will fill the powder chamber.

Descending branch.—That part of the trajectory described by the projectile after it passes the summit.

Developed armament probable error (*DAPE*).—The probable armament error as computed from a finite series of shots. It is the average armament error of a particular series of shots multiplied by 0.845.

Deviation.—The distance of a point of impact or center of impact from the center of the target. If a set of axes is drawn through the target, the Y axis being along the line of position and the X axis perpendicular to the Y axis, then the Y coordinate of the point of impact is called its longitudinal deviation and the X coordinate is called its lateral deviation. The shortest distance from the center of the target to the point of impact is called the absolute deviation.

Difference chart.—A graphic device by means of which the range and azimuth of a target from a gun or station are obtained when the range and azimuth from some other gun or station are known.

Direct fire.—Fire conducted with direct pointing.

Direct pointing.—Pointing a piece in direction or in both range and direction by means of a sight directed at the target.

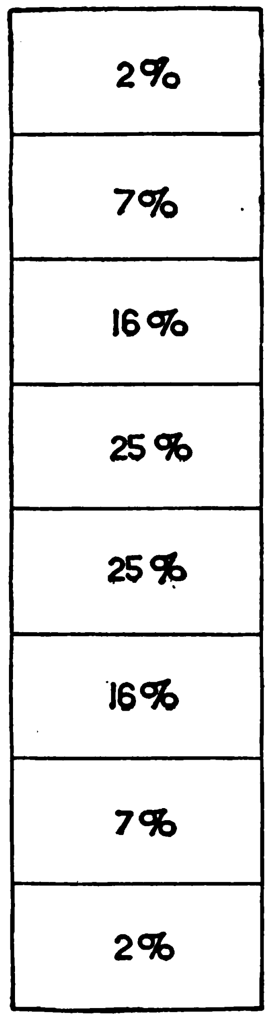


FIGURE 145.—Dispersion ladder for range.

Directing point.—A point in or near a battery for which the firing data are computed. If a gun of the battery is the directing point, it is called the base piece or directing gun.

Directrix.—The center line of the field of fire of a gun.

Dispersion.—The scattering of shots fired with the same data. The area over which the shots are scattered is called the zone of dispersion. The center of that area is called the center of dispersion.

Dispersion diagram.—A diagram made up by superimposing the dispersion ladder for direction on the dispersion ladder for range and indicating in each resulting rectangle the percentage of shots expected to fall therein.

Dispersion ladder.—A diagram made up of eight successive zones, each equal in width to one probable error. The center of dispersion is on the line between the two central zones and in each zone is indicated the percentage of shots expected to fall therein.

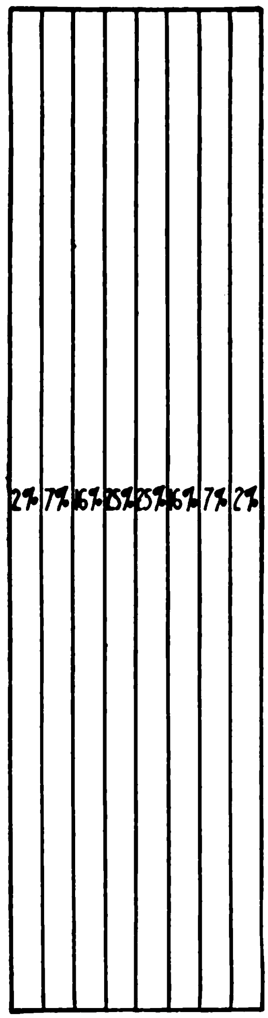


FIGURE 146.—Dispersion ladder for direction.

Displacement.—The displacement of one point from another is the distance between these points. Gun displacement is the horizontal distance in yards from the pintle center of the gun to the directing point or the directing gun of the battery.

Distant electric control.—A system for the control of the pointing of searchlights from a distance. The control consists of the controller and the necessary motors or receivers at the searchlight.

Drift.—The divergence of a projectile from the plane of departure due to the rotation of the projectile and the resistance of the air.

It may be expressed either in linear or angular units. The drift listed in firing tables includes lateral jump.

Drop.—The vertical distance from a point on the trajectory to the line of elevation.

Elements of the trajectory.—The phrase applied to the various features of the trajectory.

Elevation.—*See* Angle of elevation; Quadrant elevation.

Elevation difference.—The angular units of quadrant elevation corresponding to a particular gun difference for a particular range.

Elevation table.—A table of ranges with corresponding quadrant elevations, used in graduating, and in checking the graduations of, the range disk of a fixed cannon. The quadrant elevations listed are firing table elevations corrected for height of site.

Errors.—Divergences of points of impact or burst from the center of impact or burst. Practically, they are measured from the apparent center of impact or burst of a given series and, when so measured, are called apparent errors, as differentiated from true errors which would be measured from the true center of impact or burst.

Estimated data.—Firing data which are determined by estimation.

Exterior ballistics.—*See* Ballistics.

Field of fire.—That portion of the terrain or water area covered by the fire of a gun or battery.

Fifty percent zone.—The zone extending one probable error on each side of the center of impact within which 50 percent of the shots are expected to fall.

Fire control.—The exercise of fire direction and conduct of fire.

Fire direction.—The exercise of the tactical command of one or more units in the selection of objectives and in the concentration or distribution of fire thereon at the appropriate times.

Fire for effect.—Any fire conducted against a hostile target.

Firing azimuth.—The azimuth at which the gun is pointed for firing.

Firing data.—All data necessary for firing a gun at a given objective.

Firing elevation.—The firing table elevation corresponding to the firing range.

Firing range.—The range at which the gun is pointed for firing.

Firing tables.—A collection of data, chiefly in tabular form, intended to furnish the ballistic information necessary for conducting the fire of a particular model of gun with specified ammunition.

Fixed armament.—Seacoast artillery weapons that are emplaced in permanent firing positions.

Flank observation.—Observation of fire from a point where the observing angle is greater than 75°.

Flash defilade.—*See* Defilade.

Fork.—The difference in range, elevation, or direction required to change the center of impact by four probable errors.

Fuze.—A device which controls the time of burst of a projectile.

Grid azimuth.—Azimuth measured from grid north or south.

Gun difference.—The difference, due to displacement, between the range from a gun to the target and the range from the directing point to the target.

Gun displacement.—*See* Displacement.

Gunner's quadrant.—An instrument used on the quadrant seat of a cannon to measure the vertical angle between the axis of the bore and the horizontal.

Gunnery.—The art of firing guns. It includes the study of the flight of the projectile and of the technical considerations involved in the conduct of fire.

Height of site.—The altitude above or below the assumed datum level.

High-angle fire.—Fire delivered at elevations greater than the elevation corresponding to the maximum range. In high-angle fire the range decreases as the angle of elevation is increased.

Hit.—An impact actually on the target.

Horizontal base system.—A system of position finding in which the target is located from two observation stations.

Hundred-percent rectangle.—A rectangle whose length is eight probable errors in range and whose breadth is eight probable errors in direction. Its center is the center of dispersion.

Indirect fire.—Fire conducted with indirect pointing.

Indirect pointing.—Pointing a piece in direction by the use of a sight and an aiming point other than the target, or by the azimuth circle on the carriage, and in elevation by range drum or quadrant.

Initial velocity.—*See* Muzzle velocity.

Interior ballistics.—*See* Ballistics.

Jump.—The angle between the axis of the bore when the piece is pointed and the line of departure. Its component in the vertical plane is called the vertical jump and its component in the horizontal plane is called the lateral jump. In firing tables quadrant elevation includes the effect of vertical jump, and drift includes the effect of lateral jump.

Lateral deviation.—*See* Deviation.

Lateral jump.—*See* Jump.

Leveling.—The process of adjusting the gun and mount or an instrument so that all vertical or horizontal angles will be measured in true vertical or horizontal planes.

Level point.—A point on the descending branch of the trajectory at the same altitude as the muzzle of the gun. It is the same as the point of fall.

Line of collimation.—The line from the center of the objective lens of a telescope through, and perpendicular to, the axis of vertical rotation.

Line of departure.—The prolongation of the axis of the bore as the projectile leaves the muzzle of the gun. It is the tangent to the trajectory at the origin.

Line of elevation.—The prolongation of the axis of the bore when the piece is pointed.

Line of fall.—The tangent to the trajectory at the level point.

Line of impact.—The tangent to the trajectory at the point of impact.

Line of position.—The line of position of a point is the straight line connecting the origin with that point. Also called line of site. The point of origin is usually the gun or a position-finding instrument. Thus, corresponding to the three positions of the target, there are the line of position at observation, the line of present position, and the line of future position.

Line of sight.—The line of vision; the optical axis of an observation instrument.

Line of site.—*See* Line of position.

Longitudinal deviation.—*See* Deviation.

Low angle fire.—Fire delivered at angles of elevation at and below the elevation corresponding to the maximum range.

Magnitude method of adjustment.—A method of adjustment used when the actual magnitudes and senses of the deviations are known.

Manning table.—A table showing the assignment to duties of the personnel of an organization.

Map range.—The range from the piece to any point as scaled or computed from a map.

Mask.—Any natural or artificial feature of or on the terrain which affords shelter from view.

Maximum ordinate.—The difference in altitude between the origin and the highest point of the trajectory.

Mean error.—The arithmetical average of errors of a series of shots.

Meteorological datum plane.—The plane assumed as a basis or starting point for the data furnished to the artillery concerning atmospheric conditions. Its altitude is that of the meteorological station.

Mil.—One sixty-four-hundredth part of a circle. For practical purposes the arc which subtends a mil at the center of a circle is equal to the length of one one-thousandth of the radius.

Mistakes.—Those personnel errors which may be avoided by proper care.

Mobile armament.—Weapons that may be moved to and emplaced in temporary firing positions. In seacoast artillery this class consists of railway, truck-drawn, and tractor-drawn artillery.

Muzzle velocity.—The velocity of the projectile at the origin of the trajectory. Also called initial velocity.

Nonsystematic errors.—*See* Accidental errors.

Normal.—Geometrically the term means perpendicular to. When used in connection with reference scales of instruments, the normal setting is that reference scale setting which corresponds with a true setting of zero.

Objective plane.—The plane tangent to the ground or other material object at the point of impact.

Observation of fire.—The process of observing artillery fire. *See also* Spotting.

Observing interval.—The time interval between two successive observations made on a moving target during tracking.

Observing line.—The line joining the observer and the observing point.

Observing point.—The point on which the observer sights.

Observing sector.—The sector between the lines to the right and left limiting the area visible to the observer or limiting the area assigned for surveillance.

Orientation.—The determination of the horizontal and vertical location of points and the establishment of orienting lines or lines of known direction. Also, the process of adjusting the azimuth circles of guns or instruments or both so that they will read correct azimuths.

Orienting line.—A line of known direction over one point of which it is possible to place an angle measuring instrument.

Origin of trajectory.—The center of the muzzle of the gun at the instant of departure.

Parallax.—The angle subtended at a certain point by a line connecting two other points.

Pattern.—The distribution of the points of burst or impact of a salvo. Also the difference in range between the point of impact with the longest range and the point of impact with the shortest range, excluding wild shots. The pattern of a salvo in direction is the distance measured perpendicular to the line of position between the point of impact falling at the greatest distance to the right and that falling at the greatest distance to the left, excluding wild shots.

Penetration of armor.—The passage of any part of the projectile through all or any part of armor plate. When the projectile passes completely through the armor, complete penetration or perforation is said to have occurred.

Perforation of armor.—Complete penetration of armor.

Pintle center.—The vertical axis about which a gun and its carriage are traversed.

Plane of departure.—The vertical plane containing the line of departure.

Plane of fire.—The vertical plane containing the axis of the bore when the piece is pointed.

Plane of position.—The vertical plane containing a line of position. It is designated in a manner similar to that followed for lines of position.

Plane of site.—A plane containing the line of site and a horizontal line perpendicular to it.

Plotted point.—A point on the plotted course of the target located by plotting the position of the target at a particular instant.

Point of fall.—*See* Level point.

Point of impact.—The point where the projectile first strikes the ground or other material object.

Pointing.—The operation of giving the piece a designated elevation and direction. There are three cases of pointing:

Case I.—Pointing in which direction and elevation are imparted to the gun by means of the sight. Data are applied to the piece in the form of settings of deflection and angle of elevation.

Case II.—Pointing in which direction is imparted to the gun by means of the sight and elevation is imparted by means of an elevation scale or graduated range drum. Data are applied to the piece in the form of settings of deflection and quadrant elevation, the latter being given in terms of range when a range drum is employed.

Case III.—Pointing in which direction is given the piece by means of an azimuth circle, of a "match the pointer" indicator, or of a sight pointed at an aiming point other than the target; and elevation by means of an elevation quadrant, of a range disk, or of a "match the pointer" indicator.

Position finding.—The process of determining the position of a target with relation to the battery and the determination of a future position upon which to direct the fire.

Position of target.—Three different positions of the target are considered:

Position of target as predicted—future position of target.—The predicted position of the target at the end of the predicted time of flight.

Position of target at instant of firing—present position of target.—The position of the target at the instant the gun is fired.

Position of target at instant of observation.—The observed position of the target.

Predicted point.—A point at which it is expected the target will arrive at the end of the dead time.

Predicting.—The process of determining the position of the target at some future time.

Predicting interval.—The interval between successive predictions of future positions of the target.

Preparatory fire.—Fire that is conducted for the purpose of determining or verifying corrections to firing data.

Primary armament.—Seacoast artillery weapons of 12-inch or greater caliber, and submarine mines.

Probability factor.—A factor used as an argument in entering the probability tables. It is equal to the error not to be exceeded divided by the probable error.

Probable error.—The error which is as likely as not to be exceeded. A value which in the long run will be exceeded half the time and not exceeded half the time.

Quadrant angle of departure.—The angle between the line of departure and the horizontal.

Quadrant angle of fall.—The angle between the line of fall and the horizontal plane at the level point.

Quadrant angle of site.—The angle between the line of site and the horizontal plane at the origin.

Quadrant elevation.—The vertical angle between the horizontal and the axis of the bore when the gun is pointed in elevation.

Radian.—The angle at the center of a circle subtended by an arc equal in length to the radius. A convenient angular unit of measure equal to 1,018.5 mils.

Range.—The horizontal distance from the gun, observation station, or directing point of a battery to the target, splash, datum point, or other specified point.

Range deviation.—*See* Deviation.

Range difference.—The difference, due to displacement, between the ranges from any two points to a third point.

Range table.—See Firing tables.

Ranging shots.—Trial shots fired at a moving target for the purpose of obtaining an adjustment correction.

Reference numbers.—Arbitrary numbers used in place of actual values in the graduation of certain scales. Their purpose is to avoid the use of positive and negative values.

Relocation.—The process of determining the range and azimuth from one station to a point (or target) when the range and azimuth from another station to this point are known.

Remaining velocity.—The remaining velocity at any point in the trajectory is the actual velocity in foot-seconds at that point.

Retardation.—The negative acceleration of the projectile.

Ricochet.—A glancing rebound of a projectile on impact.

Round.—All of the component parts of ammunition necessary in the firing of one shot.

Salvo.—One round per gun fired simultaneously or fired in a certain order with a specified time interval between rounds.

Salvo point.—A point of known range and azimuth at which fire from one or more batteries may be directed.

Seacoast artillery.—All artillery weapons used primarily for fire upon hostile naval vessels. It includes both fixed and mobile armament.

Secondary armament.—Seacoast artillery weapons of less than 12-inch caliber.

Self-contained base system.—A system of position finding in which the target is located in azimuth and range from a single station using a self-contained range finder.

Self-contained range finder.—An instrument used to obtain ranges by either the stereoscopic or the coincidence principle.

Sense.—The direction of a point of impact (or center of impact of a salvo) with respect to the target, that is, over or short, right or left.

Set-forward point.—A point on the expected course of the target at which it is predicted the target will arrive at the end of the time of flight.

Sight.—A device by which the gun pointer gives the gun the proper direction for firing.

Site.—See Angle of site.

Slope of fall.—The degree of inclination of the line of fall to the horizontal. It is usually expressed as a gradient—for instance 1 on 5, meaning that the projectile drops vertically 1 yard while it is moving horizontally through 5 yards.

Smoke defilade.—*See* Defilade.

Sound ranging.—The process of locating a target by means of the sounds emitted.

Spot.—An adjustment correction based upon observation of fire—that is "spotting." The measured deviation of an impact or center of impact.

Spotting.—The process of determining the position of a point of impact or burst with respect to the adjusting point.

Straddle.—A salvo which has impacts of opposite sense. Also called a mixed salvo.

Striking velocity.—The remaining velocity at the point of impact.

Stripped deviation.—The deviation that would have resulted had there been no personnel errors and no adjustment correction applied.

Subareas.—Subdivisions of the water area in the field of fire used to assist in the indication, identification, and assignment of targets.

Summit of trajectory.—The point on the trajectory of maximum altitude.

Synchronization.—A process in which the values indicated by all receiver pointers of an electrical data transmission system are made to agree exactly with the values set on the corresponding transmitters.

Systematic errors.—Errors of a constant or progressively changing nature that cause the center of impact or burst initially to deviate from the target.

Target angle.—The angle of the target subtended by the observing base line. Also, the acute angle between the vertical plane containing the gun-target line and the vertical plane parallel to the longitudinal axis of a naval target.

Target-designating system.—A system for designating to one instrument a target which has already been located by a second instrument. It employs electrical data transmitters and receivers which indicate on one instrument the pointing of another.

Terminal velocity.—The remaining velocity at the point of fall.

Time interval.—The interval of time between two successive observations made on a moving target during continuous tracking.

Time of flight.—The elapsed time from the instant of departure of the projectile to the instant of impact or to the instant of burst.

Tracking.—The process of making successive observations on a moving target for the purpose of plotting its course.

Trajectory.—The curve described by the center of gravity of the projectile in its flight.

Trajectory chart.—A graphical representation of the elements of the trajectory in the vertical plane.

Trial fire.—Preparatory fire having for its purpose the determination of corrections for the battery as a whole to compensate for deviations not corrected for in the normal operations of data computation.

Trial shot corrections.—Corrections made as the result of trial fire which seek to move the center of impact or burst to the trial shot point.

Trial shot point.—A point at which trial fire is conducted.

Trial shots.—Shots fired at a fixed point or target during trial fire.

Twenty-five percent rectangle.—That portion of the dispersion diagram the dimensions of which are two probable errors in range by two probable errors in deflection and the center of which is on the center of impact.

Unilateral observation.—Observation of fire from one station only when the target angle is greater than 5° and less than 75°.

Verification fire.—Preparatory fire having for its purpose the test of the mechanical adjustment of all guns and fire-control equipment of the battery and of the accuracy of the corrections determined as a result of calibration and trial fire.

Vertical base system.—A system of position finding for moving targets which uses only one observation station equipped with a depression position finder.

Vertical deviation.—*See* Deviation.

Vertical jump.—*See* Jump.

Volley fire.—Fire in which each piece included in the command fires a specified number of rounds without regard to the other pieces and as rapidly as is consistent with accuracy.

Wild shot.—A shot the armament error of which is greater than four developed probable armament errors and also is greater than six firing table probable errors either in range or direction.

Wind.—*See* Ballistic wind.

Wind fire angle.—The horizontal angle measured clockwise from the plane of fire to the direction from which the ballistic wind is blowing. It is obtained by subtracting the azimuth of the plane of fire from the wind azimuth.

Wind velocity.—The velocity of the ballistic wind.

Yaw.—The angle between the longitudinal axis of the projectile and the tangent to the trajectory at the center of gravity of the projectile.

Zone.—When used with reference to mortar fire or fire from guns or howitzers using more than one size of powder charge, it refers to the area in which projectiles will fall when one particular size of powder charge is used and the elevation is varied from the minimum to the maximum.

Zone of dispersion.—The zone which would include all impacts of an infinite number of shots fired from a gun using the same firing data for each shot. Practically, the zone is considered to extend four probable errors on each side of the center of impact, and such a zone will include over 99 percent of all shots fired with the same data. The zone of dispersion is also called the hundred-percent zone.

SECTION II

ORGANIZATION OF POSITION OR BIVOUAC

144. Camouflage and camouflage discipline.—*Q*. What is military camouflage? *A*. Military camouflage is the art of deceiving the enemy as to the existence, nature, or extent of military works or bodies of troops.

Q. How may camouflage be effected? *A*.

(1) By simple concealment.

(2) By making an object or area blend with surrounding objects or areas.

(3) By making an object appear like something else.

(4) By avoiding regularity of form or spacing and breaking up straight lines of artificial works.

(5) By suppressing telltale shadows.

(6) By avoiding skylining.

(7) By erecting dummy guns or emplacements to divert attention from real objects.

(8) By avoiding noticeable changes in *previous* appearance of the terrain.

(9) By suppressing all signs of military activity.

Q. What are some of the things that betray a position, and how are they to be avoided? *A*.

(1) *Tracks.*—Beaten tracks, or even footprints in the snow, or in a grassy field, are very noticeable on a photograph. To avoid tracks, insist that men keep to paths and do not cut the corners.

(2) *Paths.*—Keep paths close to fences, hedges, houses, and along the edges of a field, if possible. Never allow a path to lead to a

position and end there. Always have it lead past the position and stop in a woods, at a dummy position several hundred yards away, or join another path or a road. Have this path used as much as the real one.

(3) *Failure to erect camouflage before emplacing guns.*

(4) *Allowing men to wander about in daytime.*—They should stay under cover to prevent detection from the air.

(5) *Camouflage which does not blend with its surroundings.*—If in a wooded area, do not camouflage a position as a house or ruins.

(6) *Regularity.*—Remember that nothing regular occurs in nature. Therefore, if using painted canvas or burlap, have jagged splotches rather than straight lines or regular shapes and figures.

(7) *Shadows.*—Avoid regular shapes. In covering a gun with fish net, interlace the material thinly toward the edges, so as to break up and conceal the shadow of the net.

(8) *Changes in previous appearance of terrain.*—The enemy may be expected to take successive photographs of the terrain. Any object which might appear innocent in itself is sure to invite scrutiny if it appears on one photograph when it was not visible on a previous photograph of the same terrain. Noticeable changes must be avoided.

(9) *Flash marks.*[1]—If using a net, roll it back before firing. If a gun is emplaced among ruins, prevent flash marks or remove them immediately as circumstances permit. If firing in a woods, arrange branches so that they may be pulled out of the way while firing.

Q.[2] How may camouflage of mobile searchlight equipment best be accomplished? *A.*[1] By concealment of the equipment in woods or buildings during daylight hours.

Q.[1] In the selection of positions for concealment of mobile searchlights, how may the creation of new tracks be avoided? *A.*[1] By selecting positions near roads and by changing positions frequently.

Q.[1] What steps can be taken to reduce the chances of an enemy locating accurately the operating positions of mobile lights? *A.*[1] Light positions can be changed from night to night.

Q.[1] How may a gun position be camouflaged? *A.*[1]

(1) By spreading a fish net or wire netting, interlaced with leaves, branches, grass, and weeds or tufts of burlap over the position.

(2) By spreading painted burlap over the position.

(3) By use of natural materials, such as brush, shrubs, and small trees.

Q.[1] What is the most important consideration in camouflage? *A.*[1]

---

[1] For gun batteries only.
[2] For searchlight batteries only.

Selection of ground which lends itself to the concealment of guns and emplacement.

Q. What points should be remembered when erecting camouflage? *A.* That not only must the position or object be camouflaged from observers on the ground, but especially from observers in the air, and most particularly it must be so camouflaged as not to appear on photographs taken from airplanes. It must be especially noted that points which the human eye may not pick up or notice often stand out most prominently on a photograph, or may be detected by use of a magnifying glass.

145. Protection against sabotage and raids.—*Q.* For what purposes may attacks by hostile mechanized forces be conducted? *A.* Such attacks may be used by the enemy while conducting reconnaissance missions, on raids to destroy important installations, to harass the defense forces, to disrupt the communication system, or in support of an attack by other forces.

Q. Who is responsible for the antimechanized defense of a command? *A.* The commander of every unit is responsible for the security of his command against mechanized attacks and raids. The measures for this defense are carefully coordinated, all available means being included in the defense plan. The measures taken to provide a defense against this type of attack will depend upon the estimated ability of the enemy to conduct this type of operation.

Q. What factors should be considered in siting antimechanized weapons? *A.* These weapons are sited to defend the natural and artificial obstacles which protect a position, and primarily to cover likely avenues of approach. The organic automatic weapons of coast artillery units are provided primarily for defense against air attack. When employed as antimechanized weapons, positions should be selected and the guns sited to provide the maximum protection against mechanized attack. The positions so selected may not be the best positions to provide a defense against air attack. Therefore, the employment of the automatic weapons available must be given careful consideration in order to provide the best protection against the type of attack which is considered most dangerous to the defense. The plans for the defense will be coordinated by higher commanders.

Q. What are some of the requirements of a suitable position for antimechanized weapons? *A.* Good fields of fire up to 1,000 yards, possibilities of flanking fire, protection against direct mechanized attack, covered routes to the firing position, availability of alternate positions which can be occupied quickly by manhandling the gun, and nearby cover for ammunition. The position should permit shifting fire to any direction from which attack may be probable.

Q. Name three means of attaining security against hostile ground attacks and raids. *A*.

(1) Information of the enemy.

(2) Concealment.

(3) Organization of the ground.

Q. What elements of enemy information should be procured for the attainment of security against hostile ground attacks and raids? *A*. Timely, accurate, complete, and continuous information of enemy dispositions, movements, composition, strength, and capabilities.

Q. In the attainment of security against hostile ground attacks and raids, what is meant by organization of the ground? *A*. Organization of the ground includes construction or improvement of obstacles, clearing of fields of fire, selection and preparation of defensive positions, and construction of bomb-, splinter-, and gas-proof shelters.

Q. What is sabotage? *A*. Malicious destruction of or injury to property by enemy sympathizers.

Q. What acts of sabotage might be expected against seacoast artillery installations? *A*. Acts of sabotage to be expected vary from simple depredations, such as the cutting of telephone lines, to attempts at demolition of matériel.

Q. During what stages of a conflict is the danger of sabotage greatest? *A*. During the early stages.

Q. What special precautions should be taken against sabotage, and to avoid surprise by raiding parties? *A*. Such precautions should include—

(1) Continuous effective employment of the intelligence agencies and the communication systems of the command.

(2) Effective patrolling to cover bridges, causeways, swamp crossings, roads and trails, and other avenues of approach to batteries, bivouacs, and other installations.

(3) Constant vigilance.

(4) Protection of installations by interior guards.

(5) With reference to beach defense they should include—

(*a*) Patrols on adjacent beaches, if not protected by the outpost forces of the other arms which have been charged with the responsibility for this protection.

(*b*) Preparations for close defense of batteries and installations, including defense against troops transported by air, regardless of whether or not supporting troops of the other arms are present.

(*c*) Underwater listening devices.

(*d*) Small boat patrols equipped with means of radio and visual signal communication.

146. Protection against low-flying aircraft.—*Q*. What types of attack may be delivered by low-flying aircraft against mobile seacoast artillery personnel and matériel? *A*. Attacks by light and dive bombardment, or equivalent naval aviation, employing demolition and fragmentation bombs, all types of aircraft automatic weapons, and gas.

Q. What active means of defense available to the ground forces are most effective against this type of attack? *A*. The antiaircraft automatic weapons.

Q. What passive means are most effective against this type of attack? *A*. Adequate cover, concealment, dispersion, and individual and collective gas protection.

Q. How are the personnel warned of an impending attack? *A*. By individual and collective alertness, and the use of suitable sound-making devices such as sirens, gongs, and whistles.

Q. How is such an attack met? *A*. All available automatic weapons should be set up to protect the position, and should be manned as soon as the alarm is given. Maximum use is made of all small arms available. Personnel not engaged in firing should scatter and make full use of available cover and concealment.

147. Construction of shelters.—*Q*. What is a shelter? *A*. A shelter is any cover, natural or artificial, that protects troops, ammunition, and supplies from fire, including gas and aerial bombs.

Q. Should large quantities of ammunition be stored in one shelter? *A*. No. It is preferable to have several shelters in order to limit the damage that may result from a single hit.

Q. Against what kind of shells should artillery troops be protected? *A*. High-explosive shell, gas shell, and bombs dropped from airplanes.

Q. How are shelters classified according to their depth? *A*.

(1) Surface shelters, constructed above ground.

(2) Cut-and-cover shelters, made by digging an open pit which is then provided with overhead cover, usually extending above the surface.

(3) Cave shelters, which are subterranean chambers, protected by the undisturbed earth above them.

Q. What determines the type and strength of shelter to be constructed? *A*. The terrain, the time and material available, the amount of protection required, and the probable length of time the position will be occupied.

Q. If the position is likely to come under fire of guns of 5-inch caliber and above, what type of shelters should be provided? *A*. Cut-and-cover or cave shelters.

Q. Which type of shelter requires the greatest amount of concealment? *A*. Surface, cut-and-cover, and cave, in the order named.

Q. How near should shelters be to the gun positions? *A*. Just as near as possible, consistent with safety and concealment (usually not over 100 yards). The purpose of shelters is to afford the troops protection *close* to their combat positions.

Q. Mention some other requirements for shelters. *A*. They should have at least two exits, proper drainage and ventilation, and protection against gas.

Q. How are shelters protected against gas? *A*. By placing a curtain of canvas, blanket, or other suitable material, weighted at the bottom, across each entrance. If it is possible, a gas trap or lock should be made by means of a short passageway into the shelter with a gas curtain at the inner end and another at the outer end of the passageway.

Q. What precautions should be taken in using old shelters? *A*. Inspect them carefully to be certain there is no gas in them.

Q. Are large or small shelters preferable? *A*. From a tactical point of view, several small shelters are preferable to one large one as they permit troops to get out to their position more quickly.

Section III

MAP READING

148. Scales, contours, and conventional signs.—*Q*. What is a map? *A*. A map is a picture of an area of ground, which shows certain important features accurately to scale.

Q. Do the features shown on a map appear as they do on the ground? *A*. No. They are represented by symbols, called conventional signs, which resemble the actual features as nearly as practicable.

Q. What is a topographical map? *A*. One which (according to its scale) shows all the natural and artificial features of the terrain, such as hills, valleys, streams, woods, roads, towns, houses, and bridges.

Q. What is a military map? *A*. A military map is one which shows particularly those features, and conveys that information, which are important for military purposes.

Q. What is meant by map reading? *A*. Map reading is the art of understanding the information given by the map.

Q. What is meant by the scale of a map? *A*. The scale of a map is the relation between any distance shown on the map and the corresponding distance on the ground. It is always the same for any one map.

Q. How is the scale of a map indicated or expressed? *A*.

(1) As a representative fraction (RF), such as 1/5,000 (or 1:5,000), which means that any distance on the map is $\frac{1}{5000}$ of the corresponding distance on the ground. The RF is always expressed with a numerator of *unity*. The RF is always the ratio of a map distance to the actual or ground distance it represents. Thus if 2 inches (on the map) represent 10 miles on the ground, the relation can at once be expressed thus:

$$\frac{\text{Map distance}}{\text{Ground distance}}=\frac{\text{2 inches}}{\text{10 miles}}$$

Then reduce the numerator and denominator to the same unit, and then reduce the numerator to *unity* to get the RF, as follows:

$$\frac{\text{2 inches}}{\text{10 miles}}=\frac{\text{2 inches}}{\text{10 miles}\times 5{,}280\text{ ft.}\times 12\text{ inches}}=\frac{\text{2 inches}}{\text{633,600 inches}}=\frac{1}{316{,}800}=\text{RF}$$

(2) In words and figures, such as 6 inches=1 mile, meaning that 6 inches on the map represent 1 mile on the ground. From this, one can easily get the RF, thus:

$$\frac{\text{6 inches}}{\text{1 mile}}=\frac{\text{6 inches}}{\text{1 mile}\times 5{,}280\text{ ft}\times 12\text{ inches}}=\frac{\text{6 inches}}{\text{63,360 inches}}=\frac{1}{10{,}560}=\text{RF}$$

(3) By a graphical scale drawn on the map, which shows ground distances in their usual units, such as miles, thousands of yards, or hundreds of feet, as they appear on the map. A graphical scale is easily made if one knows the RF of the map. Thus, suppose the RF is 1:5,000 and a graphical scale to read to 1,000 yards is wanted. Since any distance on the map is $\frac{1}{5000}$ of the same distance on the ground, 1,000 yards on the map will be as follows:

$$\frac{\text{1,000 yards}}{5{,}000}=\frac{\text{1 yard}}{5}=0.2\text{ yards}=0.2\text{ yards}\times 36\text{ inches}=7.2\text{ inches},$$

that is, one 1,000-yard division of the scale will be 7.2 inches long. This can be divided into 10 equal parts, each of which will represent 100 yards. (See fig. 150 for examples of graphical scales.)

Q. Why is it necessary to have maps of different scales? *A*. The scale of a map must be large enough to show the particular features about which information is needed. Thus, a map showing the positions of all buildings and streets in a town must be of much larger scale than a map intended only to show the size and positions of the various counties in a State. A small-scale map is one which shows a large area in a small space. Thus 1 inch=100 miles would be a very small scale map on which very little detail could be shown. A map on a scale of 1 inch=25 feet would be a very large scale map on which individual trees could be shown in their exact positions. The first map could be used by a general planning a large campaign, the second by an architect laying out a plan of a house and grounds.

Q. What determines the proper scale of a map? *A*. It should be just large enough to show the detail necessary to serve the purpose for which it is to be used.

Q. How is direction determined on a map? *A*. By referring to an arrow on the map which points due north. It is called the meridian.

Q. How is direction measured and indicated on a map? *A*. By azimuth, as in gunnery. Azimuth on a map is measured from the north point of the meridian, clockwise around the horizon. It is measured in mils or in degrees, minutes, and seconds.

Q. What are the cardinal points of direction, and what are their azimuths? *A*. North, east, south, and west. Moving clockwise around the horizon: north, the origin, is azimuth 0°; east is azimuth 90°; south is azimuth 180°; and west is azimuth 270°.

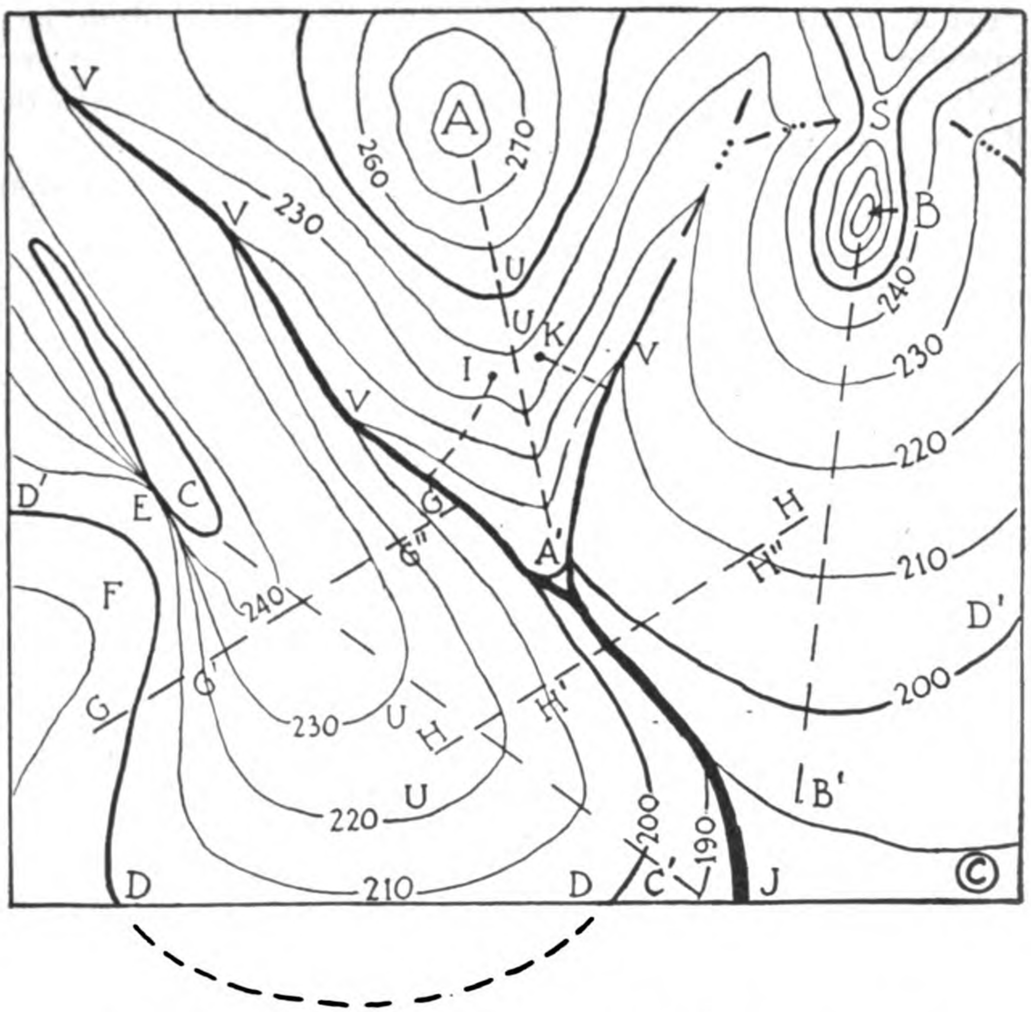
Q. What is meant by orienting a map? *A*. Placing the map in such a position that the meridian or arrow on the map points to north on the ground. Every line on the map will then be parallel to the line on the ground which it represents, and all the features on the map will be in the same relative positions as the actual objects on the ground.

Q. What is elevation? *A*. The elevation of any point is its vertical height in feet above some level, usually sea level.

Q. How is elevation indicated on a map on a flat piece of paper? *A*. By means of contours.

Q. What is a contour? *A*. An irregular line joining all points at the same elevation. A contour is thus a level or horizontal line.

Q. How are contours separated vertically? *A*. By some definite interval, such as 5, 10, 20, 50, or 100 feet, depending on the scale of the map and the nature of the ground. This constant interval is known as the vertical interval or contour interval of the map. Certain contours are numbered with their height (in feet) above sea level.



A, B. Hilltops or peaks.
C. Ridge.
DD. Contours close on themselves.
E. Cliff.
AA'. Uniform slope.
BB'. Concave slope.
CC'. Convex slope.
IG. Line of steepest slope.
B. Steep slope.
B'. Gentle slope.
S. Saddle.
UU. Hill contours.
VV. Valley contours.
A'. Stream junction.

FIGURE 147.—Typical ground forms as shown by contours.

Q. Do contours show the ground forms, such as hills, valleys, and ridges? *A.* Yes. When one has become familiar with them, they show accurately all the forms of nature.

Q. Mention briefly the principal characteristics of contours. *A.* (1) A contour is a horizontal line joining points of equal elevation.

(2) Contours are spread at uniform vertical intervals.

(3) Every contour is a continuous closed curve. (It may not close within the limits of the map.)

(4) There may be any number of separate contours of the same elevation.

(5) A small, closed contour indicates either a hilltop or a depression.

(6) Contours never touch or cross each other except in the case of a vertical or overhanging cliff.

(7) Contours are at right angles to the lines of steepest slope.

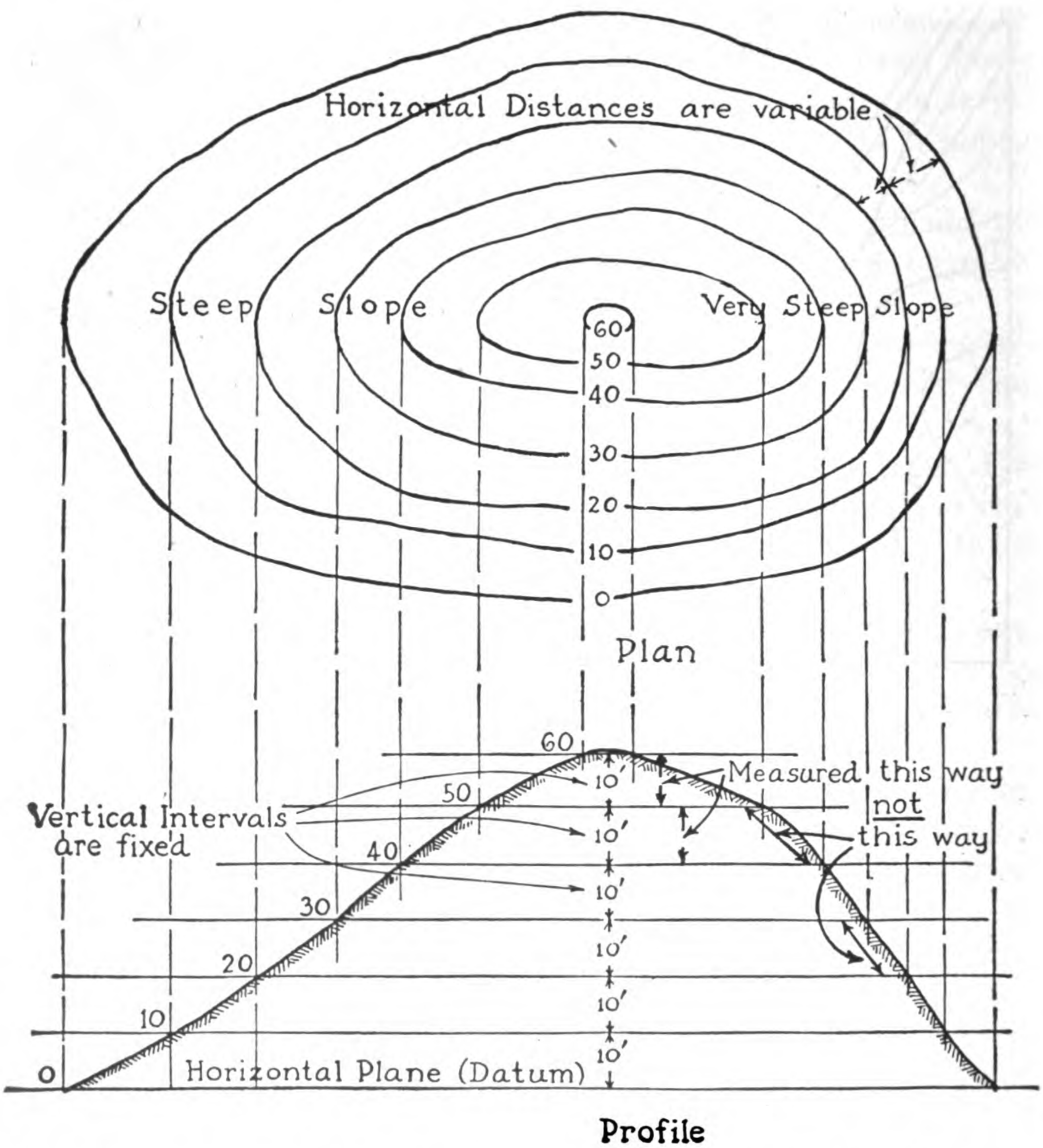


FIGURE 148.—Plan and profile of a hill. (Contours are the lines that would be left on the ground by successive horizontal slices, 10 feet thick.)

(8) The horizontal spacing of contours indicates the degree of slope, steep if they are close together, gentle if they are far apart. They also indicate the kind of slope—uniform, concave, or convex.

(9) Valley contours are usually of **V**-shape, and hill or ridge contours of **U**-shape.

(10) Adjacent contours resemble each other.

Q. How is the elevation of a point between two contours determined? *A*. By its relative distance from the contours on either side. Thus in figure 149, the elevation of the number "46" is about 527 feet.

Q. Point out the characteristic ground forms in figure 147 and explain how they are shown by the contours. *A*. (See fig. 147.)

Q. What is a slope? *A*. The inclination of ground to the horizontal. The slope of a road is called its grade.

Q. How can one determine the average grade of a length of road from a contoured map? *A*. Measure the horizontal distance along the road in feet, using the scale of the map. Find from the contours the difference in elevation between the two ends. The difference in elevation of the two ends, divided by the length of the road (both in feet), will give the average grade in percent.

Q. How is a steep grade indicated on a map? *A*. By contours close together, showing a considerable change of elevation in a short distance.

Q. What is a profile? *A*. It is a section of the ground as it would appear if it were sliced vertically with a huge knife.

Q. Give a simple method of making a profile. *A*. To make a profile of the hill shown in figure 148, along the line of the words "Steep slope, Very steep slope," draw a number of parallel lines at uniform intervals, as in the lower figure, numbering them at 10-foot intervals from 0 to 60 feet (the limiting elevations of the hill). Mark each point where a contour cuts the line "Steep slope," and project these points vertically down to the correspondingly numbered lines. Join the points thus found by a line. It will be the contour of the hill on the line "Steep slope."

Q. What are conventional signs? *A*. They are the symbols used by map makers to show the various features of the terrain. As nearly as practicable, they resemble or suggest the features they are intended to show.

Q. Point out and name the conventional signs shown in figure 149. *A*. (See fig. 149.)

Q. What colors are used on standard topographical maps and what do these colors mean? *A*. Colors are used to show certain classes of features. On the standard topographical map they show the following:

(1) *Black.*—All artificial features, such as houses and roads.

(2) *Blue.*—All water, such as streams, ponds, and lakes.

(3) *Green.*—Vegetation, such as woods and grassland.

(4) *Brown.*—The ground forms as shown by contours.

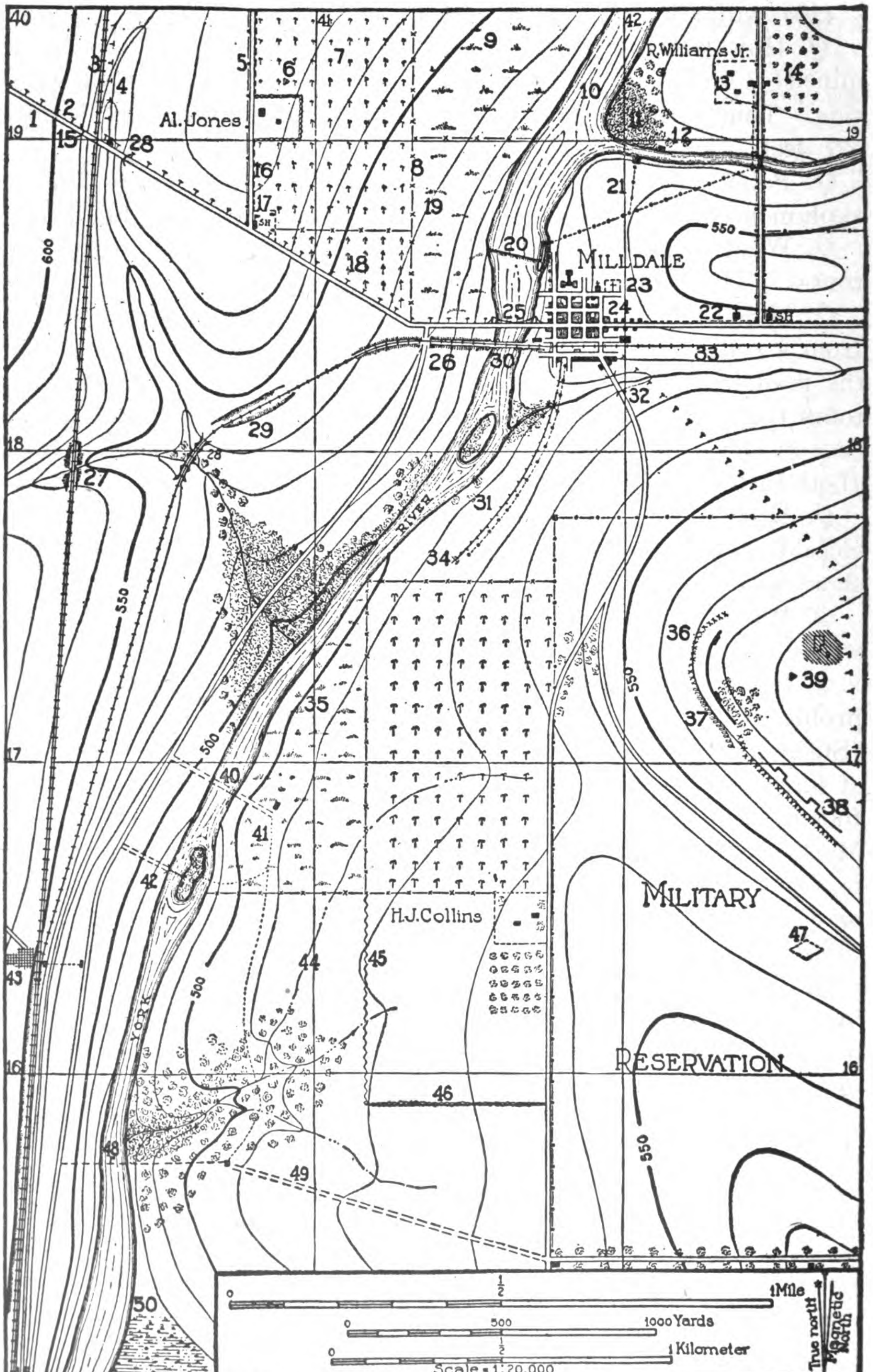


FIGURE 149.—Conventional signs.

FIGURE 149.—Conventional signs—Continued.

Numerical key

1. Good motor road.
2. Telephone or telegraph line.
3. Double-track standard-gage railroad.
4. Stream or creek (blue on a four-color map).
5. Fence, smooth wire.
6. Triangulation point or primary traverse station.
7. Cornfield.
8. Fence, barbed wire.
9. Tall tropical grass.
10. River (blue on a four-color map).
11. Woodland (deciduous trees).
12. Lone trees.
13. Buildings in general.
14. Orchard.
15. Railroad crossings, railroad beneath.
16. Fence of any kind (or board fence).
17. Schoolhouse.
18. Cultivated field, sugarcane.
19. Grassland in general.
20. Dam.
21. Electric power transmission line.
22. Church.
23. Cemetery.
24. City, town, or village.
25. Bridge, suspension.
26. Railroad crossing, railroad above.
27. Fill.
28. Bridge, steel.
29. Cut, railroad.
30. Bridge, truss, for standard-gage railroad.
31. Narrow-gage railroad.
32. Bridge, highway.
33. Railroad, single-track, standard-gage.
34. Mine or quarry of any kind (or open cut).
35. Pasture or grassland in general.
36. Wire entanglement.
37. Low or concealed entanglement.
38. Trenches (dotted when proposed).
39. Demolitions.
40. Ford, general symbol for vehicle ford.
41. Good pack trail or footpath.
42. Bridge, foot.
43. City, town, or village (generalized).
44. Intermittent stream.
45. Worm fence.
46. Stone fence.
47. Tank trap.
48. Equestrian ford.
49. Road, poor motor or private.
50. Marsh in general.

Alphabetical key

Bridge, foot	42
Bridge, highway	32
Bridge, highway, made of steel	28
Bridge, suspension	25
Bridge, truss	30
Buildings in general	13
Cemetery	23
Church	22
City, town, or village (generalized)	43
Combination showing city, town, or village	24
Crossing, railroad (railroad above)	26
Crossing, railroad (railroad beneath)	15
Cultivated field, corn	7
Cultivated field, sugarcane	18
Cut	29
Dam	20
Demolitions	39
Electric power transmission line	21
Fence of any kind (or board fence)	16
Fence, barbed wire	8
Fence, smooth wire	5
Fence, stone	46
Fence, worm	45
Fill	27
Ford, equestrian	48
Ford, for vehicles	40
Grass, tall tropical	9
Grassland in general	19
Marsh in general	50
Mine or quarry of any kind (or open cut)	34
Orchard	14
Pasture or grassland in general	35
Railroad, double-track, standard-gage	3
Railroad, narrow-gage	31
Railroad, single-track, standard-gage	33
River (blue on a four-color map)	10
Road, good motor	1
Road, poor motor or private road	49
Schoolhouse	17
Stream or creek (blue on a four-color map)	4
Stream or creek, intermittent	44
Tank trap	47
Telephone or telegraph line	2
Trail or footpath	41
Trees, lone	12
Trenches (dotted when proposed)	38
Triangulation point or primary traverse station	6
Wire entanglement	36
Wire entanglement (low or concealed)	37
Woodland (deciduous trees)	11

149. Location of position by coordinates.—*Q*. How are military maps divided? *A*. Into squares 1,000 yards on a side by two sets of parallel lines, one of these sets being at right angles to the other. (See fig. 150.)

Q. What is this system of lines or squares called? *A*. A grid system, or system of rectangular coordinates.

Q. What is the use of this grid or coordinate system? *A*. It is used to make it possible to describe and locate points on a map by referring their positions to the coordinate lines.

Q. What are the coordinate lines running from left to right called? *A*. X lines.

Q. What are the other coordinate lines called? *A*. Y lines.

Q. Describe the grid system for the continental United States.

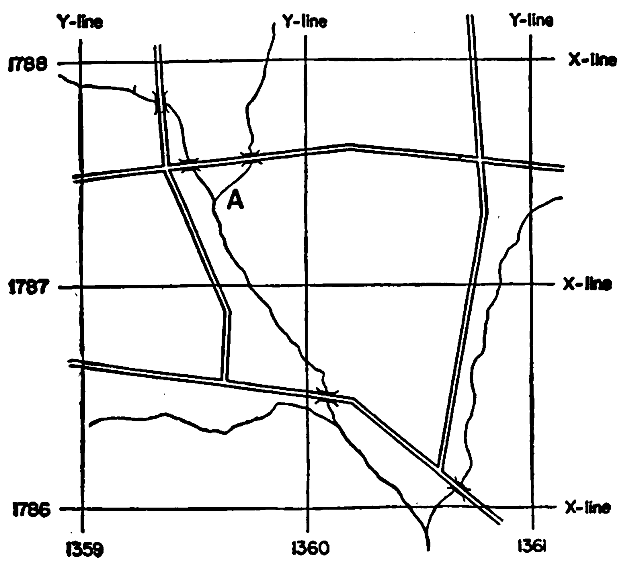


FIGURE 150.—Rectangular coordinates. A 1,000-yard grid printed upon a terrain map (1 : 20,000 scale). (Not reproduced to scale.)

A. The country is divided into zones running north and south, each covering 9° of latitude. The central true meridians of adjacent zones are 8° apart, hence there is an overlap of 1° at the boundaries, included in both adjacent zones. The west longitudes of the central meridians of the zones are 73°, 81°, 89°, 97°, 105°, 113°, and 121°. In each zone the Y lines are all parallel to the central true meridian. The direction of the Y line at any point is called grid north; it is the same as true north only at the center of the zone. The X lines are perpendicular to the Y lines, and so they are true east and west lines only at the center of the zone. In each zone the origin of coordinates, or zero point, is to the west and south of the zone, and hence all coordinates are positive. (See fig. 150.)

Q. What is the X distance or X coordinate of a point on a map?

A. The distance of that point to the right of the origin of measurement measured along an X line.

Q. What is the Y distance or Y coordinate of a point on a map? *A*. The distance of that point upward from the origin of measurement measured along a Y line.

Q. What is the origin or point from which measurements are made? *A*. A point off the map to the west and south. The distance from this origin, in thousands of yards, is indicated on each X line and each Y line.

Q. In order to locate a point on a map, what information is useful? *A*. The X and Y coordinates of that point.

Q. In what order are the coordinates of a point always given. *A*. First the X coordinate and then the Y coordinate.

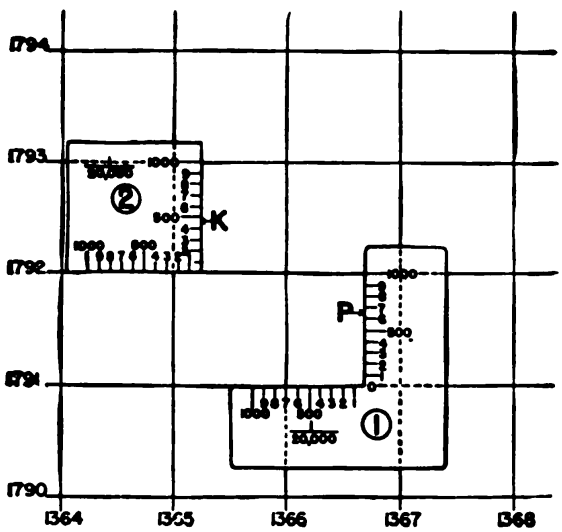


FIGURE 151.—To plot the position of a point with a coordinate scale on a terrain map (1 : 20,000 scale) having a 1,000-yard grid. (Not reproduced to scale.)

Q. How can their order be remembered easily? *A*. Remember that in the alphabet X comes before Y, or remember the rule "Read right up."

Q. How can one X line be distinguished from the other X lines or one Y line from the other Y lines? *A*. Each set of lines is numbered.

Q. How are the X lines numbered? *A*. In the left- and right-hand margins, increasing upwards from the bottom of the map.

Q. How are the Y lines numbered? *A*. Along the upper and lower margins, increasing from left to right of the map.

Q. Is the number of a coordinate line given in the margin of a map the full number of that line? *A*. No. It is only a part of its full number.

Q. Are there any coordinate lines on a map that have their full numbers given? *A.* Yes. The first X line at the bottom of the map and the first Y line at the left of the map.

Q. Explain in detail how to read the coordinates of any point on a gridded map. *A.* The coordinates of any square in the grid system are the X and Y coordinates of the lower left-hand (southwest) corner of the square. The coordinates of the lower left-hand square in figure 151 are 1,364,000–1,790,000 but are usually written 1364–1790, it being understood that each number represents thousands of yards. These coordinates also locate to the nearest thousand yards any point in the lower left-hand square of figure 151. To locate a point more closely, assume that each side of the square in question is divided into 10 equal parts, each of which represents 100 yards. Then the coordinates of the center of the lower left-hand square would be expressed as 1364.5–1790.5, which locates the center to the nearest hundred yards in each direction. The method may be further refined to read to the nearest 10 yards.

Q. What is a coordinate scale? Explain its use. *A.* A coordinate scale is a right-angled ruler made of thin metal, celluloid, or other material with scales on it equal in length to the grid interval of the map being used (fig. 151). To plot any point on the map, for instance the point P of which the coordinates are given as 66.70–91.65, place the coordinate scale on the map in position ① as shown in figure 151. The position of P can be marked at once with a pin or sharp pencil. It should be noted here that the first two numbers of the coordinate expression 1366.70–1791.65 have been dropped because they are common to all points in the section of map under consideration. The process of reading the coordinates of a point appearing on the map is the reverse of the method given for plotting a point on the map.

Q. How many norths are indicated on an artillery map? *A.* Three. True north, magnetic north, and grid north. (See fig. 149.)

Q. Define each. *A.*

(1) True north is geographic north, or the direction of the north pole.

(2) Magnetic north is the direction in which the compass points when used in the area covered by the map. The angular difference between true north and magnetic north is called the magnetic declination.

(3) Grid north is the direction in which the Y lines of the coordinate system point.

Q. When indicating direction, which north is generally used? *A.* Grid north.

Q. On what kind of maps is such a system of coordinates usually found? *A.* On topographical maps.

Q. What type of maps are often used to cover harbors and water areas? *A.* Coast and Geodetic Survey maps.

Q. Do these maps generally have a system of grid coordinates? *A.* No. There is, however, a local system of grid coordinates placed on these maps so points can be located in the same way.

Q. What do these maps show? *A.* Coast line, channels, depths of water, location of lights, channel markers, and certain permanent features of the terrain along the shore.

NOTE.—In addition, the candidate should be required to give the coordinates of several points on a map.

150. Following route indicated on map.—*Q.* How is a route, selected from a map, usually indicated? *A.* It is indicated by naming successive points along the route that can easily be identified locally.

Q. How are the best roads identified on the ground? *A.* Usually they will be paved, and will be wider, straighter, and have easier grades than secondary roads. If not paved, they will at least be wide and show signs of traffic. They usually have telegraph or telephone lines running parallel to them. Except in very sparsely settled country, the principal roads will also be indicated by signposts at intersections and Federal and State numbers which are shown on commercial route maps.

Q. What points along a route are most easily identified? *A.*

(1) Large towns.
(2) Villages.
(3) Important crossroads or junctions.
(4) Crossings of large streams.
(5) Railroad crossings.
(6) Crests of important hills or ridges.
(7) Passes or gaps through lines of hills.

Q. How may an indicated route be traced on a map? *A.* By locating in succession the towns, crossroads, and other important points named.

Q. How are crossroads and road junctions indicated on a map? *A.* By numbers sometimes followed by a letter as 423 or 423–A.

Q. How would crossroad 418–A be written in indicating a route? Road junction 403? *A.* CR 418–A. RJ 403.

Q. To what do the numbers in the previous answer refer? *A.* To the elevation of the crossroad or road junction.

Q. In case a crossroad or junction is not plainly marked on the map, how would it be indicated? *A*. By its coordinates, as CR (4365.5-6427.3) or RJ (7295.4-8665.4).

NOTE.—The candidate should be able to trace out on a map a route that has been indicated to him.

151. Data as to roads, bridges, fords, grades, and swamps.—
Q. What information concerning a road can usually be obtained from a good topographical map? *A*.

(1) The distance between any two points.

(2) Whether or not the road is paved, and often the kind of pavement.

(3) The width of the road, that is, whether narrow, wide, or quite wide.

(4) The steepness and length of important grades.

(5) The stream crossings, whether bridges, fords, or ferries, and sometimes the kind and principal dimensions of bridges; width, depth, nature of bottom, and velocity of current in the case of fords; and the kind of ferry.

Q. What is usually the most critical question in the selection of a route? *A*. The stream crossings.

Q. How would one (candidate) decide the question as to whether a certain bridge was safe for the transport accompanying his organization. *A*. Reports on the practicability of all bridges should be secured in advance, if possible. If not, the following observations will indicate the safety of bridges in most cases.

(1) Bridges on important routes habitually carry heavy commercial trucks and busses moving at high speed, and are therefore safe for artillery transport moving slowly.

(2) If a bridge is massive and reasonably new, or apparently in good condition as to flooring, paint, etc., it is probably safe.

(3) Bridges may be compared with similar bridges that have been crossed. If they look too light or appear to be of older design than other bridges, they should be regarded with suspicion.

(4) If there is any chance that the enemy may have tampered with a bridge, its abutments, piers, flooring, and truss members or cables should be examined to make sure they are intact.

(5) If in doubt about any bridge, send across some lighter vehicle and watch the bridge as it crosses. If there is no excessive sway or vibration, the bridge is probably safe for the next heavier load. Send loads across one at a time and at very slow speed.

Q. How may the practicability of a ford be determined? *A*. Note the swiftness of the current. Send a line of men to wade across, preferably barefoot, to determine the depths, nature of the bottom, and whether the banks are steep or slippery or both. Some of the lighter vehicles may then be sent across, and these can assist the heavier vehicles by pulling them out on the far side, if necessary.

Q. In case a bridge or ford proves impassable, what should be done? *A*. Detour to another crossing.

Q. What, in general, can be said as to the practicability of routes? *A*. That, in general, important main routes are practicable for artillery transport; that in the case of less important routes it is desirable to have a reconnaissance made in advance by competent experts; and that any route that lacks a bridge at an important crossing is of doubtful practicability.

NOTE.—The candidate should be required to examine a route shown on a map, to give all the information concerning it that can be obtained from the map, and his opinion as to the practicability of the route.

SECTION IV

ELEMENTARY PRINCIPLES OF ELECTRICITY, MAGNETISM, AND INDUCTION

152. Electricity.—*Q*. What is the term used to designate the pressure that causes a current of electricity to flow? *A*. It is called electromotive force, potential or, more commonly, voltage.

Q. What is a volt? *A*. The unit for measuring electromotive force.

Q. What is an ampere? *A*. A unit for measuring the magnitude (amount) of an electric current.

Q. What is resistance? What is the unit of resistance? *A*. Resistance is the opposition offered by a conductor to the flow of an electric current. The unit of resistance is the ohm.

Q. What is Ohm's law? *A*. The electric current in a conductor equals the voltage applied to the conductor divided by the resistance of the conductor.

Q. What are three simple formulas by which Ohm's law may be expressed? *A*.

(1) $\text{Amperes}=\frac{\text{volts}}{\text{ohms}}\left(I=\frac{E}{R}\right)$

(2) $\text{Volts}=\text{amperes}\times\text{ohms}\ (E=IR)$

(3) $\text{Ohms}=\frac{\text{volts}}{\text{amperes}}\left(R=\frac{E}{I}\right)$

Q. What are the common sources of electrical power? *A*. Batteries, generators, and magnetos.

Q. What are the two principle types of batteries? *A*. Storage (wet) batteries and dry batteries.

Q. What is a conductor? *A*. Any substance offering very little resistance to the flow of electric current is known as a conductor.

Q. What is insulation? *A*. Insulation is any substance that restricts or prevents the flow of an electric current. Rubber, porcelain, enamels, linen, and paper are used extensively for insulation.

Q. What is an insulated conductor? *A*. A conductor covered with insulation to prevent grounds or short circuits.

Q. What is direct current? *A*. A current flowing constantly in one direction.

Q. What is alternating current? *A*. A current flowing first in one direction, then in the opposite direction, changing direction many times every second.

Q. What is a cycle? *A*. A complete change or alteration from a current in one direction to the opposite direction and back to the original direction, is known as a "cycle." The frequency of an alternating current means the number of cycles that occur in a second, as 25 (sometimes employed on power lines) or 60 (commonly employed).

Q. What is a circuit? *A*. A circuit is the complete path through which current can flow, including the source of power, the conductors, and electrical devices such as lamps, bells, or motors.

Q. What is a closed circuit? *A*. A continuous path with a return to the source of power.

Q. What is an open circuit? *A*. An incomplete or broken circuit in which no current can flow.

Q. What is a switch? *A*. A mechanical means by which an electric circuit is closed or opened.

Q. What kind of current is obtained from a battery? *A*. Direct current only.

Q. What are the poles or terminals of a battery? *A*. The two connections between the battery and its circuit. They are known as the positive (+) and negative (−) poles. The positive pole is that from which the electrical current flows out of the battery, and the negative pole the one by which it returns again to the battery.

Q. Which is the positive and which the negative pole of a dry cell? *A*. The carbon is the positive pole and the zinc is the negative pole.

Q. What is the voltage of a dry cell? *A*. About 1½ volts.

Q. What is the voltage of one cell of a storage battery? *A.* About 2 volts.

Q. What is meant by the expression "in series"? Show how to connect a battery in series. *A.* See fig. 152, upper. The cells of a battery are said to be in series when the positive terminal of each cell is connected to the negative terminal of the next cell. The cells are thus in tandem, the entire current generated by all of them passing through each cell.

Q. What is the voltage of a battery with the cells connected in series? *A.* The sum of the voltages of the separate cells. Thus, if each cell

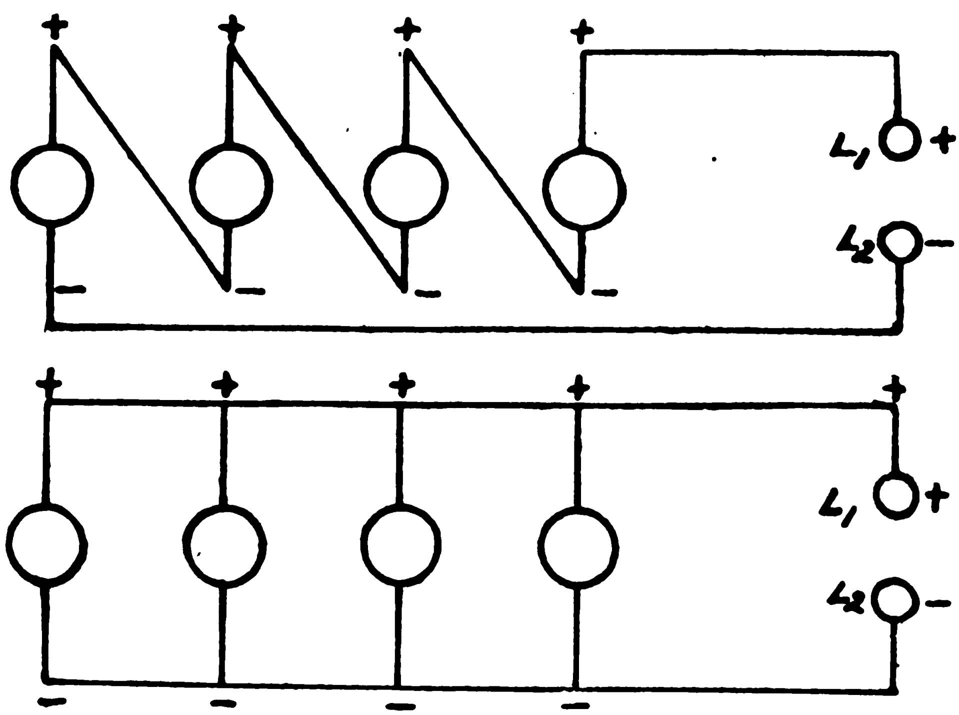


FIGURE 152.—Upper: Batteries connected in series. Lower: Batteries connected in parallel or multiple.

has a voltage of 2, a battery of 4 cells connected in series has a voltage of $(2\times4)=8$.

Q. What is the current of a battery with the cells connected in series? *A.* The average current of the separate cells of a battery. Thus, if each cell produces a current of 20 amperes, a battery of 4 cells connected in series will also produce a current of 20 amperes.

Q. Assume that each of the cells in figure 152, upper, is a dry cell with a voltage of 1½ volts. What is the voltage of the combination? *A.* The electromotive force or voltage of the combination of cells will be 6 volt $(4\times1\frac{1}{2})$.

Q. What is meant by the expression "in parallel" or "in multiple"? Show how to connect four batteries in parallel. *A.* See figure 152, lower. Batteries are said to be in parallel when all their positive terminals are connected to a common point (L_1), and all their negative terminals to another point (L_2). The batteries are thus abreast, a portion only of the resultant current passing through each battery.

Q. What is the voltage of a battery with the cells connected in parallel? *A.* The average voltage of the separate cells of the battery. Thus, if the voltage of each cell is 2, a battery of 4 cells connected in parallel will also have a voltage of 2.

Q. What current will be obtained from a battery with the cells connected in parallel? *A.* The sum of the currents of the undivided cells. Thus, if each cell produces a current of 20 amperes, a battery of 4 cells connected in parallel will produce a current of $(4 \times 20) =$ 80 amperes.

Q. Assume that each of the cells in figure 152, lower, is a dry cell with a voltage of 1½ volts. What is the voltage of the combination? *A.* The electromotive force or voltage of the combination of cells will be 1½ volts.

Q. How is the capacity of a storage battery stated? *A.* In ampere-hours.

Q. What is an ampere-hour? *A.* A steady current of 1 ampere flowing for 1 hour.

Q. What is meant by saying that a battery has a capacity of 60 ampere-hours? *A.* It means that it can furnish 60 amperes for 1 hour or 1 ampere for 60 hours.

Q. What is electrolyte? *A.* The fluid content of a wet (storage) battery.

Q. What care is necessary to preserve a storage battery? *A.*

(1) Refill the battery with distilled water so that the plates are always covered with electrolyte.

(2) Never allow the battery to discharge fully.

(3) Do not add sulfuric acid to the battery.

(4) Keep battery always in an upright position.

(5) Never leave a battery connected when current is not required.

(6) Keep battery fully charged as much as possible.

(7) Handle the battery with care to prevent breaking the container.

(8) Treat terminals with vaseline or grease to prevent corrosion.

(9) Keep battery, battery room, and all accessories clean.

Q. Why is it necessary to use distilled water in a storage battery? *A.* Because ordinary water usually contains minerals which are acted upon by the acid and form combinations which soon render the battery useless.

Q. How is it determined whether a storage battery is charged or discharged? *A*. By measuring the specific gravity of the electrolyte (liquid) with a hydrometer. When fully charged, the specific gravity is 1.300; when fully discharged, 1.130. A battery should never be discharged so that its specific gravity is below 1.200.

Q. What is the meaning of the term specific gravity as applied to an electrolyte? *A*. It means the weight of the fluid as compared to the weight of an equal volume of water. The specific gravity of water is taken as 1.000.

153. Magnetism and induction.—*Q*. What is a permanent magnet? *A*. A bar of iron or steel which possesses the property of attracting or repelling other pieces of iron or steel.

Q. What is an electromagnet? *A*. A coil of wire through which a current is flowing. Its magnetism is increased by placing it about a core of soft iron.

Q. Explain briefly the principle of electromagnetic induction. *A*.

(1) If an electric circuit is moved in the vicinity of a magnet, or if a magnet is moved in the vicinity of an electric circuit, a current of electricity is set up or "induced" in the circuit. This is the principle used in the generator and magneto.

(2) If two electric circuits are placed close to each other, any variation in the current passing through one circuit will set up or induce a current in the other circuit. This principle is used in the induction coil and transformer.

Q. Explain the construction of an induction coil. *A*. To construct an induction coil, two separate coils of insulated wire are wound spirally about an iron core. Each coil forms a circuit by itself. One of the coils, called the primary, consists of a relatively small number of turns of coarse wire. The other coil, called the secondary, consists of a relatively large number of turns of fine wire.

Q. Explain the operation of an induction coil. *A*. An electric current is passed through the primary coil. If this current is varied or changed in any way, either by turning it on or off, increasing or decreasing its intensity, or reversing its direction, an induced current will be set up in the secondary coil, which lasts as long as the change of current in the primary coil continues.

Q. How can the voltage in the secondary coil of an induction coil be determined? *A*. The voltage (EMF) of the current induced in the secondary coil is approximately equal to the voltage in the primary coil, multiplied by the ratio between the number of turns in the two coils. Thus if the number of turns in the primary coil is 8 and in the secondary coil 96, and the voltage in the primary coil is 10, the voltage of the induced current in the secondary coil will be $10 \times 96 \div 8 = 120$ volts.

Q. Will an alternating current passing through the primary coil induce a current in the secondary coil? *A*. Yes, because the voltage in the primary coil is constantly changing in direction and intensity, which is the condition necessary to induce a current in the secondary.

INDEX

INDEX

INDEX

INDEX

INDEX

INDEX

INDEX

[A. G. 062.11 (10–3–41).]

BY ORDER OF THE SECRETARY OF WAR:

G. C. MARSHALL,
Chief of Staff.

OFFICIAL:

J. A. ULIO,
Major General,
The Adjutant General.

DISTRIBUTION:

IBn and H 4 (3); IC 4, 155-mm Searchlight Battery (15); (155-mm Gun Battery (20); 155-mm Hq Btry (R & Bn) (15); Ry Gun Battery (20); Ry Hq Btry (R & Bn) (12); RTC 155-mm & Ry Btry (30); RTC Hq Btry (10)).
(For explanation of symbols see FM 21-6.)

U. S. GOVERNMENT PRINTING OFFICE: 1942

For sale by the Superintendent of Documents, Washington, D. C.