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SUBMARINE MINING

Prepared Under Direction of the Chief of Coast Artillery

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PART ONE

GENERAL PRINCIPLES OF SUBMARINE MINE DEFENSE

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SECTION I

THE USE OF CONTROLLED MINES IN COAST DEFENSE

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1. Responsibility for controlled submarine mines.—The Coast Artillery Corps is charged with the responsibility for the design, supply, and tactical operation of all controlled submarine mine equipment to be used in coast defense.

2. Limitations of this manual.—Controlled submarine mines constitute an essentially passive means of defense to supplement other measures employed for the immediate local defense of the important harbor entrances. Therefore in this manual treatment of the tactical principles involved in coast defense is limited to their application to the employment and coordination of controlled mines as one element of harbor defense.

3. Army functions in coast defense.—See Joint Action of the Army and the Navy (1927), Chapter IV: For specific functions, paragraph 12; for auxiliary tasks, paragraph 13.

4. Navy functions in coast defense.—See Joint Action of the Army and the Navy (1927), Chapter IV: For specific functions of naval local defense forces, paragraph 16; for auxiliary tasks, paragraph 17.

5. Joint plans.—In so far as joint plans are concerned with controlled mines, it should be understood that the methods of employment prescribed in this manual have been established in conformity with the principles laid down in Chapters IV and V, Joint Action of the Army and the Navy.

SECTION II

DEFINITIONS AND POLICIES PERTAINING TO CONTROLLED MINES

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6. Functions of submarine mines.—In general, the functions of submarine mines, whether the controlled mines of the Army or the contact mines of the Navy, are as follows:

a. To effect the destruction or serious damage of hostile vessels which approach within effective range.

b. To supplement the offensive action of other weapons in repelling hostile naval attack.

c. To prevent the close approach or entry into a harbor of hostile surface vessels under cover of night, fog, or smoke, when by reason

of the invisibility of the ships from shore, other weapons of the Army and Navy are wholly or partially ineffective.

d. To limit or prevent the navigation by hostile submarines of channels or water areas.

e. To restrict the freedom of maneuver of hostile naval forces in formation.

f. By the moral effect of an unseen threat, to enforce a constant element of caution and uncertainty in the planning and execution of all hostile naval operations within the water areas known or believed to be protected by mine fields.

g. To give warning of hostile submarine activities or of the presence of hostile surface vessels.

7. Principles governing the employment of controlled and contact mines.—Consideration of the characteristics of the two types of mines leads to the formulation of the following principles for the employment of controlled and contact mines, *so far as harbor defense is concerned:*

a. Controlled mines should be used to close such portions of harbor entrances as lead to channels required for the use of friendly naval forces and friendly commercial shipping, or which include a debouching area required by our naval forces. In addition, controlled mine fields should be limited to distances not to exceed 10,000 yards from the shore and to depths not greater than 250 feet. Specific details governing the location and tactical employment of controlled mines are included in Sections III and IV.

b. Contact mines should be used to close all portions of harbor entrances navigable by hostile naval forces, not required for use by friendly naval forces or commercial shipping, particularly to block off large areas or routes of access in deep water or far offshore, except where the set of tides or currents is such that contact mines which have broken loose will be likely to be washed into areas which will endanger friendly naval forces or commercial shipping.

8. Definition of controlled mine.—A controlled submarine mine, as employed by the United States Army, may be defined as a water-tight steel case, containing explosive and a firing device, with means for control of fire by electrical connection to shore. The case is of such size that its free buoyancy would cause it to float on the surface but for the fact that it is held at a predetermined submergence by the length of mooring rope by which it is attached to the anchor which retains it at the location at which planted.

9. Components of controlled mine system.—The essential components of the Army's system of controlled mines are as follows:

a. The mines themselves, complete with explosive, compound plugs, mine transformers, moorings, and anchors. The unit for planting and control is the *group of mines*, consisting of 19 mines planted at intervals of 100 feet across the waterway to be defended, with submergence as required by tactical conditions. The mines in each group are numbered from left to right as viewed by an observer on the inshore side of the group, No. 1 being on the left, No. 10 in the center, and No. 19 on the right. One group of mines thus defends a frontage of about 1,900 feet (18 intervals plus 50 feet to each flank). The defense required for a particular water area, in width and depth, is provided by the appropriate number of complete groups of mines. The groups of mines themselves are numbered normally from left to right looking offshore, beginning with the most advanced line if the project includes two or more lines of mines.

b. The control devices.—In the present standard single-conductor system consist, external to the mine itself, of the 19 lengths of single conductor cable leading from the several mines of a group of mine back to the distribution box, the distribution box containing the selector and accessories, the single-conductor cable leading back from the distribution box to the terminal hut on shore, the lead-covered cable running in conduit from the terminal hut to the mining casemate, and the instruments and wiring included on the modified operating board. In the obsolete 19-conductor system, the selector and accessories in the distribution box are omitted, 19-conductor cable replaces the single-conductor cable between distribution box and casemate, and for the modified operating board is substituted the original operating board with its master block and 19 individual mine blocks.

c. Power and switchboard equipment.—This includes a direct current generator (either direct connected to a stationary gasoline engine, or belt-driven by an oil engine), an 80-volt storage battery, motor-generator sets as a source of alternating current, firing current, casemate transformers, a power panel for the control and distribution of direct current and alternating current circuits, and for the standard single-conductor system, an interrupter panel.

d. Tools and stores required in the handling and maintenance of mine equipment.

e. Structures.—These include for each project, one or more of each of the following types of structures:

(1) *Mining casemate* which houses the power and control equipment.

(2) *Mine storehouse* for the storage of mines, anchors, mooring ropes, and accessories.

(3) *Loading room* for loading and assembling mines.

(4) *Magazine* for storage of explosive.

(5) *Cable tank* for storage of cable.

(6) *Mine wharf* for use in loading mine planters.

(7) *Trackage*, connecting structures listed in (2), (3), (4), (5), and (6) above.

(8) *Mine group commander's station.*

(9) *Base end stations.*

(10) *Plotting room.*

f. Mine planting vessels.—These include regular and auxiliary mine planters, distribution box boats, and motor mine yawls.

g. Position finding equipment.—This includes the necessary base end observing instruments, mine group commander's telescope, plotting board, predicting device, stop watch, telephones, and telephone lines.

h. Searchlights for illuminating the mine field at night. These may or may not be separately assigned to the mine group command.

i. Rapid fire guns for protecting the mine field.

10. Fundamental principle of design.—The outstanding characteristic feature of the Army-controlled mine is the use of direct current for operation, supervision, and signaling, and of alternating current for all firing. When a mine is to be fired, either by observation or contact, the direct current through the completed circuit to that mine is interrupted and replaced by alternating current. Without alternating current applied to the system the mines are absolutely safe for friend or foe. This fundamental principle of operation should be borne in mind in connection with every consideration, either tactical or technical, which arises concerning the employment of Army-controlled mines.

11. Policy for storage of mine equipment.—Upon the imminence of war one of the first defensive measures may be to put down the controlled-mine projects. Hence the War Department has adopted the policy that controlled mines, with accessory essential items required to plant and operate them, will be stored locally, contiguous to the projects to which they pertain, in readiness for immediate use and in quantities sufficient to plant the authorized projects and provide maintenance of these projects for a specified period after planting.

SECTION III

TACTICAL PRINCIPLES FOR PREDETERMINATION OF A CONTROLLED MINE PROJECT

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12. Tactical principles.—The specific principles governing the tactical employment of controlled mines are divided into two categories; the first involves the predetermination of the project and its relation to other measures for harbor defense; the second involves the actual conduct of the mine defense during war. The problems involved in the first category are generally solved in time of peace, and as a result of joint Army and Navy plans the details are incorporated in the authorized underwater defense projects for the several harbor defenses.

13. Tactical considerations for predetermination of a mine project.—The problems which must be considered and harmonized involve the following:

a. Location of mine field.

b. Number, sizes, and types of mines, with weight of explosive charge.

c. Types and sizes of anchors.

d. Disposition of groups of mines within the field, which involves location of free channels, navigational aids, leader gear, torpedo nets, submarine nets, contact mines, and reefs or other obstructions affecting mine-planter operation.

e. Routing of cables to shore.

f. Availability and location of searchlights and guns for the protection of the mine field.

g. Provision of necessary mine-planting vessels.

14. Location of controlled mine fields.—The location of the controlled mine field, or fields, for a particular harbor defense, is based upon the following considerations:

a. The specific mission required to be fulfilled.—If the required mission is to prevent the penetration of a harbor entrance by way of one or more narrow channels which are needed for our own use, the

controlled mine field should have its inner limit far enough in advance of the channel mouths so that a hostile blocking vessel run through the mine field at high speed, if hit by a mine, will be unable to reach the channel before sinking. The maximum distance ordinarily allowable for this advance of the inner limit of the mine field beyond the channel mouths is 2,000 yards. If the mission is similar, but the channels are so wide that they can not thus be blocked, this advancing of the mine field is not necessary. If the controlled mine field is intended to provide an emergency debouching area for our naval forces, its location and extent must be such as to provide the deployment frontage required by the Navy.

b. The necessity for protection by the fire of secondary armament and by searchlights.—In general, regardless of range of the guns available, this will restrict the outer limit of a mine field to about 8,000 yards from the positions of the most advanced searchlights. From the same consideration, the distance to the inner limit of the mine field or to its nearest flank should not be so reduced that any part of the mine field is inside the limit of minimum range of the armament available to protect it. In certain places where the armament is sited unusually high, this is a matter of importance.

c. Hydrographic conditions.—These include the depth of water, the velocity and set of currents, tidal variations, and the presence of reefs or other obstructions to navigation. The minimum depth of water in which mines may be planted is limited by the matériel to about 20 feet; in a particular project, the minimum depth at which mines will be planted is determined from a study of the conditions peculiar to that project. On the other hand, with the most favorable conditions as to current and tide, the maximum practicable depth of water for controlled mines is about 250 feet, due to the weight of cable and mooring rope. Excessive currents reduce the efficiency of controlled mines in two ways, first by increasing the normal or intended submergence of the mines, and second by twisting and presently breaking the cables and mooring ropes. In general, controlled mines should not be planted in water areas where the maximum current velocities exceed 3 knots. Even in those harbor entrances where such excessive current velocities occur, there are generally to be found water areas where the maximum current velocities are less than 3 knots. Such water areas should be sought for the location of the controlled mine field, and if lacking, the use of controlled mines may be rejected as impracticable. While in general, the range of tidal variation is not sufficient to prevent the efficient employment of controlled mines, there are a few localities where the tidal variation

presents a problem calling for especial consideration. The presence of reefs or other obstructions to navigation demands consideration from three standpoints: First, as effective obstacles in themselves, they may serve to reduce the amount of mine matériel required to close a harbor entrance, or may constitute a convenient flank for the mine barrage; second, as interference with the maneuvers of a mine planter in planting operations, the location of the mine field must be so chosen that these obstructions will not prevent putting down every portion of the desired mine barrage; and third, the presence of such obstructions in the mine field must not prevent the patrolling of the mine field in thick weather by vessels of the naval inshore patrol.

d. Economy.—From the standpoint of relative expense of controlled mines and their accessories, and the limited amount of matériel and casemate capacity now available, as well as from the length of time necessary to plant them, and the difficulties of subsequent maintenance and replacement, the location of controlled mine fields and their resulting extent should be such as to limit the number of mines required to the minimum. The general principle is that controlled mines should be used only where and to the extent that contact mines or other available means of defense will not serve the purpose. It will sometimes be the case that both controlled mines and contact mines will be used for the defense of portions of a harbor entrance.

e. Location of other elements of the underwater defense.—In connection with nets, boom defenses, and leader gear, the location of these accessories and controlled mines must mutually be so chosen that there will be the minimum interference with controlled mine cables.

f. Support of primary armament.—A secondary consideration, which in certain localities is of some importance, is that the controlled mine field should supplement the primary armament by prohibiting hostile occupation or penetration of water areas which can not effectively be covered by the primary armament.

g. Interference of cables.—In planning a controlled mine project, consideration must be given to the possible interference with the maintenance of submarine mine cables due either to the planting of a project in great depth on a narrow front, or to the overlaying of mine cables by fire control and other telephone cables and subaqueous sound ranging cables, put down after the mine project is planted.

15. Number, sizes, and types of mines.—The number of mines to be employed is determined by the frontage and depth considered necessary in the location of the mine field. Defense in depth will require at least two and sometimes three lines of mines. For each of

these lines, one mine per hundred feet is required. In this connection, however, there must be considered the actual disposition of groups of mines. The selection of the sizes and types of mines to be employed depends in part on tactical considerations, and in part on the sizes and types actually available from the very large number of mines on hand. From the tactical standpoint it would be desirable to have every mine contain 200 or 250 pounds of trotol. The smallest mine case that will carry 200 pounds of trotol with sufficient free buoyancy is size 40. In water areas with little or no current, the size 40-mine case may be used in depths up to about 65 feet. In stronger currents, the maximum depths must be less. A desirable size mine case for all moderate conditions of current and depth is the size 43. For more extreme conditions the 46, 47, 48, or 50 sizes are required. The size 32 spherical mine case will carry only 100 pounds of trotol, and therefore its use is limited to such mine fields or to such parts of mine fields as will not reasonably be expected to defend against capital ships. There is, however, a special use for which the size 32 mine with its 100-pound charge is well adapted. This case is that of projects involving three or more lines of mines with deep water. The mines of one or more lines should be planted with great submergence so as to intercept submarines running submerged, and these deeply planted mines could very well be size 32. As between the two general types of mine cases, spherical and cylindro-spherical, the spherical case will be affected less by strong currents than the cylindro-spherical case of the same displacement, for the reason that a spherical structure exposes the least surface of any form of equal cubic capacity. For this reason, in all extremely swift and deep waters, the size 50 spherical case would be desirable to use. However, on account of the limited number of this size and type available, coupled with the fact that a considerable number of the cylindro-spherical type, in sizes 46, 47, 48, and 50, is on hand, it is necessary, in many projects to designate numbers of these less modern types for employment in certain parts of the mine field. The general principle to be followed in the determination of a project, is to assign to the various groups the sizes and types of mines that can be made available, in such a way as to put spherical mines (other than size 32) in the swiftest currents, and the largest mines in the deepest water.

16. Types and sizes of anchors.—The types and sizes of anchors and sizes of mooring ropes are also matters which depend largely on matériel available. In general cast-iron anchors should be used wherever there is not a wide variation in depths in the area

covered by a single group of mines, while automatic anchors should be used only for such parts of a mine field where the irregularity of the bottom does cause these wide variations in depth. The great advantage obtained by the use of automatic anchors is the saving of time when planting the project by not having to take exact soundings on the line of mines, and by not having to cut mooring ropes to exact lengths. This advantage is of course minimized where the bottom is so regular that individual soundings are not necessary, and especially so if mooring ropes are cut and tagged before the imminence of hostilities. In practice, no greater uniformity of submergence is obtained with automatic anchors than with cast-iron anchors. For description and weights of anchors, see Part Four. The present standard type of automatic anchor is the Model 1916. All earlier models on hand are retained for use as cast-iron anchors, disregarding the automatic feature. The size of anchor depends upon the size of mine, depth of water, strength of current, and character of bottom. So much depends on this last factor, that the actual selection of anchors to be used should result from experiment in each water area.

17. Disposition of groups of mines.—Within the mine field the groups of mines must be so disposed as to meet the following requirements:

a. The fundamental basis for the arrangement of groups of mines is to insure that a hostile vessel approaching an entrance channel or water area to be protected by the mine field will be sure to pass over at least one mine, and if possible, several other mines. This object is attained in part by the use of two or three lines of mines, and in many situations may be facilitated by placing the groups of mines so that the line of mines is at an oblique angle to the probable route of access, which has the practical effect of placing mines which are planted at 100-foot intervals, at smaller intervals perpendicular to the direction of approach.

b. The groups of mines must be so disposed as to provide free passageways through the mine field. These passageways must be such that an unpiloted vessel would have great difficulty in traversing them, and as their successful navigation by friendly ships will depend on pilots using specially provided aids to navigation, the establishment of passageways through mine barrages and the aids to navigation dependent thereon should be governed by the following factors:

(1) Courses through mine barrages should, as far as possible, be laid out to parallel the current streams.

(2) Whenever possible, ranges should be used to mark the passageways through the mine barrages and should lead through the centers of the openings in the lines of mines, or clear of the ends of such lines, so that the range marks will be kept closed and not be held open to clear the mines.

(3) Where it is impracticable to fix ranges on shore to indicate the courses to be steered (as at the capes of the Chesapeake Bay) it is better for changes in course to be marked by boats or temporary buoys placed in position, as needed, by the pilot vessel.

(4) When lines of mines are laid comparatively close to each other a single range should preferably lead through the openings, especially where tidal currents are strong and the range becomes back range in one direction.

(5) If it is desirable, or when it may be necessary because of changes in direction of the channel, to establish separate ranges to lead through each line of mines, such ranges should, if possible, cross in the area between the lines of mines and at as large an angle as is consistent with the object in view, so that changes of course will be small with easy curves and in but one direction when changing from one range to come to and steady on the other.

(6) When one or both of the marks of a range are not natural objects, and especially where a single range is used to lead through the lines of mines, arrangements should be made to disguise the range marks when they are not being used by authorized vessels.

(7) Passageways and courses through mine barrages should be in water which permits passage of the deepest-draft vessels that can pass in through the entrance channels.

(8) Passageways through mine barrages should be sufficiently wide at points where changes of course are made to permit the *longest* ships to make the turn without swinging bow or stern into the mines on the edges of the passageways.

c. A type of navigational aid which may be expected to find increasing employment for the safe pilotage of vessels through free passages in mine fields is the electric cable "leader gear." Where leader gear is to be used it should be put down before mine cables are laid, so as not to interfere with the repair or replacement of the mine cables.

d. The scope of this manual does not properly include a discussion of the conditions which may make the use of torpedo nets, submarine nets, and booms necessary or desirable. However, when the use of any or all of these types of obstruction has been decided upon,

their location and the disposition of mine groups must be mutually determined so as to insure the following conditions:

(1) Operations of the mine planter or distribution-box boat must not be rendered impossible or hazardous in the planting and maintenance of any mine group by the proximity of a net or boom.

(2) Operations of gate vessels or net patrols must not be rendered impossible or hazardous by the too close proximity of controlled mines.

(3) The moorings of nets and booms must not interfere with controlled mine cables.

e. With respect to a barrage of contact mines used to supplement the controlled mine field in the underwater defense of a harbor entrance, the controlled mine groups must be so disposed that none of the mine-planting vessels used for planting and maintaining the controlled mines will be imperiled by the contact mines. This problem involves a consideration of prevailing currents and other hydrographic features, but in general it requires that at no point should contact mines and controlled mines be nearer than 1,000 yards.

f. The successive lines of mines in the controlled mine field must be far enough apart so as to give the mine planter ample seaway during planting operations. In general this will require that the successive lines be separated by at least 750 yards, although there are some areas of extremely quiet water where distances between lines as small as 300 yards may be permitted.

18. Routing of cables.—The routing of controlled mine cables between the shore and the distribution boxes should be planned so as to meet the following requirements:

a. The cables should land at a point where the terminal hut may be concealed and protected from observed fire.

b. The route should be as short as possible, so as to economize cable and reduce the lengths exposed to injury.

c. The route should be outside of ship channels, but must follow channels or depths which can be navigated by a mine planter at any stage of tide. This requires at least 15 feet at low water.

d. Where possible, the route should be in water that can be traversed by a mine planter while laying cable in any weather short of a severe storm, and such that there is not a serious scour of current along a rocky bottom.

e. There must be the minimum of crossing of mine cables with fire-control, commercial, and leader gear cables.

19. Guns and searchlights.—In the determination of a controlled mine project it should be recognized that it is futile to place controlled mines, except in water areas which can be covered by fire

of secondary armament and which can be illuminated by searchlights. From the standpoint of location of controlled mine fields, this principle has been considered in paragraph 14 *b*. From another standpoint it is necessary to consider whether sufficient guns and searchlights are available or can be made available to provide adequately for the protection of all parts of the mine field which conceivably can be attacked simultaneously by mine sweeping or countermining operations. This is a question which must be determined for each local situation, and its controlling effect is to limit the extent of employment of controlled mines to the available support of guns and searchlights, regardless of the fact that so far as location alone is concerned, all parts of the proposed mine field could be covered by some guns and some searchlights.

20. Mine-planting vessels.—Necessary mine-planting vessels must be provided in units, each designated as a mine planting flotilla and consisting of 1 mine planter, 1 distribution box boat, and 3 motor mine yawls. The number of mine planting flotillas to be provided will depend upon the time limit within which the mine project is required to be put down, the number of mine batteries assigned, and the average rate at which one unit can put down one group of mines. The average rate at which one flotilla can put down one group of mines, including laying the shore cable, loading mine matériel aboard the planter, and proceeding to the mine field, planting the group of mines and returning to the mine wharf will vary in accordance with numerous factors, among which are the distance from shore to the mine field, the state of the weather, tide and currents, depth of water, and availability and training of the personnel. The rate will vary between 10 and 30 working hours per group of mines.

SECTION IV

TACTICAL PRINCIPLES FOR THE CONDUCT OF MINE DEFENSE

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21. General problems involved.—As stated in paragraph 12, the second category of principles governing the tactical employment of controlled mines is concerned with the actual conduct of the mine defense during war. The conduct of mine defense, based upon a predetermined project for which the matériel and installations are available, presents the following general problems:

a. Time and manner of planting the project.

b. Surveillance of the mine field and attack of hostile vessels.

c. Protection of the mine field.

22. Time and manner of planting the project.—Each mine project will be planted when so directed by the War Department, or as provided for in approved joint local defense plans. The controlling element in the coordination of this work is to insure that matériel is ready for the mine planter so that it can fully utilize the hours of sufficient daylight for work on the water. It will be found that in the long run no time will be saved by attempting to lay cable or plant mines in extreme darkness. The plan for putting down the project should include the sequence to be followed in planting the groups of mines. In general, the groups of mines farthest offshore should be planted first, so that the mines first planted need not be crossed or have to be passed around, while planting subsequent groups of mines. In certain projects it may be prescribed that designated groups of mines will not be planted until called for by the Navy, or until the port is closed. In such cases, care must be taken in planting the groups of mines first to go down, to leave ample seaway for the planter in the subsequent planting of the delayed groups of mines.

23. Surveillance of the mine field.—Surveillance of the mine field must be continuous throughout the 24 hours of the day during the continuance of hostilities. This surveillance has three purposes: First, as a basis for tactical decisions concerned in the attack of hostile vessels; second, to insure that the mine field is rendered safe for the passage of friendly naval forces and commercial shipping; and third, to insure the protection of the mine field itself. Thus, surveillance of the mine field calls for two complete reliefs in the manning table for the mine group commander's station, base-end stations, plotting room, and casemate.

24. Nature of tactical decisions.—On the approach of a hostile vessel or naval force, the tactical decisions which must be made are—

a. Whether to fire or to withhold fire.

b. Whether to fire by observation, by contact, or by delayed contact.

25. Decisions as to fire.—The decision whether to fire or to withhold fire should be covered by instructions contained in the battle orders of the harbor defense commander. The considerations involved are the fact that whenever a mine is fired, the mine field is to that extent weakened until the mine can be replaced, and the relative importance of the enemy element, or the seriousness of its threat to the defense under the conditions existing. Consequently, it may occur that an unimportant vessel should be allowed to pass, especially if it is being followed by more important vessels. Furthermore, if the hostile operation can be recognized as a reconnaissance precedent to an attack in force, the attack of a reconnoitering element will disclose the location of the mine field. On the other hand, it is a general principle that during night or fog when surveillance by observation is impossible, all hostile elements traversing the mine field should be attacked by contact fire. This principle is subject to the qualification that whenever a controlled mine field is to be set for contact fire during a period of nonvisibility, advance notice must be given through the commander of the naval local defense force to all elements thereof.

26. Methods of fire.—The methods of fire in the order of their tactical importance are delayed contact fire, contact fire, and observation fire.

a. Delayed-contact fire.—(1) This method of fire offers the greatest assurance of serious injury to a capital ship or any other type of vessel provided with "blisters" or other form of torpedo protection. By delayed contact fire it is possible not only to insure that the mine explodes in direct contact with the hostile ship but also to increase the likelihood that before the explosion occurs the mine will have been dragged underneath the "blister" protection, so that it fires against the vulnerable bottom section of the ship.

(2) As compared with contact fire, delayed contact fire affords the option of withholding fire after the mine has signaled being struck.

(3) In addition, the setting of a mine field for delayed contact fire provides the means for surveillance as to passage of submerged submarines through the mine field, a form of surveillance which is not otherwise possible.

(4) Delayed contact fire is executed as follows: After the command "Delayed contact fire—Group(s) (such number)—(so many) seconds delay," the firing switch is closed on the control panel of the mine signaled at the expiration of the prescribed number of seconds.

(5) When fire is directed with a prescribed number of seconds delay, the number of seconds delay to be prescribed will depend on the type and speed of the hostile vessel being attacked, bearing in mind that when employing the standard single-conductor mine system an inherent delay varying from 0 to 3 seconds occurs between the actual hitting of the mine and the stopping of the selector contact arm on the mine contact of the mine hit. The prescribed delay should be computed for each known type of vessel that it may be necessary to attack and for the tactical and cruising speeds of each type. In general, these delays will vary from 0 second for the most modern destroyers at tactical speed to 13 seconds for a battleship at cruising speed. The effort in each case is to secure an explosion directly under the bottom amidships.

b. Contact fire.—This method of fire will be resorted to only to meet one of two tactical conditions: *First*, when it is known or believed that several hostile vessels are about to cross the mine field at different points simultaneously; *second*, when a hostile vessel is about to cross the mine field at such high speed as to make it probable that delayed contact fire or observation fire would be ineffective; or, *third*, when fog or smoke prevents observation of the mine field and patrol vessels have been warned.

c. Observation fire.—This method of fire is of extremely limited application. Ordinarily it should be resorted to only to meet one of three tactical conditions: *First*, when it is necessary to attack one hostile vessel at a time when a friendly vessel or other hostile vessels of types not to be attacked are either in, about to enter, or have just left, the mine field; *second*, when by reason of mines damaged or previously fired, a gap exists in the mine field such that from the predicted course of a hostile vessel either form of contact fire would be ineffective, and yet a mine can be fired by observation, near enough to a vessel's course to gain destructive effect; or *third*, when it is known that hostile elements are employing paravanes to sweep and explode controlled mines. Except in the cases above noted, if a mine field is properly laid out, a ship should not be able to enter and traverse a mine field without hitting a mine, and as the destructive effect of a mine explosion is greatest when it occurs in direct contact with a vessel's hull, either method of contact fire is more certain to

be effective than observation fire. Furthermore, it should be remembered that the accuracy of observation fire diminishes with the lapse of time after the mines are planted, due to dragging of mines by storms or boats.

27. Measures for protection of casemate and of mine fields.—*a.* In addition to the hazard of injury by hostile fire, mining casemates (and the cables connecting them to the shore) are especially vulnerable to sabotage. For this reason these vital elements should be protected constantly by adequate sentinels from the very imminence of hostilities.

b. Protection of controlled mine fields depends upon the following measures:

(1) Surveillance from shore, utilizing the observing stations of the mine group command, as well as other fire-control stations of the harbor defense, assisted by the harbor defense searchlights.

(2) Surveillance by elements of the naval inshore patrol.

(3) Surveillance by subaqueous listening devices operated by the Army or the Navy or both.

(4) The fire of the secondary armament of the harbor defense against hostile surface vessels attempting mine sweeping or countermining.

(5) The attack of hostile planes engaged in observation or countermining with depth bombs by the antiaircraft artillery or the Air Corps or both.

(6) The attack of hostile surface vessels by gunfire or of hostile submarines by depth bombs by vessels of the naval inshore patrol.

(7) Concealment of mines from aerial observation.

(8) In some cases the protection afforded by antisubmarine nets and contact mine barrages.

28. Protective surveillance from shore.—The protective surveillance from shore will be maintained in connection with tactical surveillance continuously except when poor visibility renders it impossible. Its utility is predicated not only on constant vigilance, but equally on the maintenance of effective communications with the batteries of the secondary armament, the antiaircraft artillery, the supporting Air Corps force, and the searchlights. The tactical employment of searchlights is covered by TR 435–330.

29. Naval surveillance.—The surveillance of the controlled mine field by elements of the inshore patrol of the naval local defense force will at all times be of great importance, and especially so at such times as poor visibility renders ineffective the surveillance from shore. In order to be effective, careful training and coordina-

tion are essential. Regulations governing this coordination are covered by Chapter V, Joint Action of the Army and the Navy.

30. Subaqueous surveillance.—Wherever installed subaqueous listening devices should be used to supplement the surveillance from shore and from the inshore patrol. To render this service effective, direct telephone communication should be established between the headquarters of the subaqueous installation and the mine-group commander's station.

31. Secondary armament.—The fire of the secondary armament of the harbor defense is the principal means for the prevention of mine sweeping and countermining. Success depends upon the training and constant readiness of the mine and gun groups assigned the mission and upon the maintenance of communications between the mine group and the gun groups. The tactical employment of the secondary armament is covered in TR 435–20.

32. Antiaircraft defense.—The prevention of hostile air observation and countermining with depth bombs may prove to be of great importance and calls for the successful cooperation of the antiaircraft artillery and the Air Corps.

33. Naval protection.—The attack of hostile surface vessels by gunfire or of hostile submarines by depth bombs will be undertaken by vessels of the inshore patrol whenever their size and armament will permit. Vessels of the inshore patrol should exercise care not to blanket the fire of the shore guns by their own positions.

34. Concealment of mines.—The only effective method of concealment of mines from aerial observation is sufficient submergence, and even this is not always effective in certain situations, particularly in the Tropics, where a combination of bright sunlight, unruffled water surface, clear water, moderate depth, and light-colored bottom reveals the location of the mines to an aerial observer, not so much by his ability to see the mines themselves as by his ability to see their shadows on the bottom. Experiments so far conducted in the direction of protective coloration of mines have proved ineffective.

35. Protection by nets and contact mines.—Although the desirable location of an antisubmarine net is to landward of a controlled mine field, the placing of the net to seaward may occasionally be required by local conditions, in which case such placing has the advantage of restricting very considerably hostile mine sweeping or countermining by surface vessels. In projects where the controlled mine field is supplemented by an adjacent or outer barrage of contact mines, the presence of these contact mines serves to some extent to limit the access of hostile vessels intended to attack the controlled mine field.

PART TWO

ORGANIZATION, COMMAND, AND ADMINISTRATION

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SECTION V

THE MINE GROUP

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36. The mine group, definition and composition.—A mine group is a tactical unit charged with the controlled mine defense of a harbor, and comprises the personnel, submarine mine equipment, structures, vessels, and armament necessary to plant, operate, and protect part or all of the authorized controlled mine project. The *mine group* should not be confused with the *group of mines*, defined in paragraph 9 *a*.

37. Organization of the mine group.—*a*. The personnel of the mine group is organized as follows:

(1) Mine group commander.
(2) Mine group staff.
(3) Mine group detachment.
(4) Mine property detachment.
(5) One or more mine batteries.
(6) One or more rapid fire gun batteries.
(7) One or more mine planting flotillas.

b. The detailed internal organization of each unit, section, detachment, or detail is provided by the Tables of Organization prepared for the corresponding harbor defense regiment. It is intended that the general framework of organization will be so flexible that the elements of each mine group can be organized so as exactly to meet the needs presented by the particular mine project which it is to handle. War Tables of Organization will not provide that a mine battery will man rapid fire guns, as the gun defense in mine groups will be provided by separate gun batteries. On the other hand, peace strength Tables of Organization will provide that mine bat-

teries man rapid fire guns. This arrangement is necessary on account of depleted personnel, and contemplates that the peace time training of mine batteries should provide not only for their own expansion to war strength but also should furnish a training nucleus for a war time gun battery. War Tables of Organization should provide sufficient personnel for two complete reliefs for mine group detachments, battery range sections, and battery casemate sections. When the mine field or fields can be controlled from one M′, M″, and casemate, and two mine batteries are assigned, the necessary two reliefs for range section and casemate section will be provided by one range section and one casemate section per battery. When but one mine battery is assigned, this battery must provide the necessary two reliefs. If the mine group command includes two or more mine fields so situated that separate installations of M′, M″, or casemate are required for their control, the necessary provision therefor should be made in Tables of Organization.

c. Whenever for any reason the mine group is required to function at greatly reduced strength, the organization will be suitably modified, so as to consolidate duties and functions, and avoid unnecessary overhead.

d. Such gun batteries as are assigned to the mine group are organized and employed according to the principles prescribed for the battery in the gun group. See TR 435–300.

e. Searchlights and personnel therefor will not generally be included in the organization of the mine group. Searchlights are operated under the direction of the searchlight officer of the harbor defense, groupment or group to which they pertain. The tactical use of searchlights is covered by TR 435–330.

f. A manning table for each unit, section, detachment, and detail, exhibiting the actual assignments of all personnel to duty therein will be prepared and kept up to date, and a copy posted in the command post or station of the corresponding element.

38. The mine-group commander.—*a.* The mine-group commander is responsible for the tactical efficiency of the mine group and for the adequacy and serviceability of its armament and mine equipment.

b. He assigns the officers of the mine group to batteries and to the mine group staff in accordance with their especial fitness, having regard also to the importance of widening the experience of all officers in the several phases of mine work. His appointment of a mine property officer is subject to the approval of the harbor defense commander.

39. The mine-group staff.—The mine-group staff includes an operations officer, a communications officer, and a mine property officer. If necessary, two or all three of these assignments may be made to one officer.

a. The operations officer is the executive officer for the mine group, and in general is responsible for the exercise of all functions pertaining to plans and training, and intelligence. He commands the mine-group detachment, and directly supervises the training and duties of the command detail and fire-control detail.

b. The communications officer is responsible for the efficient functioning of all means of communication and of the group-message center, and directly supervises the training and duties of the communications detail and message-center detail of the mine-group detachment. In the unusual case where searchlights are assigned to the mine group, he acts as searchlight officer, and is responsible for the efficiency of the searchlights and the personnel pertaining thereto.

c. The mine-property officer is responsible for the procurement, storage, care, preservation, issue, and accounting for all property designated as submarine mine property, in accordance with pertinent Army Regulations, and Circular No. 4, War Department, 1927, and has direct charge of all mine structures. He directly supervises the training and duties of the mine-property detachment. In order to assist him in the care and repair of electrical and power equipment, he has the services of an electrical specialist, noncommissioned staff. See paragraph 40 *c*.

40. The mine-group detachment.—*a.* The personnel of the mine-group detachment is permanently assigned from the harbor-defense section of the headquarters battery, harbor-defense regiment. If in peace the headquarters battery is in an inactive status or reduced strength requires it, the necessary minimum personnel for the mine-group detachment will be permanently assigned from the battery or batteries included in the mine group.

b. The mine-group detachment includes a command detail, a fire-control detail, a communications detail, and a message-center detail.

c. Except when prevented by a temporary exigency of the service, the mine-group detachment will at all times include a noncommissioned staff officer, electrical specialist, permanently assigned from the headquarters battery of the harbor-defense regiment. He will not be included in any of the component details of the mine-group detachment nor given any tactical assignment but, under the supervision of the mine-property officer, will be charged with the technical inspection, care, and repair of all electrical and power equipment of

the mine group, including that which is in use by the mine batteries. In the technical operation of the casemate he directly supervises the training and duties of the casemate electrician and casemate section. He will personally conduct the maintenance tests prescribed in paragraph 129. He supervises the repair of and conducts tests of submarine-mine cable in accordance with TR 1160–15.

41. The mine-property detachment.—*a.* The personnel for the mine-property detachment is permanently assigned from the mine battery or mine batteries pertaining to the mine group, and normally consists of the mine-property detail from each mine battery. It will consist of the minimum number of trained clerks and storehouse keepers necessary to assist the mine-property officer in carrying on routine operations. The extra demands occasioned by receipts, issues, and maintenance will be met by fatigue details from the mine batteries. In this connection see paragraph 42 *e*.

b. The chief clerk will normally be the chief loader of one of the mine batteries. If there is more than one mine battery, the chief loader of each battery will normally be assigned to duty in the mine-property detachment.

42. Command and administration of the mine group.—*a.* The mine group is a tactical unit whose tactical efficiency depends not only upon properly coordinated employment when in action; but also to a unique extent upon a great amount and variety of technical operations prior to battle. These technical operations include the preparation and preservation of mine equipment in time of peace, and the assembly and planting of the mines and accessories during or upon the imminence of war. By reason of the very bulk and weight of the matériel to be handled, a vast amount of physical labor is involved. Furthermore, the planting of a mine project demands the simultaneous prosecution of numerous operations at separate places on shore and on the water, each of which must be correctly and quickly executed. Moreover, at certain stages of the work, it is necessary that some of the detachments and details be temporarily augmented by men from other details. All of these conditions impose the requirement that tactical command be closely related to, and supported by, a high standard of technical and administrative command.

b. Among the problems to be solved to attain effective command in the mine group, the more important are the following:

(1) The development of a working program for the installation of the project.

(2) The devolution of responsibility for immediate control of the several parts of the program.

(3) The testing of the working program and familiarizing of mine personnel with its details during peace training.

(4) Effective supervision by the mine group commander of the execution of the working program, which can not be expected to be automatic.

c. The working program for the installation of the mine project should provide for the following:

(1) A detailed bill of material for each group of mines, showing types and sizes of mines and of anchors, weights of charge, length of cables, sizes and lengths of mooring ropes, types of compound plugs, mine transformers and circuit closers, types of end fittings for mooring ropes, quantities of all items of accessories and stores.

(2) Exact locations for distribution boxes, and a workable control system from shore to insure putting them at these locations.

(3) Routings for cables.

(4) Sequence for planting the groups of mines.

(5) Allocation of berthing space at the mine wharf for the mine planters and the distribution box boats to be used.

(6) Schedule for mine planters to refuel and blow boilers.

(7) Detailed schedule showing the sequence of work for the various sections, detachments, and details, covering the duties of each, so that the uninterrupted planting of groups may proceed, in the order determined upon.

(8) Provision for necessary reinforcement and reliefs for the various details at the times required.

(9) Provision for surveillance of the mine field from the time planting begins.

(10) Arrangements for hot meals at regular hours, particularly for men in small boats who can not leave the mine field.

d. In order to prepare the working program, the following basic data will have to be determined, based upon actual local conditions:

(1) Man-hour labor rates for the different kinds of work to be performed.

(2) Number of men required to carry on each operation, considering the space, utensils, lifting gear, trackage, and rolling stock available.

(3) Time to lay shore cable to each distribution box.

(4) Time from dock back to dock to plant each mine group, considering distance from shore, depths, currents, and rough water.

(5) Time per trip for each loaded car from cable tank, storehouse, and loading room, to mine wharf, including turn-around.

(6) Accurate soundings for each group of mines, kept up to date by annual survey, if the bottom is other than rock or hard scour.

(7) Matériel supplied for the project.

e. The following principles should govern as to responsibility for the handling of mine equipment by personnel of the mine group:

(1) When the equipment is being used in connection with training or with the planting and maintenance of the project in war, responsibility for the proper handling and care of the equipment rests with the tactical chief of subdivision which requires the use of the equipment.

(2) When the equipment is being repaired, adjusted, painted, or otherwise handled in connection with necessary storage and maintenance, the mine property officer retains responsibility for the equipment and for the work to be done, even if the work is being performed by details from the mine batteries, under the direct supervision of their own officers.

f. After the project is planted, the mine group commander normally exercises tactical command from the mine primary station of the mine group, which bears the same designation as that of the mine group, for example M'_1 or M'_2. In order that the mine group commander may be free to exercise the necessary supervision over all elements of the mine group, when he leaves his command post, some member of the mine group staff, or a battery commander, will be left constantly on duty, with full authority to exercise tactical command if emergency occurs during the absence of the mine group commander. The functions of tactical command of the mine group consist in the exercise of mine fire direction and of fire control over the assigned rapid fire gun batteries, operation of attached searchlights, surveillance of the mine field, evaluation and dissemination of intelligence, contact and cooperation with other group commands, all in accordance with missions assigned by the groupment or fort commander. In the usual case, the mine group commander will occupy the same station with the mine battery commander who exercises conduct of fire over the mine field. This arrangement permits the instant communication of orders and commands, but must not be allowed to cause undue interference by the mine group commander with the mine battery commander who is charged with the responsibility of mine conduct of fire.

g. In the exercise of tactical command, the typical fundamental lines of telephone communication are shown in Figure 1.

In this diagram telephone lines emanating from M′, which at M′ are manned by personnel of the communications detail of the

mine group detachment, are those indicated by wavy lines. All other telephone lines shown are manned by personnel from the range section of a mine battery. The observer for the mine group commanders' telescope is from the fire-control detail of the mine group detachment, while the observers at both base end instruments M′ and M″ are from the range section of a mine battery.

h. In the unusual case where the mine group command includes two or more mine fields so remote from each other that separate installations of M′, M″ and casemate are necessary to control each mine field, the mine group commander takes station at one M′, and the necessary modifications in communications and manning parties are

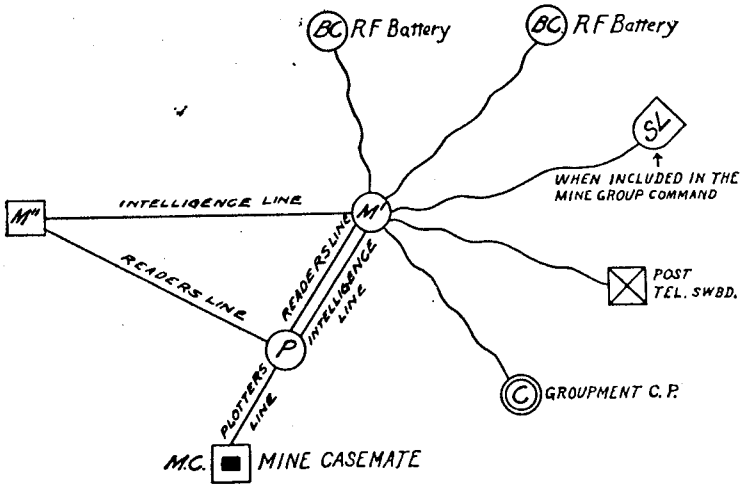

FIGURE 1.—Typical communication lines

effected to enable the mine group commander to retain tactical command over all mine fields, with a battery commander or other officer conducting the fire from each M′.

SECTION VI

THE MINE BATTERY

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Type organization 44
Expert gunners 45
Battery formations and marching maneuvers 46

43. The mine battery, definition.—The mine battery is the smallest administrative unit assigned to controlled mine defense from a coast artillery harbor-defense regiment, and is also a tactical unit used in the installation, operation, and maintenance of the mine project of a harbor defense. It is normally commanded by a captain.

44. Type organization.—*a.* The type organization of a mine battery is shown in Figure 2.

b. On a peace-strength basis the organization also includes one or more gun sections.

45. Expert gunners.—The authorized expert gunners for the mine battery are as follows:

a. Casemate electrician.
b. Chief loader.
c. Chief planter.
d. Coxswain.
e. Plotter.
f. Observer.

46. Battery formations and marching maneuvers.—The mine battery is formed and marched in a manner similar to that

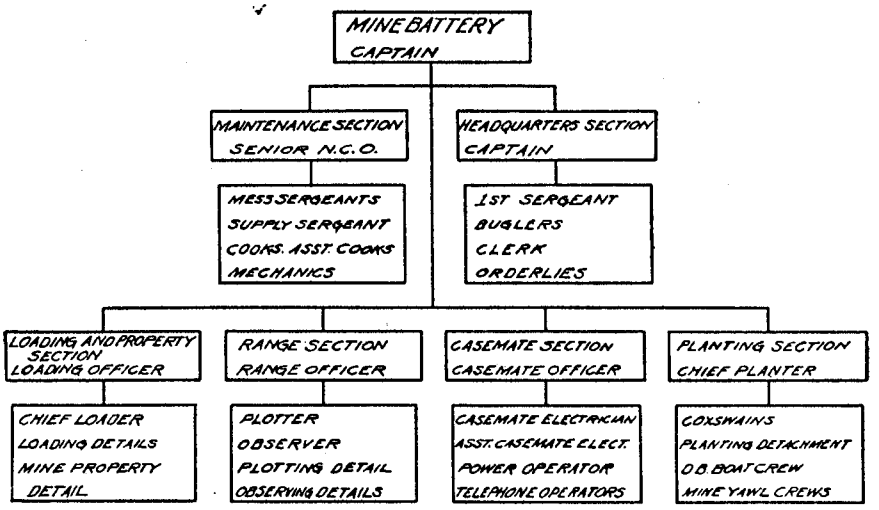

FIGURE 2.—Mine battery, organization

prescribed in Section VI, TR 435–300, with such obvious modifications as are required by differences in organization.

SECTION VII

THE MINE PLANTING FLOTILLA

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47. The mine-planting flotilla, definition and composition.—*a.* The mine-planting flotilla is a tactical unit within the mine group, consisting of one mine planter, one distribution box boat, and three mine yawls, together with the personnel to man these vessels.

b. From the standpoint of organization of personnel the mine-planting flotilla consists of—

(1) The mine-planter commander.
(2) The executive officer.
(3) One mine-planter crew.
(4) One planting detachment.
(5) One distribution box boat crew.
(6) Three mine-yawl crews.

48. The mine-planter commander.—*a.* The mine-planter commander is the senior commissioned officer of the Coast Artillery Corps assigned to duty with a ship of the Army Mine Planter Service.

b. The mine-planter commander not only commands the mine planter to which assigned but commands and is responsible for the operation of the other vessels in the flotilla and for the tactical and technical training of their crews and of the mine-planting detachment attached to his flotilla. His duties with regard to the operation and administration of the mine planter are prescribed in AR 90–150 and AR 90–155. Instructions governing the operation of distribution box boats and mine yawls are included in AR 90–160.

49. The executive officer.—When two commissioned officers are available for assignment to a mine planter, the junior will be assigned as executive officer. The duties of the executive officer will be to assist the mine-planter commander in such manner as the latter may direct, in the administration, operation, and training of the mine planter and the mine planting flotilla.

50. The mine-planter crew.—*a.* The mine-planter crew consists of the warrant officers, United States Army Mine Planter Service, headquarters detachment, deck department, engine department, and steward's department.

(1) *Master.*—The senior deck warrant officer on duty aboard the mine planter is master of the ship. The master is charged directly with the navigation and maintenance of the mine planter, and with the training and efficiency of the mine-planter crew. His duties in connection with the operation and administration of the ship are prescribed in AR 90–150.

(2) *Mates.*—The second and third warrant officers in seniority of the deck department are, respectively, first mate and second mate. Their duties are prescribed in AR 90–150.

(3) *Engineers.*—The senior and next senior warrant officers of the engine department are assigned, respectively, as chief engineer and assistant engineer. Their duties are prescribed in AR 90–150.

b. Headquarters detachment.—The headquarters detachment consists of the enlisted clerks and radio operators required for accounting, records, correspondence, and communications.

c. Deck department.—The deck department consists of the authorized number of soldiers required for the usual duties of seamen and to man the antiaircraft machine guns. The senior noncommissioned officer of the deck department is assigned as boatswain and the next senior as boatswain's mate.

d. Engine department.—The engine department consists of the authorized enlisted complement of firemen and oilers.

e. Steward's department.—The steward's department consists of the mess sergeant, stewards, cooks, and kitchen police necessary to operate the three messes required on the ship and to police the staterooms of officers and warrant officers.

51. The planting detachment.—The planting detachment is an element of the planting section of a mine battery. It consists of the chief planter, a port detail and starboard detail, each consisting of 1 noncommissioned officer and 8 privates, and an afterdeck detail consisting of 1 noncommissioned officer and 3 privates. The planting detachment is charged with the preparation of mines and accessories aboard the planter and with planting and taking up mines and laying cable. During work pertaining to its tactical assignment, the planting detachment is under the control of the mine-planter commander, and for the time being becomes a part of the crew of the mine planter.

52. The distribution box boat crew.—The distribution box boat, depending on type and size, carries a crew of 1 noncommissioned officer, rated coxswain, as master, 1 noncommissioned officer or private as engineer, and from 2 to 4 privates as deckhands.

53. The mine-yawl crew.—Each mine-yawl crew consists of one noncommissioned officer as coxswain and two privates, one of whom is assigned as engineer and the other as deck hand.

54. Administration of the flotilla.—*a.* The organization of the mine-planting flotilla is such as to concentrate under the control of one competent officer the administration, operation, maintenance, and training of the ship and boat service required in the mine group.

As a unit, the technical specialists and crews of all its component vessels are available to meet any emergency for the repair or upkeep of any vessel.

b. The training of all crews should be such as to insure a certain degree of interchangeability between crews.

c. When the mine planter is required to leave station for fueling, repairs, or transportation service during the absence of the mine-planter commander, the control of the distribution box boat and mine yawls will be taken over by an officer of the mine group detailed by the mine-group commander.

d. Whenever boats of any type are assigned to the mine group in excess of the normal quota for the mine-planting flotilla, such boats and their crews are assigned to the flotilla.

PART THREE

DESCRIPTION AND OPERATION OF CASEMATE AND ELECTRICAL EQUIPMENT

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SECTION VIII

POWER EQUIPMENT

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55. Equipment in the casemate.—*a.* The 5-kilowatt gasoline electric generating set (or Hornsby-Akroyd oil engine and gener-

ator), storage battery, motor generators, casemate transformers, power panel, interrupter panel, and operating boards are installed in the mine casemate, and the necessary tools and materials used in connection with this equipment are also kept there.

b. (1) *The descriptions of equipment in this manual and the instructions in their use as well as instructions for all operations presuppose the installation of the standard single-conductor mine system.*

(2) Upon the receipt of this manual at any post where the old 19-conductor mine system is still in use reference should be made to the Manual for Submarine Mining, 1912, until the standard single-conductor mine system is installed.

56. Five-kilowatt gasoline electric generating set.—Two makes have been supplied the service—the General Electric and the Sturtevant. The engine is of the 4-cylinder, 4-stroke cycle, water-cooled, vertical type, direct connected to a 5-kilowatt generator. This set is a source of direct current for use in charging the storage battery.

57. Engine of General Electric 5-kilowatt set (figs. 3 and 4).—*a.* This is a 10-horsepower engine with a 3-inch bore and a 6-inch stroke.

b. Cooling system.—(1) The cooling water for the jacket may be supplied from a radiating tank or reservoir, from a special automobile-type radiator, or direct from the city mains or pressure supply. In the first two cases the water enters at W1, passes through the gear pump W, thence to the water jacket, leaving at W2. When cooling water is furnished from a pressure supply the gear pump should be removed from the engine and a valve placed in the outlet pipe beyond the engine. This will keep the engine jackets full and regulate the amount of flow. Otherwise the water system is the same as described above.

(2) The amount of cooling water should be such that at full load the temperature of the water leaving is between 180° and 190° F.

(3) When cooling tanks are used they should be so placed that the minimum water level will be above the pump at all times.

(4) A drain cock should be placed at the lowest point of the supply pipe for emptying the system of water whenever it is necessary that the engine stand idle during freezing weather. The engine jackets may be drained by the cock at W3. After the water has stopped running from this cock the engine should be turned backward a few times to empty the water pump. To aid in draining, as well as in filling the jackets, a small air cock should be tapped into the outlet

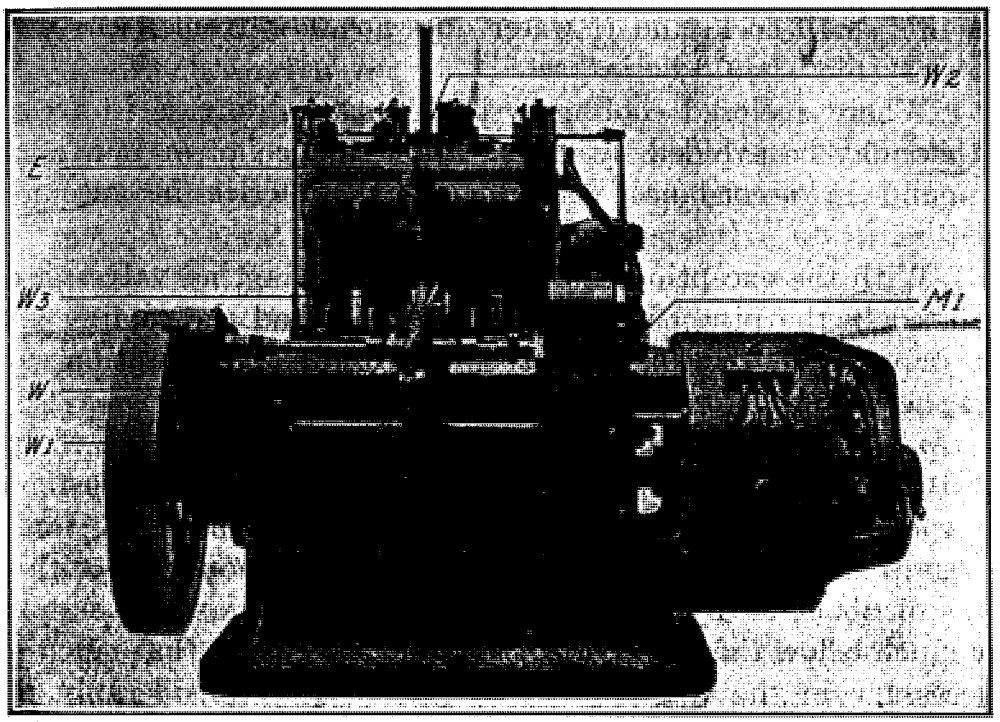

FIGURE 3.—General Electric 5-kilowatt gasoline electric generating set, valve side

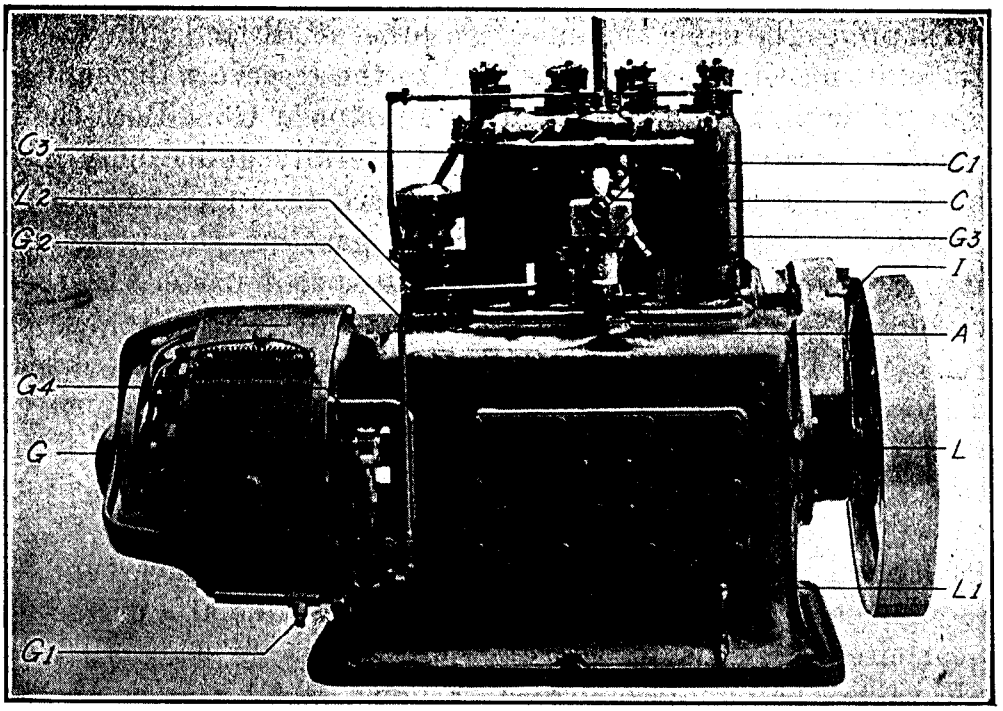

FIGURE 4.—General Electric 5-kilowatt gasoline electric generating set, carburetor side

pipe just above the engine, which will allow the passage of air to and from the system. Each time the engine is started it is well to open this small cock, and if water does not flow from it the water-cooling system should be inspected.

(5) Where a closed cooling system is used drainage in freezing weather may be avoided by the addition of alcohol or nonfreezing compound in accordance with the usual practice in automobile radiators.

(6) With the exceptions noted in the foregoing, no valves should be placed in the pipe between the outlet W2 and the cooling apparatus or waste, as the closing of such a valve during operation would burst the jackets.

c. Gasoline supply system.—(1) This is so designed that the gasoline supply tank may be located under ground and outside the engine room. The vertical distance from the bottom of the tank to the pump inlet should not exceed 5 feet, and should be within a radius of about 30 feet from the engine. If the gasoline supply is very much below the pump or so far from the engine that much pipe is necessary in the suction line, it will require considerably more pumping to fill the carburetor than if the tank were more favorably situated. From the supply tank a ¼-inch pipe runs to the ¼-inch union at G1 (fig. 4) through which the gasoline is drawn by the pump G and forced to the carburetor C through pipe G2. The pump supplies the same amount of gasoline at all loads, the excess at loads below maximum being returned to the reservoir through a ⅜-inch overflow pipe connected to the carburetor at G3. Both the supply and the overflow pipes should be carefully and evenly graded from the engine to the tank; all dips, pockets, and siphons should be avoided. Pipes which are to carry gasoline should have the joints made up with some special gasoline-proof paste. In the absence of any such compound yellow oxide of lead (litharge) and glycerin will be satisfactory. The gasoline pump may be operated by hand when the engine is idle, being of the spring-return type, operated by an eccentric on the cam shaft. This permits filling or priming the carburetor before starting by pressing down on plunger G4.

(2) The carburetor C is of the overflow Venturi tube type, having a chamber or pocket to retain sufficient gasoline at a correct level for carbureting. The quality of the mixture is controlled by a needle valve, the handle of which is shown at C1 as a notched and numbered disk. A spring C3 retains the needle valve in any set position and also indicates the amount of opening. The needle

valve, for ordinary operating conditions, should be opened about three-fourths of a turn (condition of weather and quality of gasoline may vary this either way).

(3) Below the carburetor is a valve, the handle of which is shown at A, for controlling the air taken into the carburetor. By this valve the air may be varied from all hot taken from the crank case to all cold from the room, or none at all. The letters "H," "C," and "S" cast on the valve body indicate the respective positions of the valve handle for the above conditions.

d. Flywheel markings and indicated positions of valves and pistons.—(1) On the circumference of the flywheel are drawn a number of lines, each stamped with its distinguishing marks or title. When the flywheel is so turned that these lines come opposite the indicator I the various positions of the valves or pistons are indicated as follows:

(*a*) "Top of cylinder 1 and 4"—1 and 4 pistons top of stroke.
(*b*) "Top of cylinder 2 and 3"—2 and 3 pistons top of stroke.
(*c*) "I. O. 1"—intake valve opens, exhaust valve closes, No. 1 cylinder.
(*d*) "X. O. 1"—exhaust valve opens No. 1 cylinder.
(*e*) "I. C. 1"—intake valve closes No. 1 cylinder.
(*f*) "Ignition"—use explained under ignition system.

(2) When one set of valves is correctly timed, all are, as the cams are rigidly fixed on the shafts in relation to each other.

e. Ignition system.—(1) The ignition apparatus consists of a high-tension magneto. A short-circuiting switch is provided.

(2) The firing sequence of this engine is 1–2–4–3, the cylinders being numbered consecutively from the front, or cranking, end of the machine. The ignition cables running from the magneto distributor to the spark plugs are marked with numbered tags indicating the number of the cylinder to which they are connected; and the distributor block on the magneto is stamped showing the number of lead for that particular terminal. The advance and retarding of the ignition are obtained by moving the arm, M1 (fig. 3), down or up, respectively. On the frame of the make-and-break the lines stamped "S" and "R" indicate respectively the starting and running positions for the arm, M1.

(3) If it becomes necessary to check the timing of the magneto the following should be closely observed:

Turn the flywheel, watching closely the intake valve of No. 1 cylinder, until the line on the flywheel stamped "Ignition" is op-

posite Index I, *after* the intake valve of No. 1 cylinder has closed; see that the smaller pin of the magneto coupling is in its uppermost position and that the timing arm, M1, is in maximum retard. The make-and-break should be just opening and a white figure "1" should be seen through the window in the distributor block behind the lead marked "C."

f. Lubrication system.—(1) The crank case of the engine is the reservoir for all lubricating oil and should be kept filled with 5 gallons of N. F. O. gas-engine oil (cylinder oil) supplied by the submarine mine depot, to the height marked on the sight gauge at L1. The true height of the oil is shown by this gauge only when the engine is not running. From the reservoir the oil passes through a strainer to a spring return plunger pump, and by it is forced through the sight feed, L, to troughs passing under the connecting rods. The connecting rod heads are provided with cast fingers which strike into the oil, splashing it to all parts of the engine. Ducts and pockets are provided so that oil is led to all parts. Excess oil drains back to the reservoir to be used again. The sight feed at L furnishes a visible indication of the working of the oil pump. Oil should be replaced after 200 hours of operation.

(2) Oil may be put into the crank case at L2.

(3) Parts not automatically lubricated and requiring attention are—

(*a*) Links on oil and gasoline pumps.
(*b*) Collar and pivots of governor.
(*c*) Bearings of magneto.
(*d*) Grease cups.
(*e*) Gasoline pump; the hemp packing of this pump should be soaked in glycerin, and the wells in the top of the glands should be kept filled with the same liquid.

g. Starting the engine.—(1) Check the oil and water.

(2) Fill the carburetor chamber by hand operation of the gasoline pump.

(3) Check needle valve and set air-valve handle A about four notches from S.

(4) Open short-circuiting switch and set magneto timing lever at S.

(5) Crank the engine; this should be done by spinning. *Always* start the spinning operation by *pulling up; never push down.*

(6) After the engine has started, turn air-valve handle around between H and C, and advance the ignition to the running position. The engine is now ready to load.

h. Stopping the engine.—To stop, turn off the needle valve, or close the short-circuiting switch; the former method is recommended.

i. Care of engine.—(1) At all times there must be sufficient lubrication, clean fuel, and plenty of cooling water.

(2) It is well to take part of the carburetor air from the crank case at all times, as this keeps the oil vapors from leaking through the bearings, etc., into the room.

(3) Whenever the various pump glands are repacked or tightened, the gland nut should be screwed down *tight*, then *loosened* a turn or two. This pushes the packing well into place, while not permitting excessive pressure during operation.

(4) When tightening the main bearings, if the two halves of the linings are kept in the same position no trouble will be experienced in aligning the shaft, as nearly all the wear comes on the lower half of the lining. In order to insure the replacement of the linings in their correct positions, on an edge of each lining is stamped a number indicating its proper place. These numbers are upright when read from the exhaust side of the engine.

(5) When starting on cold days it will be found necessary to give much more gasoline than ordinarily. In this connection, the fact that gasoline drips from the carburetor does not necessarily imply that the mixture is too rich in gasoline.

(6) Whenever it is thought necessary to regrind the exhaust valves, they should first be cleaned carefully with gasoline, for when the valves are clean it will often be found that grinding is not necessary.

j. Governor trammel.—A small 4-inch rod with ends pointed and bent down similar to a U shape is furnished for checking the setting of the governor rod. This instrument is stamped with the words, "Gov. Trammel" and the number of the set. Small prickpunch holes are made in the top of the governor rod and in the heads which screw onto this rod, one of which works in the throttle lever and the other in the governor lever. If these heads are ever removed from the rod they should be replaced in such a position that the two prickpunch holes are at just the right distance for the points of the trammel to set in them. This insures the throttle being in the correct position when connected to the governor.

58. Generator of General Electric 5-kilowatt set.—*a. Description.*—(1) This is of the multipolar type, is designed to run at a speed of 750 revolutions per minute, and when so running to generate 40 amperes at 125 volts continuously.

(2) The magnet frame is of cast steel and is made in one piece, so constructed as to be bolted to the engine frame. The magnet cores are of cast steel of high permeability and are bolted to the magnet frame. The armature core consists of sheet-iron laminations assembled on a spider of cast iron. The space blocks in the core form air ducts which communicate with the interior of the armature and insure thorough ventilation of the core windings.

(3) The armature winding is of the series drum-barrel type.

(4) Care should be taken to see that all connections, both between the coils and on terminal boards, are made as tight as possible in order to reduce the contact resistance to a minimum.

(5) The generator is compounded for 120 volts no load and 125 volts full load, allowance being made for 4 per cent drop in engine speed. Where necessary a German silver shunt is provided in order to give the correct compounding.

b. Setting of the brushes.—(1) The direction of rotation of these machines is counterclockwise when facing the commutator end, and the brushes are always arranged so that they trail with reference to the rotation of the commutator. The nuts on the brush holder studs should be tightened up so that the studs will be held perfectly rigid; then clamp the body of the brush holder firmly on the stud with lower edge of the box three thirty-seconds inch from the surface of the commutator. Care should be taken to see that the lower side of the box is parallel with the surface of the commutator; in other words, the distance of the point, A (fig. 5), from the commutator should be the same as that of the point, A_1. Also, be careful to see that the brushes are staggered; that is, that the brushes on any one stud do not follow exactly behind those on the next stud ahead. The brushes should then be inserted in the boxes, properly sandpapered and fitted to the surface of the commutator.

(2) The brushes should be properly spaced by placing a paper ring around the commutator marked with equal spaces to correspond to the number of poles.

(3) The pressure of the brush should be from three-fourths to 1 pound, and can be adjusted easily by placing the adjusting lever in one of the various notches. Nothing is gained by increasing the pressure per square inch on a carbon brush above 2 pounds, as the contact resistance per square inch beyond this point is practically not reduced, whereas the friction is increased in direct proportion to the pressure.

(4) Fit the carbon brushes carefully to the commutator by passing beneath them No. 0 sandpaper with the rough side against the

brush and the smooth side held down closely against the surface of the commutator. Move the sandpaper in the direction of rotation of the armature and draw it back for the next cut with the brush raised to free it of sandpaper; then lower the brush and repeat the operation until a perfect fit is obtained. If the brush requires considerable sandpapering No. 2 sandpaper may be used at first, but the final fitting should be done with No. 0. If an attempt be made to fit the brushes without raising them while drawing the sandpaper back, it will in every case fail to give satisfactory results.

(5) Across the brush holder yoke is chiseled a line. This line is to come just under the arrow on the right-hand side of the upper arm of the bearing bracket. When this is the case the brushes are in the

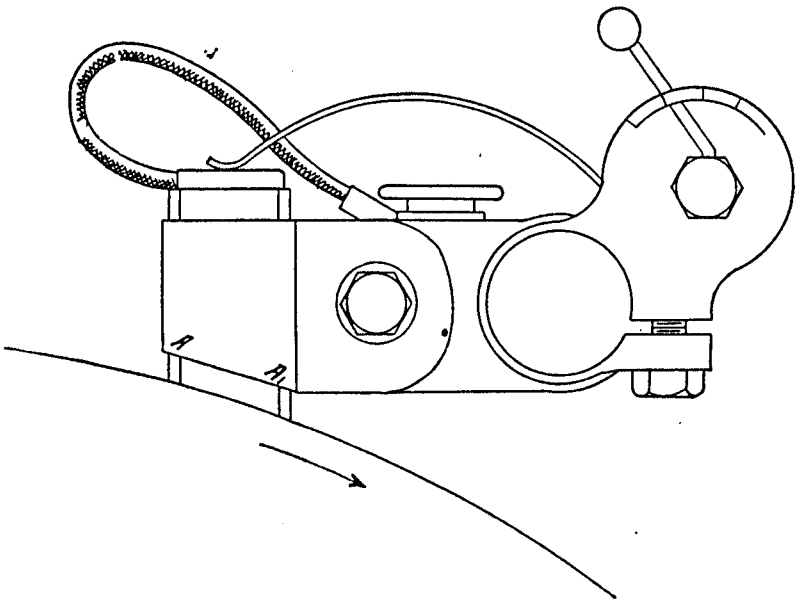

FIGURE 5.—Carbon and brush holder, General Electric 5-kilowatt set

correct position and the generator will compound according to the name plate stamping. No movement of the brushes is necessary for variations of load.

c. Care of the commutator.—(1) The commutator, brushes, and brush holder should be kept perfectly clean and free from carbon or other dust at all times. Wipe the commutator from time to time with pieces of dry, clean canvas; do not use lubricant of any kind.

(2) If the commutator, when running, begins to give trouble by roughness with attendant sparking or excessive heating, it is necessary immediately to take measures to smooth the surface. Any delay will increase the trouble and eventually cause high temperatures, throwing of solder, and possible displacements of the segments. No. 0 sandpaper fitted to a segment of wood with a radius equal to that of the commutator, if applied in time to the surface when running

at full speed (if possible with the brushes raised) and kept moving laterally back and forth on the commutator, will usually remedy the fault. If this does not suffice, it then will be necessary to take the armature out, tighten up the segments, and turn them off true. A machine tool will not leave the surface smooth enough to give perfectly satisfactory results. It is always necessary, before putting on a load after the commutator has been turned, to smooth the surface carefully with the finest sandpaper, thus removing all traces of the tool point.

(3) The outboard bearing should be filled with the best grade of thin lubricating oil, being careful not to allow it to overflow. Oil throwing is usually due to excess of oil and can be avoided by care in filling the oil reservoir. This bearing should be examined at least once a day, while the machine is in operation, to see that the oil rings are turning properly and that there is sufficient oil in the reservoir. When it is necessary to renew the oil draw the old oil from the reservoir by means of the oil plug in the shield.

59. Wrenches for General Electric 5-kilowatt set.—There is furnished with each set a wall cabinet containing a complete set of wrenches suitable for dismounting, assembling, and adjusting the various parts.

60. Engine of Sturtevant 5-kilowatt set (figs. 6 and 7).—*a.* The engine has a 3¼-inch bore and a 5-inch stroke.

b. Cooling system.—Similar to that described in paragraph 57 *b*.

c. Gasoline supply system.—(1) Similar to that described in paragraph 57 *c*.

(2) The carburetor is the overflow type supplied by a plunger pump. To fill the carburetor ready for starting turn the flywheel over until the pointer is opposite the word " pump "; then by means of the hand-plunger pump situated on the carburetor side of the engine fill the carburetor bowl until gasoline overflows the little partition, which may be seen by lifting the lid of the carburetor.

(3) There must always be a filter or fine strainer in the suction line of the gasoline pump, as very small particles in the fuel will cause trouble. The suction pipe must be air-tight and as short and straight as possible.

d. Valve timing.—(1) The timing gears are keyed onto straight shafts; they are easily removed when necessary, and can be put back on the shaft in but one position. Therefore, when meshing up the timing gears it is necessary only to see that the marked teeth are in contact. Each of two adjacent teeth on one gear has a number stamped on the front end, and on the gear running with it is one

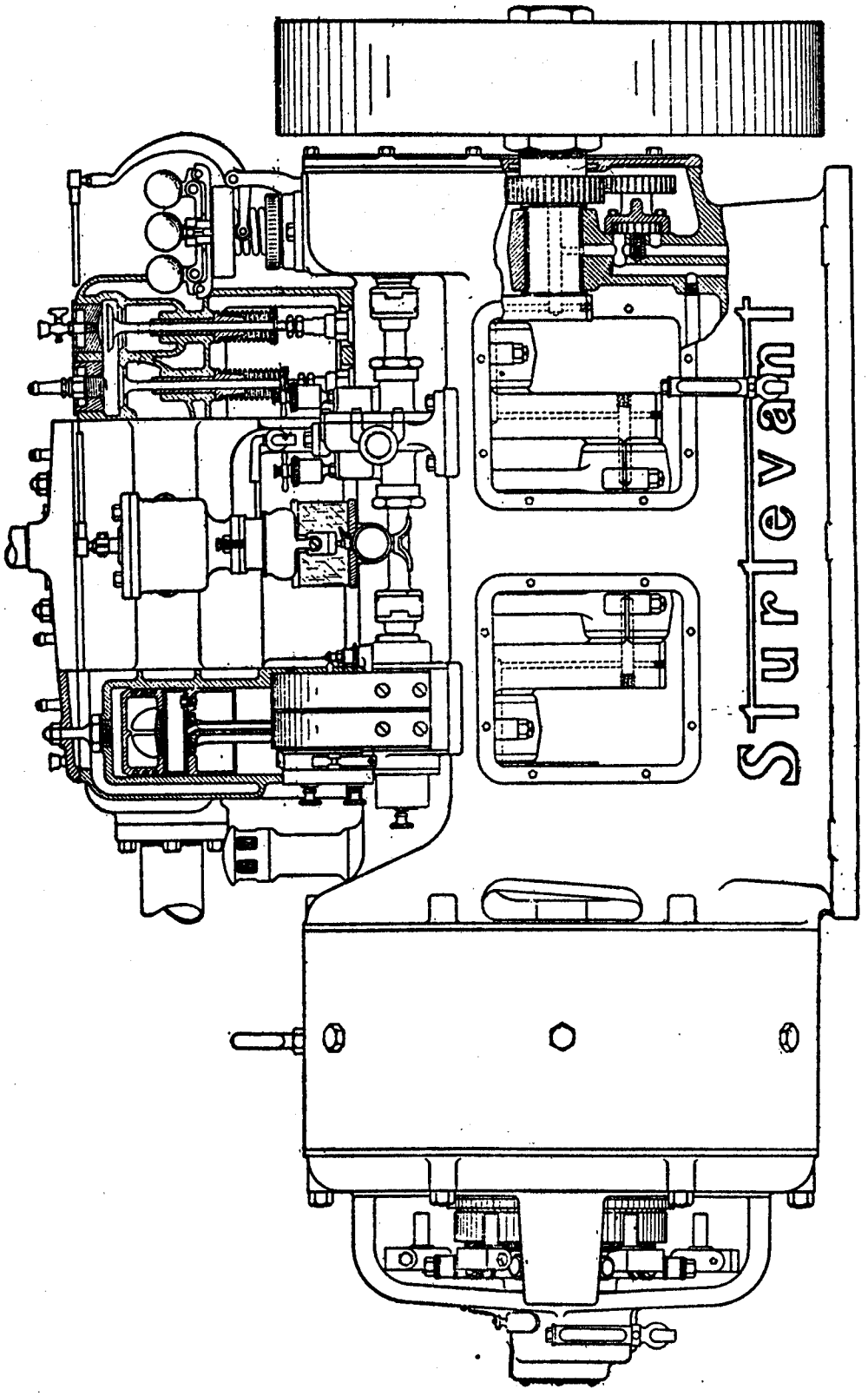

FIGURE 6.—Sturtevant 5-kilowatt gasoline electric generating set, elevation

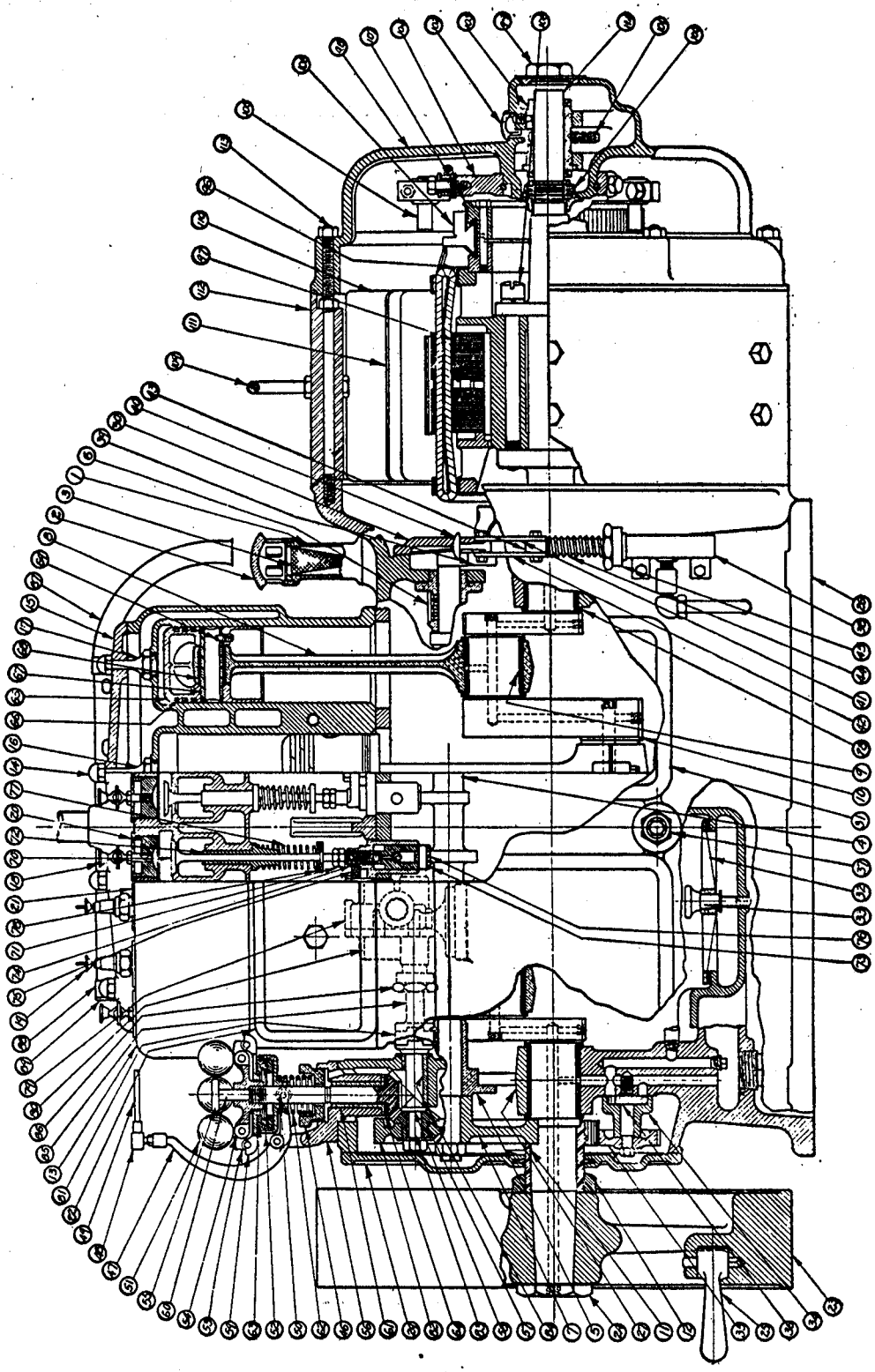

FIGURE 7.—Sturtevant 5-kilowatt gasoline electric generating set, section

tooth bearing the same number. This tooth should be placed between the numbered teeth on the first gear.

(2) In case it is necessary to replace a broken gear with a new one, place the new gear face up, set the old gear on it with its face also up, and with the keyways in line; then mark the teeth of the new gear exactly like those of the old one.

e. Ignition system.—Ignition is furnished by a high-tension magneto operated by a gear from the camshaft. The firing order of this engine is 1–3–4–2.

f. Lubrication system.—(1) Lubrication is by means of a pressure system from the oil supply in the engine base, the pressure being maintained by a gear pump. From the pump the oil is forced to the main bearings and then through the drilled crankshaft to the big end bearings of the connecting rods. The wrist pins, cylinders, and camshaft bearings are lubricated by the oil thrown from the crankpin.

(2) Parts not automatically lubricated and requiring attention are—

(*a*) Gasoline pump links.
(*b*) Generator bearing.
(*c*) Grease cups.

(3) To fill the oil reservoir in the engine base, see that the drain cock is closed, unscrew the top of the breather or vent pipe on top of the base, and pour oil into the base through the strainer in the pipe until its level rises in the sight glass to the top notch in the glass guard. The level should never be allowed to fall below the lower notch in the glass guard. The capacity is 2 gallons. N. F. O. engine oil supplied by the Submarine Mine Depot should be used and should be replaced every 50 operating hours.

(4) To fill the oil well in the generator bearing, see that the drain cock is closed, then raise the oil ring cover and pour in oil until the level rises in the sight glass to the notch in the glass guard; do not overfill.

g. Starting the engine.—(1) Check the oil and water.

(2) Turn the flywheel until the pointer is opposite the word "pump"; then fill the carburetor bowl with gasoline by means of the hand-operated plunger pump.

(3) Open the magneto cut-out switch.

(4) Close the starting valve in carburetor air intake.

(5) Pull out the starting handle in the flywheel, and grasping it with the right hand give a quick pull, rotating the engine in a clockwise direction.

FIGURE 7.—Sturtevant 5-kilowatt gasoline electric generating set, section

(6) After the engine has started open the starting valve in the carburetor at once, see that the oil pressure gauge registers at least 15 pounds if the engine is cold and somewhat less if hot. Also see that the oil ring in the generator bearing is revolving with the shaft; if not, it usually can be started by simply touching with the finger.

(7) There is no necessity for advancing and retarding the spark on this engine, and no means for so doing is provided.

h. Stopping the engine.—Turn off gas, or close the magneto switch; the former method is recommended.

i. Care of engine.—See paragraph 57 *i.*

j. Governor.—(1) The governor and governor valve should be considered nonadjustable except in case of serious trouble.

(2) The only adjustment on the governor itself is the large milled nut supporting the spring. By screwing this nut out, the speed of the engine is raised and vice versa.

(3) The governor is disassembled by removing two set screws in the spider which carries the balls and unscrewing the spider. In assembling, see that No. 1 ball and roller work in arm numbered 1.

(4) In replacing the valve after it has been removed for cleaning, see that it is inserted in the seat so that, when closed, the numbers on valve and seat are opposite. In replacing the valve cover and valve lever, be careful that the V slot in the latter lines with that in the spindle.

k. Catalogue reference numbers.—The item numbers shown in the table are Sturtevant catalogue reference numbers, and are not Submarine Mine Depot code numbers.

Item No.	Name of part	Item No.	Name of part
	ENGINE		ENGINE—continued.
1	Breather (body).		Cylinder—Continued.
2	Breather cap.	17	Cylinder cover stud (short).
3	Breather filter ring.	18	Priming cup.
4	Camshaft.	19	Spark plug.
5	Camshaft bearing (front).	20	Valve cap (priming cup).
6	Camshaft bearing (back).	21	Valve cap (spark plug).
7	Camshaft gear.	22	Valve cover.
8	Connecting rod.	23	Flywheel.
9	Connecting rod bushing.	24	Flywheel nut.
10	Crankshaft.	25	Flywheel cranking handle.
11	Crankshaft gear.	26	Frame.
12	Crankshaft gear nut.	27	Bearing cap (main).
13	Cylinder.	28	Bearing bushing (main).
14	Cylinder cap nut for studs.	29	Cover (gear end).
15	Cylinder cover.	30	Cover (generator end).
16	Cylinder cover stud (long).	31	Cover (large handhole).

Item No.	Name of part
	ENGINE—continued.
	Frame—Continued.
32	Oil filter.
33	Oil filter thumb nut.
34	Oil pump case.
35	Oil pump drive gear.
36	Oil pump gear.
37	Oil relief valve.
38	Fuel pump (body).
39	Fuel pump cam lever.
40	Fuel pump lever.
41	Fuel pump link (plain).
42	Fuel pump link (tapped).
43	Fuel pump plunger.
44	Fuel pump spring.
45	Fuel pump stuffing box nut.
46	Governor (adjusting nut).
47	Governor arm.
48	Governor arm ball and socket joint.
49	Governor arm connecting rod.
50	Governor arm rollers.
51	Governor ball.
52	Governor ball bearing seat.
53	Governor ball rollers.
54	Governor ball spider.
55	Governor ball stop nut.
56	Governor bracket.
57	Governor bevel gear.
58	Governor bevel gear thrust collar.
59	Governor roller spider.
60	Governor shaft and gear.
61	Governor shaft bushing.
62	Governor spring.
63	Governor thrust bearing (B. B.)
64	Governor thrust washer.
65	Piston.
66	Piston ring.
67	Piston wrist pin.
68	Piston wrist pin bushing.
69	Piston wrist pin locking screw.
70	Valve.
71	Valve adjusting nut.
72	Valve bushing.

Item No.	Name of part
	ENGINE—continued.
	Valve—Continued.
73	Valve push rod body.
74	Valve push rod guide.
75	Valve push rod guide yoke.
76	Valve push roller.
77	Valve spring.
78	Valve spring cap.
79	Water pump (body).
80	Water pump cover.
81	Water pump coupling.
82	Water pump drive gear.
83	Water pump drive shaft.
84	Water pump drive shaft bushing.
85	Water pump shaft.
86	Water pump stuffing box nut.
87	Wire tube (magneto).
88	Wire tube clip.
89	Wire tube plug.
	GENERATOR
96	Armature.
97	Armature core.
98	Bearing case.
99	Bearing end cap.
100	Bearing oil deflector.
101	Bearing oil ring.
102	Bearing oil well cover.
103	Bearing sleeve.
104	Brush ring.
105	Brush stud.
106	Bolt (armature).
107	Commutator (frame).
108	Commutator segment.
109	Eyebolt.
110	Field coils.
111	Pole piece.
112	Magnet (frame).
113	Magnet frame through bolts.
114	Shaft.

61. Generator of Sturtevant 5-kilowatt set.—*a. Description.*—(1) This is of the multipolar type with a normal speed of 900 revolutions per minute, and when so running generates 40 amperes at 125 volts continuously.

(2) The magnet frame is of cast or forged steel, cylindrical in shape, and so constructed as to be bolted to the engine base. There are six pole pieces of steel laminations so bolted to the magnet frame as to be removable without disturbing the armature or dismantling

the generator. The pole pieces are of such a shape that they provide a support for the field coils, and so distribute the magnetic flux as to produce sparkless commutation under wide variations of load.

(3) The armature is of the ironclad, slotted-drum type, built of soft annealed steel punchings.

(4) The generator is compound wound, with long shunt connection, and designed to give a flat external characteristic with a load varying between no load and full load with 125 volts at terminal.

b. Adjustment of brushes.—The brush holders are of the sliding socket type and are provided with braided copper cable shunts which relieve the brush holder bodies and springs from carrying the current. The brush holders are supported by a ring, which in turn is clamped into position on the inside hub of the bearing bracket. The brush rigging is thus held firmly, and although it may be shifted easily, there is no danger of the brushes being thrown out of position or tilted. The brushes may be adjusted individually or removed while running. The correct setting of the brushes is indicated by mark. The brushes may be fitted to the commutator by the use of sandpaper as explained in paragraph 58 *b* (4).

c. Care of commutator.—See paragraph 58 *c*.

62. Wrenches for Sturtevant 5-kilowatt set.—A set of 10 wrenches in a wall cabinet is furnished for dismounting, assembling, and adjusting the various parts.

63. Ten-kilowatt gasoline electric generating set.—This set has been supplied to several posts. The engine has a 5-inch bore and a 6-inch stroke. The description and operation of this set are, in general, similar to that described above for the General Electric 5-kilowatt set.

64. Hornsby-Akroyd oil engine (figs. 8 and 9).—*a. Description.*—(1) This engine is in use only where a 5-kilowatt gasoline electric generating set has not been supplied. The engine drives the casemate generator, which is a source of direct current for use in charging the storage battery.

(2) It is a horizontal single-acting, single-cylinder kerosene engine operating on a 4-stroke cycle. As the piston moves forward oil is sprayed into the vaporizer and vaporized by striking the hot walls opposite, and at the same time air is drawn into the cylinder. As the piston returns, the air and gas are mixed, and near the end of the stroke an explosion takes place which moves the piston forward again. During its return the products of the explosion are forced out through the exhaust valve. The above operations are

continuous. The piston receives an impulse. due to the explosion, every two revolutions of the flywheel.

(3) At the back of the cylinder, in prolongation of its axis, is a cast-iron box called the vaporizer, which is always open to the cylinder. Before starting the engine this vaporizer must be heated by an external lamp so that it will vaporize the oil when it is first pumped into it. After the engine has started running the lamp is no longer required, as the vaporizer is kept at a sufficient heat by the internal explosions.

(4) A small oil pump, worked by the air-valve lever, draws oil from the oil tank under the engine and forces it into the vaporizer at the proper time. The oil, on its way from the pump to the vaporizer, passes through a valve box attached to the vaporizer; this valve box has two valves, a horizontal one kept closed by a spring which the oil forces open as it goes into the vaporizer, and a vertical one also kept closed by a spring. Should the engine run too fast the governor opens this latter valve and allows some of the oil to flow back to the oil tank through the waste pipe. This valve also can be opened by turning the little regulating handle, which will stop the supply of oil to the vaporizer and stop the engine.

b. Heating the vaporizer.—(1) Fill the lamp with oil by means of the filling pipe until the oil is 1 inch below the pipe, and put a piece of wick, which should consist of a piece of ordinary asbestos wick packing, into each of the cups around the pipes. Pour a little alcohol or kerosene into each cup under the coil and light it. The cups may be filled with kerosene by closing the air-escape valve and working the air pump. When this is nearly burned out pump up the reservoir with air by the air pump. Oil will issue from the small nozzle and give a clear flame. When it is desired to stop the lamp turn the thumbscrew on the reservoir filling nozzle to let the air out. Should the nozzle become choked it should be cleaned with the small needles for that purpose.

(2) The heating of the vaporizer is one of the most important things to be attended to, and care must be taken that it is hot enough at starting. If the vaporizer is not as hot as it should be the engine will run badly and perhaps soon stop. Failure of engines to run properly can in most cases be traced to this source. No time should be lost in starting the engine after the vaporizer has been heated sufficiently, as the engine may not run satisfactorily if the vaporizer is allowed to cool after heating it. The lamp should be left burning a few minutes after starting.

c. Oiling the engine.—(1) Oiling the engine should always be done during the heating-up of the vaporizer. See that the oil cups on the two main crankshaft bearings are fitted with proper wicks and filled with oil. Adjust the lubricator on the large end of the connecting rod and oil the small end which is inside the piston.

(2) Also oil the following:

(*a*) The bearings on the horizontal shaft and the skew gearing.

(*b*) The rollers at the ends of the valve levers and their pins.

(*c*) The pins on which the valve levers rock.

(*d*) The governor spindles and joints, and the bevel wheels which drive same.

(*e*) The joints that connect the governor to the vertical valve of the overflow.

d. To operate the engine.—(1) See that the water supply is satisfactory; the water in the tank should be above the return pipe.

(2) See that the cocks which admit water to the water jacket of the vaporizer valve box are open, that the cock on the main water pipe from the bottom of the tank is open, and that the drain cock is closed.

(3) See that there is oil in the reservoir.

(4) Start the lamp and place it under the vaporizer.

(5) Open the relief cock.

(6) Turn the engine forward until the crank pin is down.

(7) Throw the lever to "TO START."

(8) Fill the oilers and see that the valve from the reservoir to the supply pipe is open. The vaporizer should be heated from 10 to 20 minutes; never try to start until it is red hot.

(9) Give several strokes to the pump; oil should overflow at the glass.

(10) Turn the hand regulator to "OPEN."

(11) Give two strokes to the pump. Vapor will issue from the cock on the cylinder if the vaporizer has been heated sufficiently.

(12) Close cock on top of cylinder.

(13) Pump two strokes.

(14) Man the flywheel by putting one foot on a spoke that is nearly horizontal and the hand on a rim or a spoke. Start the wheel backward; bring the wheel around as far as possible so as to force the piston sharply up against compression. Release the wheel. Explosion should take place and the engine should start forward. Do not attempt to force the crank past dead center.

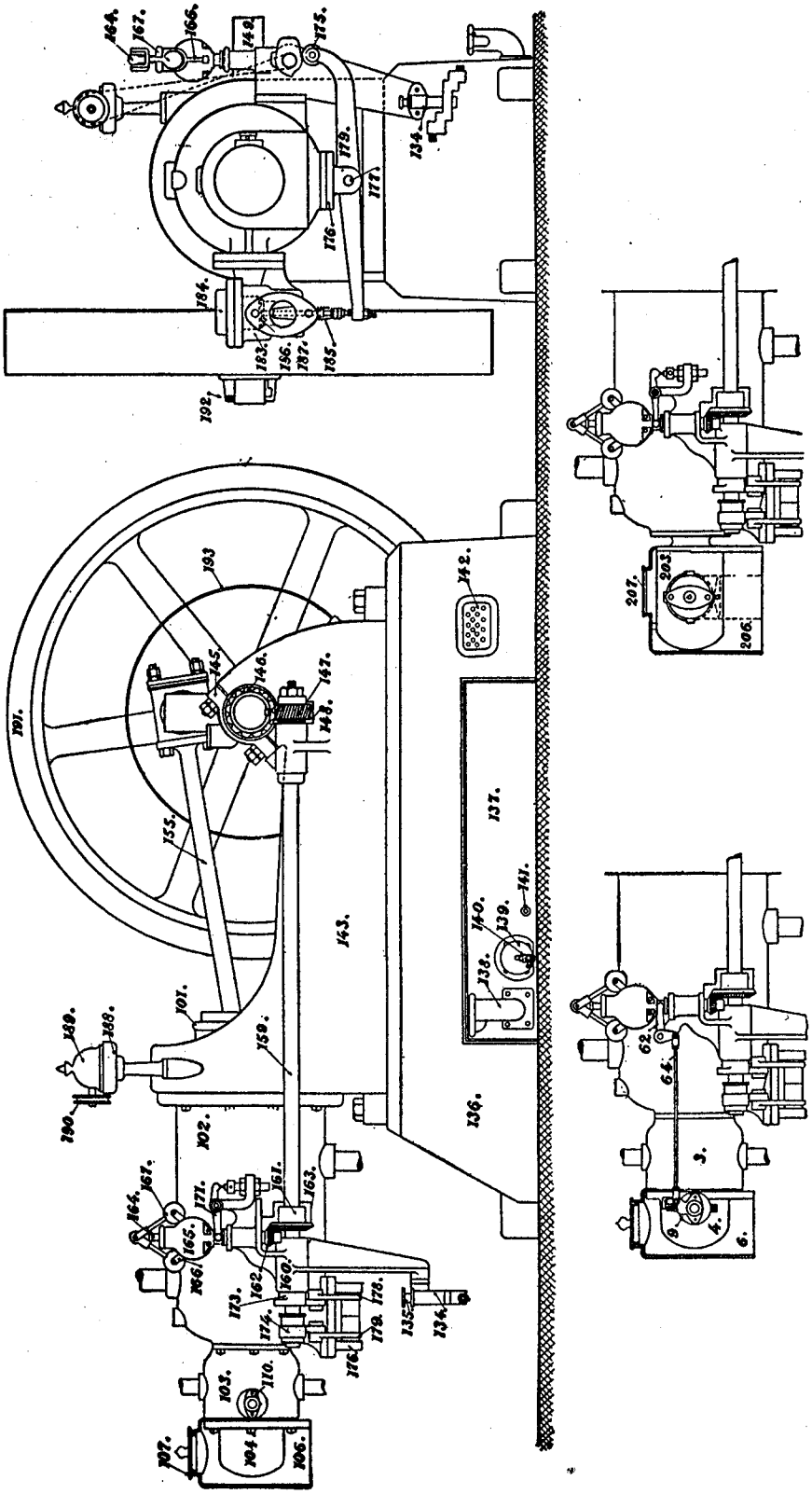

FIGURE 8.—Hornsby-Akroyd oil engine

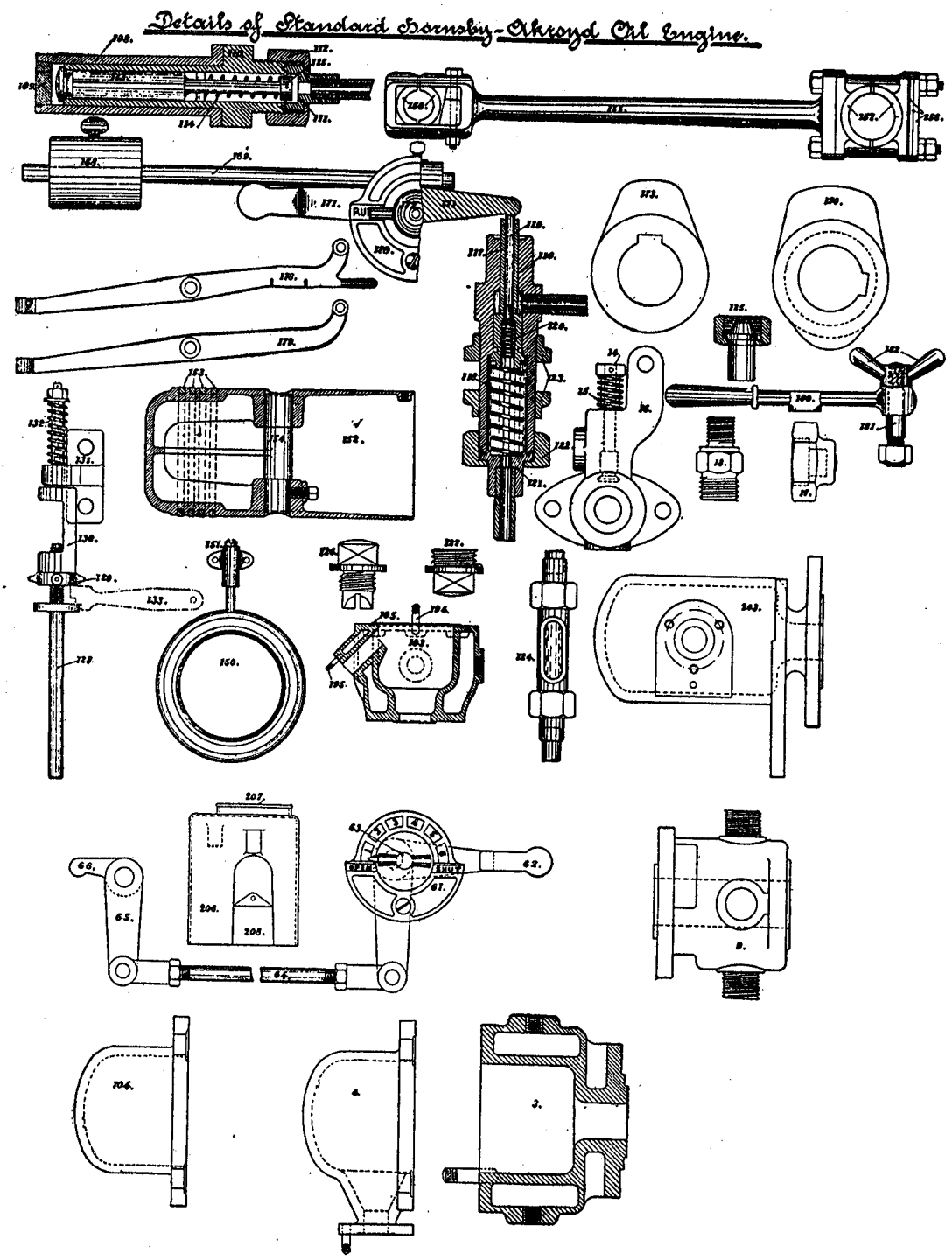

FIGURE 9.—Parts of Hornsby-Akroyd oil engine

(15) Take hold of the starting lever, and when the engine has sufficient speed to carry it past compression, throw the lever to "TO WORK."

(16) Open oil feeders; see that the cylinder oil is feeding.

(17) Regulate the pump stroke until *a little oil shows at the overflow.*

(18) Remove the lamp after the engine has run a few minutes.

(19) Regulate the speed by means of the governor counterweight.

e. To stop engine.—(1) Turn hand regulator to "SHUT." When the engine stops, cut off the oilers.

(2) After shutting down, if there is danger of freezing, drain the water from the circulating pipes and cylinder jacket, and from the valve box if water jacketed; otherwise they may crack or burst.

(3) If it is desired to stop the engine for a short time only, put the lamp back under the vaporizer to keep it hot.

f. Oil pump.—When the cylinder is working at its full power the distance between the round flanges on the pump plunger should be such that the hand gauge (supplied with the engine in the tool box) will allow the part stamped "1" just to fit in between the flanges. If at any time the positions of these flanges be altered they can be readjusted to this gauge. The other lengths on the hand gauge are useful for adjusting the pump to economize oil. When running on a medium load, use length marked "2"; on a light load, use length marked "3." See that the pump packing is not too tight.

g. Care of engine.—(1) Keep the engine clean; remove all surplus oil that accumulates on the cylinder. Keep all brass parts bright, and iron parts not painted free from rust. The vaporizer spray nozzle should be cleaned occasionally, as a deposit of carbon here is a common cause of the engine not running well. Keep the water tank, oil reservoir, and oil lubricators filled. Keep the starting lamp filled with oil and the nozzle open, using a small needle provided for that purpose. In frosty weather see that the water is drained out, as explained in *e* (2) above.

(2) When the engine needs repainting, it should be rubbed down until all the varnish is removed and a coat of steel colored paint applied. This coat should be rubbed until no brush marks remain and one or two coats of varnish applied. The steel colored paint should be applied flat. One gallon of this paint is more than enough to give an engine two coats.

h. Numbers and names of parts of Hornsby-Akroyd oil engine (see figs. 8 and 9).—The item numbers shown in the table are reference numbers only, and not Submarine Mine Depot code numbers.

Item No.	Name of part	Item No.	Name of part
3	Vaporizer jacket.	143	Bed plate.
4	Vaporizer cap.	144	Left or long bearing cap.
6	Vaporizer cover.	145	Right or short bearing cap.
9	Vaporizer valve box jacket.	146	Spiral gear worm.
14	Vaporizer return valve.	147	Spiral gear wheel.
15	Vaporizer return valve spring.	148	Spiral gear guard.
16	Vaporizer valve box body.	149	Crankshaft.
17	Vaporizer valve box body screw cap.	150	Crank pin oiler.
18	Vaporizer valve box coupling.	151	Crank pin oiler elbow.
61	Governor regulating plate.	152	Piston.
62	Governer fork.	153	Piston rings.
63	Governor fork spindle.	154	Wrist pin.
64	Governor connecting rod.	155	Connecting rod.
65	Governor connecting rod lever.	156	Connecting rod wrist end brass.
66	Governor return valve lever.	157	Connecting rod crank end brass.
101	Cylinder liner.	158	Connecting rod compression plates.
102	Cylinder casing.	159	Cam shaft.
103	Vaporizer jacket.	160	Governor bracket.
104	Vaporizer cap.	161	Governor bevel wheel.
105	Vaporizer copper joint ring.	162	Governor pinion.
106	Vaporizer cover.	163	Governor gear guard.
107	Vaporizer cover lid.	164	Governor spindle.
108	Vaporizer valve box sleeve.	165	Governor counterpoise.
109	Vaporizer spray nozzle.	166	Governor counterpoise lever.
110	Vaporizer oil inlet sleeve.	167	Governor balls.
111	Vaporizer spray nozzle coupling.	168	Governor counterweight.
112	Vaporizer spray nozzle coupling nut.	169	Governor counterweight lever.
113	Vaporizer spray nozzle inlet valve.	170	Governor regulating plate.
114	Vaporizer spray nozzle inlet valve spring.	171	Governor fork and overflow lever.
115	Vaporizer spray nozzle valve collar.	172	Governor fork and overflow lever spindle.
116	Oil return valve casing.	173	Air valve cam.
117	Large oil return valve.	174	Exhaust valve cam.
118	Large oil return valve spring.	175	Cam rollers.
119	Small oil return valve.	176	Lever fulcrum bracket.
120	Small oil return valve spring.	177	Lever fulcrum pin.
121	Governor oil pipe coupling.	178	Air valve lever.
122	Governor oil pipe coupling nut.	179	Exhaust valve lever.
123	Lock nut for oil return valve casing.	180	Cam shifting lever.
124	Oil overflow gauge.	181	Cam shifting lever pin.
125	Half union, cone and nut.	182	Cam shifting lever lock nut.
126	Oil pump cap.	183	Air and exhaust valve box.
127	Oil pump plug.	184	Air and exhaust valve box cover.
128	Oil pump plunger.	185	Air and exhaust valve springs.
129	Oil pump plunger lock nut.	186	Air valve.
130	Oil pump plunger head.	187	Exhaust valve.
131	Oil pump plunger head guide.	188	Cylinder lubricator body.
132	Oil pump plunger spring.	189	Cylinder lubricator cover.
133	Oil pump gauge.	190	Cylinder lubricator pulley.
134	Oil pump body.	191	Flywheel.
135	Oil pump gland.	192	Flywheel key guard.
136	Base of engine.	193	Splasher.
137	Oil tank.	194	Stud bolts for vaporizer and cap.
138	Oil tank inlet elbow.	195	Stud bolts for spray sleeve.
139	Filter box.	203	Unjacketed vaporizer.
140	Filter cock.	206	Unjacketed vaporizer cover.
141	Drain cock for oil tank.	207	Unjacketed vaporizer cover lid.
142	Air inlet plate.	208	Guide for cover.

65. Accessories for Hornsby-Akroyd oil engine.—*a. Wrenches.*—These consist of a set of 12 single-end wrenches with openings varying from ¼ to 1¼ inches.

b. Asbestos sheet packing, one-thirty-second inch thick, with wire insertion, for use in making gaskets.

c. Crandall packing, one-fourth inch.—Spiral graphite packing one-fourth inch square, for use in packing the oil pump.

66. Casemate generator (figs. 10 and 11).—*a. Description.*—A direct current shunt-wound generator for use with the oil engine.

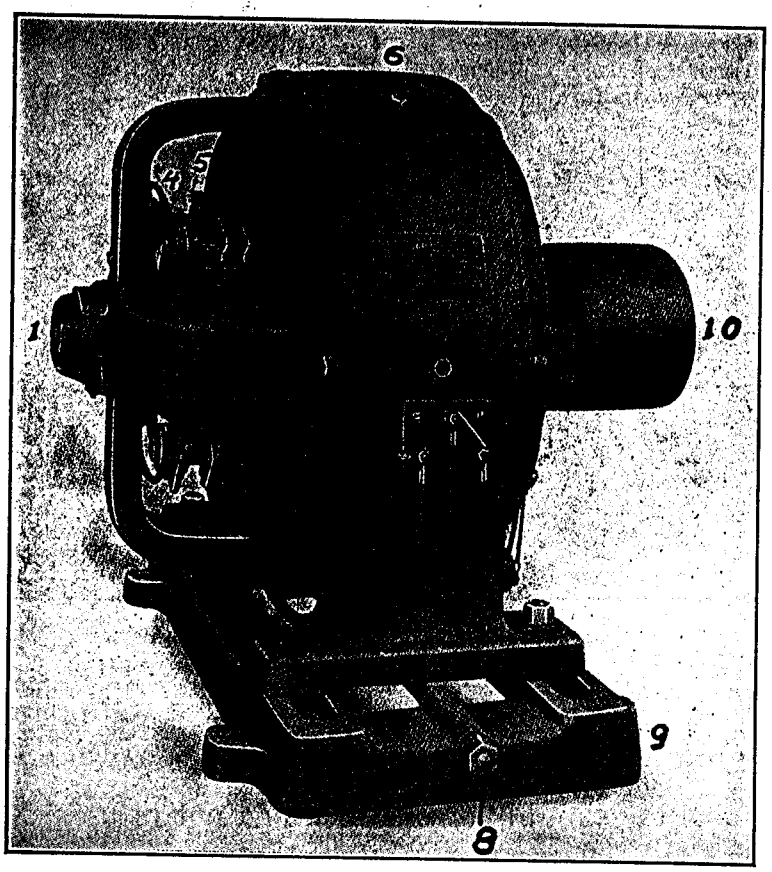

FIGURE 10.—Casemate generator

b. Care and operation.—(1) The belt between the oil engine and the generator should not be too tight.

(2) The generator should be fastened to a firm foundation with anchor bolts, and should be well insulated by using a layer of dry wood between the concrete and base plate.

(3) The best dynamo oil should be used for the bearings.

(4) Commutators should be clean and smooth, and the brushes should fit on them with large contact surfaces. The commutators should be cleaned occasionally with a little paraffin on canvas.

(5) The machine should run smoothly without any unusual noises and without undue heating of its bearings on account of friction. The armature is not well ventilated and it heats unduly. The machine must be watched carefully, and on the first sign of undue heating the generator should be stopped and allowed to cool. Water should never be poured on it to cool it.

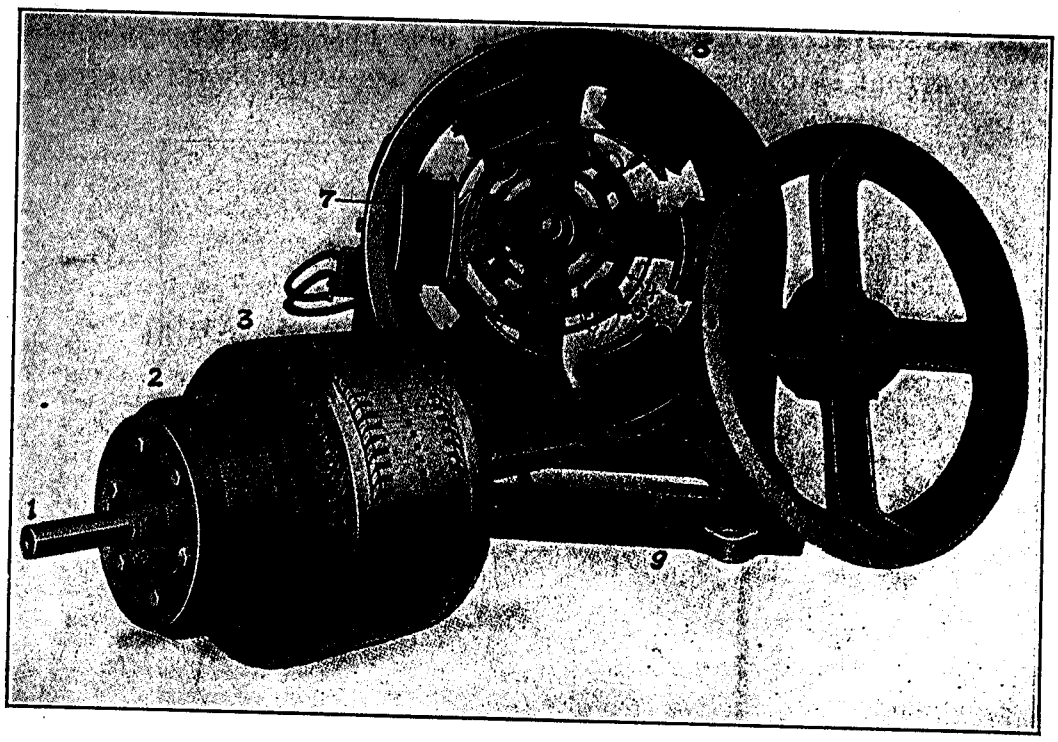

FIGURE 11.—Casemate generator disassembled

1. Shaft.
2. Commutator.
3. Armature.
4. Rocker arm.
5. Brushes and brush holder.
6. Frame.
7. Field coils.
8. Belt tightener.
9. Base plate.
10. Pulley.

(6) The machine should be covered when not in use.

(7) All electrical connections should be clean and firmly made.

c. Adjustment of brushes.—The brushes should be so adjusted that, when running at full speed, no sparking occurs. The best position of the brushes is found by trial, and the position should then be marked so that if disturbed they can be put back in place readily.

67. Carbon brushes and copper gauze brushes.—The code numbers and uses of the various types of brushes are as follows:

Submarine mine code number	Used with
2403–5G	Generator of General Electric 5-kilowatt set.
2403–5S	Generator of Sturtevant 5-kilowatt set.
2403–10G	Generator of General Electric 10-kilowatt set.
2599	Fan motor of General Electric 10-kilowatt set.
2981	Wagner generator, with old style brush holders.
2982	Wagner generator, with Baylis brush holders.
2983	Wagner generator, with Baylis brush holders rewound for 110 volts, 15 amperes.
3068	General Electric direct current-alternating current motor-generator set, motor end.
3069	Mechanical appliance direct current-alternating current motor-generator set, motor end.
3067–GE	General Electric direct current-alternating current motor-generator set, generator end.
3067–MA	Mechanical appliance direct current-alternating current motor-generator set, generator end.
4331	Diehl direct current-direct current motor-generator set, motor end.
4332	Diehl direct current-direct current motor-generator set, generator end.
4353	Interrupter motor.
4375	Interrupter contact arms.

68. Casemate oiler set.—For use in the casemate; it is made of heavy brass and consists of the following:

1 tray, 12 inches diameter.
1 filler, 4¾ inches diameter, 7-inch nozzle.
1 oiler, 2¾ inches diameter, 3-inch nozzle.
1 oiler, 3⅜ inches diameter, 3-inch nozzle.
1 oiler, 3⅜ inches diameter, 9-inch nozzle.

69. Casemate storage battery.—*a. Description.*—(1) This is a 40-cell chloride accumulator with a normal charge and discharge rate of 5 or 15 amperes according to installation. The voltage may be taken at 2 volts per cell. The type of the 5-ampere cell is D–5, and of the 15-ampere cell E–7, in which the letter denotes the size of the plate and the figure the number of the plates per cell. Any new installations will be of the 15-ampere size. There are two positive plates and three negative plates in each of the 5-ampere cells, and three positive plates and four negative plates in each of the 15-ampere cells.

(2) This battery supplies direct current for testing mines and cable ends, for signaling purposes, for running the motors of the motor-generator sets, and for both machine and manual operation of the selectors in the standard single conductor system. Current from this battery may also be used for lighting the casemate.

b. Location of battery room.—(1) This should be a separate room, well ventilated, dry, and of moderate temperature. Extremes of

temperature affect the proper working of a battery; if the air is damp there is danger of leakage due to grounds.

(2) Ventilation of the room should be good, not only to insure dryness, but also to prevent an explosion, as the gases given off during charge form an explosive mixture if confined. For this reason never bring an exposed flame near the battery when it is gassing.

(3) Direct sunlight should not fall on the cells.

(4) The trays (if wood trays are used) and benches on which the cells rest should be painted with acid-resisting paint, and all metal work (iron and copper) with asphaltum varnish.

c. Installation.—When it is necessary to install a storage battery, detailed instructions will be furnished by the submarine mine depot upon request.

d. Electrolyte.—This is dilute sulphuric acid of a specific gravity of 1.210, or 25° Baumé, as shown on the hydrometer at 70°. The electrolyte should cover the top of the plates by one-half to three-fourths inch, and must be cool when poured into the cells. The jars should be numbered with acid-resisting paint and a line made with the same material to indicate the height at which the electrolyte should be kept. It will be necessary to add electrolyte only at long intervals to replace any loss.

e. Battery in regular service.—(1) After the initial charge is complete, the battery is ready to be put into regular service. A battery must not be repeatedly overcharged, undercharged, overdischarged, or allowed to stand completely discharged. Standing completely discharged will cause permanent injury.

(2) After the completion of a charge (initial or with the battery in regular service) and the current turned off, the voltage will fall immediately to about 2.2 volts per cell, and then to 2 volts when the discharge is started. If the discharge is not begun at once, the pressure will fall quite rapidly to about 2.05 volts per cell, and remain there while the battery is on open circuit.

(3) A cell should be selected as a "pilot cell"; that is, one that is in good condition and representative of the general condition of the battery. The height of the electrolyte in this cell must be kept constant by adding a small quantity of water each day. This cell is to be used particularly in following the charge and indicating when it should be stopped.

(4) Never continue the discharge below 1.75 volts per cell at full load at a rate of 5 or 15 amperes according to the type of cell. In ordinary service it is better to stop the discharge at 1.9 volts. Begin

charging immediately when the battery is discharged. For a regular charge, continue until the specific gravity is about 1.207 per cell.

(5) The fall in specific gravity of the electrolyte serves as an indication of the amount of discharge and is in direct proportion to the ampere-hour discharge, thereby differing from the drop in voltage, which varies irregularly for different rates and degrees of discharge. For this reason, under ordinary conditions, the fall in specific gravity is preferable in determining the amount of discharge.

(6) The actual amount of variation in the specific gravity of the electrolyte between a condition of full charge and a complete discharge depends upon the quantity of solution in the containing vessel compared with the bulk of the plates. When cells are equipped with the full number of plates, the range will be about 35 points (0.035 sp. gr.); for example, if the maximum specific gravity reached on the preceding overcharge is 1.209, the extreme limit beyond which the discharge should not be carried is about 1.174.

(7) If the battery is discharged daily, give it an overcharge once a week by charging until the specific gravity is about 1.210 per cell and there is no further rise for five successive 15-minute readings. When the battery is but little used, freshen it up regularly and give it an overcharge once in two weeks. At the end of a regular charge the cells gas moderately; at the end of an overcharge they gas freely. Add distilled water to bring the cells to the proper height before the overcharge.

(8) The regular charge should be continued until the specific gravity of the pilot cell has risen to within five points of the maximum as shown on the last previous overcharge. For example, if on the previous overcharge the maximum is 1.210, then on the following regular charges the current should be cut off when the specific gravity of the pilot cell reaches 1.205. With an old battery whose plates are not uniform, readings should be taken on each cell to determine the end of charge.

(9) As the temperature affects the specific gravity, correction must be made for any change of temperature. The temperature correction is one point (0.001 sp. gr.) for 3° change in temperature. For example, electrolyte, which is 1.210 at 70°, will be 1.213 at 61° and 1.207 at 79°.

f. Inspections.—(1) Inspect each cell carefully the day before the overcharge. See that no foreign substance is lodged between the plates; if there is, remove it or push it down to the bottom of the jar by means of a piece of wood or hard rubber. Never use any metal for this purpose. See that the sediment at the bottom of the jar does not reach to the plates.

(2) Daily readings of the specific gravity and voltage should be taken from the pilot cell and recorded, the voltage readings always being taken when the current is flowing. On the occasion of each charge, read and record the specific gravity of each cell before the charge and again after the charge. The form for the Casemate Storage Battery Record is described and illustrated in paragraph 264 *c*.

(3) At the end of each charge it should be noted that all cells are gassing moderately, and at the end of an overcharge, freely.

g. Unevenness of cells.—(1) If any of the cells read low and do not gas freely with the others at the end of charge, examine them for scale or foreign matter between the plates. If, after removing any such cause of trouble, the readings do not come up at the end of the overcharge, the cell must be cut out of the circuit on the discharge, to be cut in again just before beginning the next charge.

(2) Impurities in the electrolyte will cause a cell to work irregularly and the plates to deteriorate. If it be known that there is any impurity in the electrolyte, steps should be taken to remove it at once. The solution should be replaced immediately, the cell being thoroughly flushed with water before putting in the new electrolyte. The change should be made when the battery is fully charged, as the impurities will be in the electrolyte when the battery is charged. Immediately after the change the cell should be charged.

h. Sediment.—The accumulation of sediment in the bottom of the jars must be watched and not allowed under any circumstances to get up to the plates; if this occurs, rapid deterioration will result. To remove the sediment the simplest way is to lift the elements out after the battery has been fully charged, draw off the electrolyte, and dump the sediment; then clean the jar with water and get the elements back and covered with electrolyte as quickly as possible, so that the plates will not dry out. Electrolyte, not water, will be required to complete the filling of the cells, the specific gravity of which should be 1.210.

i. Evaporation.—Never let the surface of the electrolyte get down to the top of the plates; keep it from one-half to three-fourths inch above the top of the plates by the addition of pure water, which should be added at the beginning of a charge, preferably the overcharge. It will not be necessary to add electrolyte except at long intervals or when cleaning the jars.

j. Putting the battery out of commission.—(1) If it is ever necessary to put the battery out of commission for a time, proceed as follows: After thoroughly charging, siphon off the electrolyte

(which may be used again) into convenient receptacles, preferably clean carboys which have never been used for any other kind of acid, and as each cell becomes empty immediately fill it with fresh, pure water. After all the cells have been filled with water, let them stand 12 to 15 hours, then draw off the water. The battery may now stand without further attention until it is again to be put into service; then proceed as in the case of the initial charge.

(2) If for any reason any cell becomes discharged before the others, it should be cut out on discharge and worked up to normal before being used.

(3) Should the battery sulphate, charge and discharge it frequently, using not less than one-half normal rate at any time and increasing to full rate as the plates show signs of recuperation. Keep the temperature of the cells below 100° F. Frequent exercise will clear the plates in a badly sulphated battery.

(4) Keep records of all charging voltages, specific gravities, and troubles with the cells.

k. Condensed instructions for operating the storage battery.— (1) Avoid excessive charging. A battery should never be undercharged, overdischarged, or allowed to stand completely discharged.

(2) Keep the electrolyte at the proper height (one-half to three-fourths inch) above the top of the plates.

(3) The daily and weekly readings should be taken and recorded regularly and accurately.

(4) Carefully inspect each cell at regular intervals.

(5) If any low cells develop, bring them back to condition at once.

(6) Do not let sediment get up to the plates.

(7) Do not let impurities, either solid or liquid, get into or remain in the cells.

(8) Keep the battery room well ventilated, especially while charging.

(9) Never enter the battery room with an exposed flame during or shortly after the gassing period of the charge.

(10) Keep the jars, sand, trays, table, floor, and other parts of the battery room clean.

(11) Keep the iron, copper, or other metal work about the battery room free from corrosion.

(12) Keep all connections bright and clean.

(13) Post a copy of these instructions in a conspicuous place in the battery room.

l. Storage battery ground detector circuit.—The object of this circuit is to detect grounds in either the storage battery or storage-battery leads. The circuit is shown in Figure 14. To test for grounds trip (open) the double circuit breaker and place the direct-current plug in the top receptacle. Press in on the left-hand switch key below the bottom direct-current receptacle and glance at the direct-current voltmeter; this tests the positive lead and battery for grounds. If the battery or positive lead is not grounded the voltmeter pointer will remain at zero. A reading on the voltmeter means a flow of current, hence a ground. To test the negative lead and battery for grounds, press in both switch keys and glance at the direct-current voltmeter.

70. Accessories for storage battery.—*a. Acid pitcher.*—A 2-gallon earthenware pitcher for use in transferring electrolyte from the carboy to the storage-battery cells.

b. Acid-resisting paint.—A black acid-resisting asphalt varnish for coating storage-battery trays and benches.

c. Hydrometer for storage battery.—A small commercial glass hydrometer with a specific-gravity scale graduated from 1150 to 1250. It is used to determine the specific gravity of the electrolyte in the storage-battery cells.

d. Rubber gloves.—Used for protecting the hands against electrolyte while working around the storage battery.

e. Syringe.—The barrel or body is about 9½ inches long and 2 inches in diameter. With the exception of the soft rubber washer, the syringe is made of hard rubber throughout. The cubical content of the barrel with the syringe fully assembled is 12 ounces of water, and in actual operation it will handle not less than 10 ounces. It is used to add distilled water and electrolyte to the cells and to withdraw therefrom electrolyte and small particles of impurities.

f. Thermometer.—A glass tube mercury filled thermometer inclosed in a glass cylinder, the lower end of the cylinder being weighted with shot so that the thermometer will float upright in the electrolyte. It is from 8 to 10 inches long, graduated from 10° to 110° F., and is used to obtain the temperature of the electrolyte in the cells.

g. Wrench for bolt connector for storage battery.—A T socket wrench about 4 inches long for use on the bolt connectors which connect the lugs of adjoining cells.

SECTION IX

ELECTRICAL CONTROL AND FIRING EQUIPMENT

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Mine fuze	98
Selector box (figs. 28 and 29)	99

71. Power panel.—*a. Description.*—A front view of this panel is shown in Figure 12, a rear view in Figure 13, and its wiring diagram in Figure 14. It consists of an enameled slate panel on which are mounted a double-pole circuit breaker; a switch for the lamps at the top of the board; a reverse current circuit breaker; alternating-current voltmeter receptacles; an ammeter; an alternating-current voltmeter; a direct-current voltmeter; direct-current voltmeter receptacles; two switch keys in a storage battery ground detector circuit; a battery rheostat; a direct-current power switch; a field rheostat; a row of switches for distributing power from the direct-current busses; a row of switches for distributing power from the alternating-current busses; and a switch for testing fuzes. All switches are labeled.

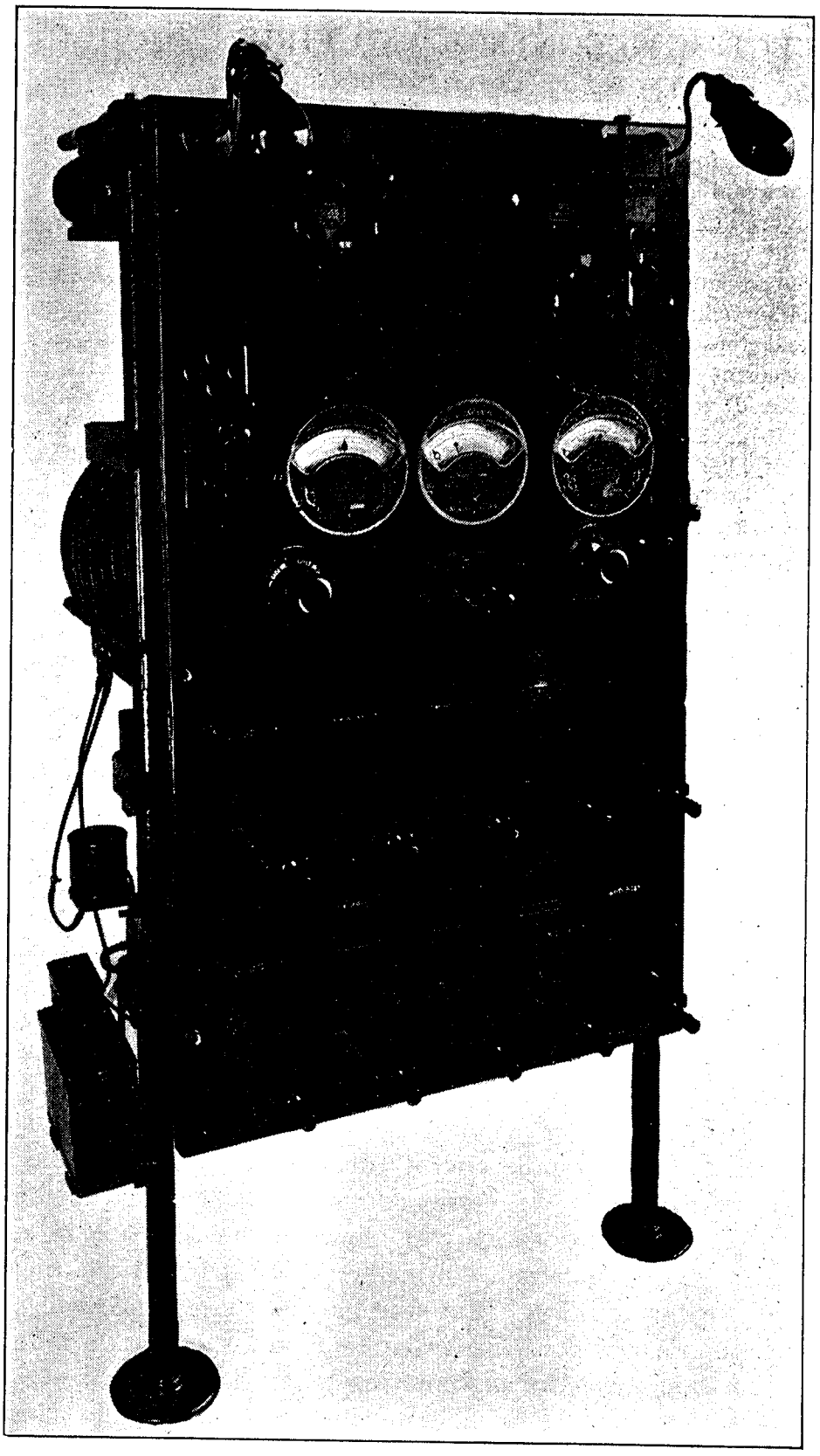


FIGURE 12.—Power panel, front view

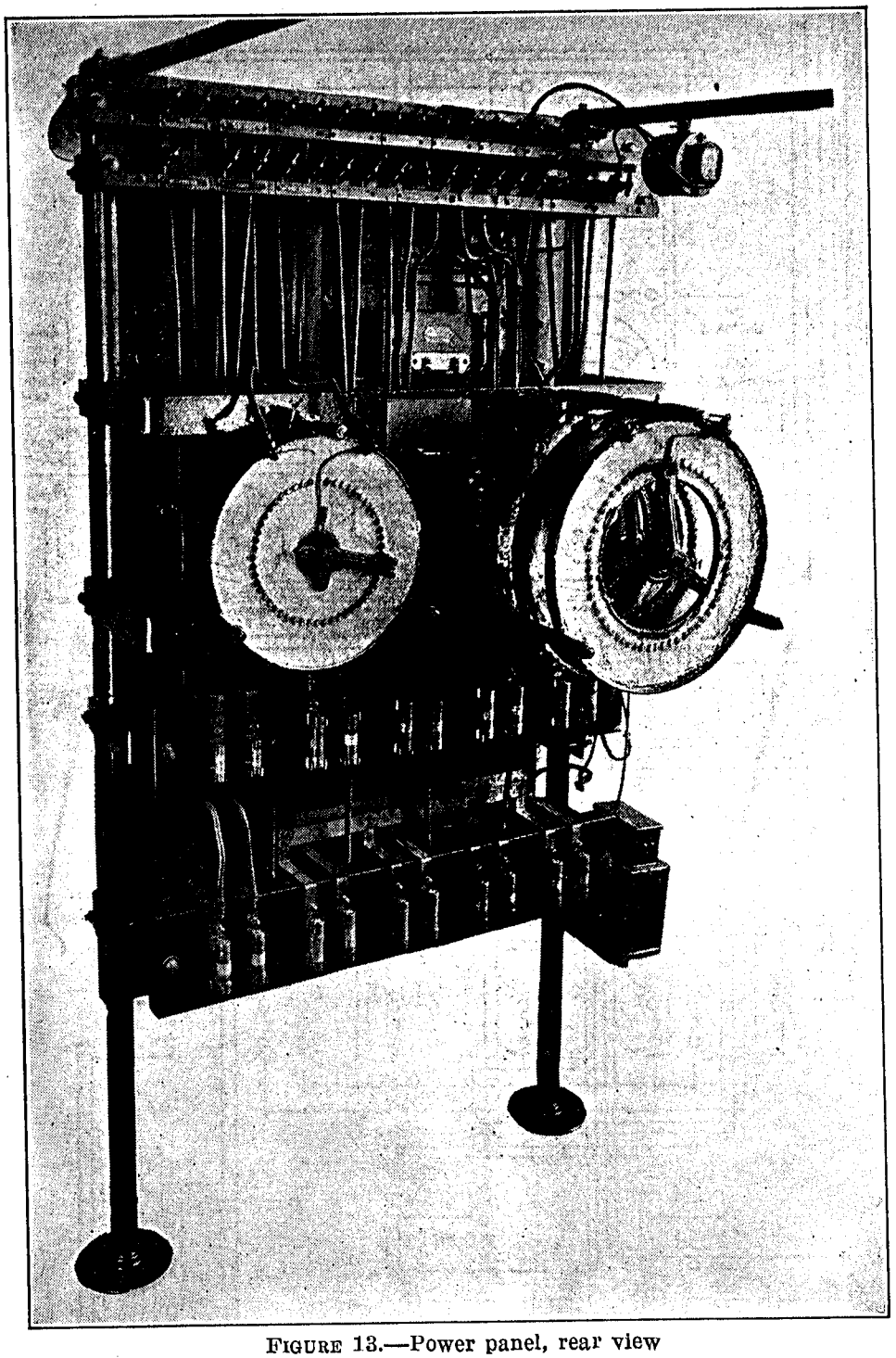


FIGURE 13.—Power panel, rear view

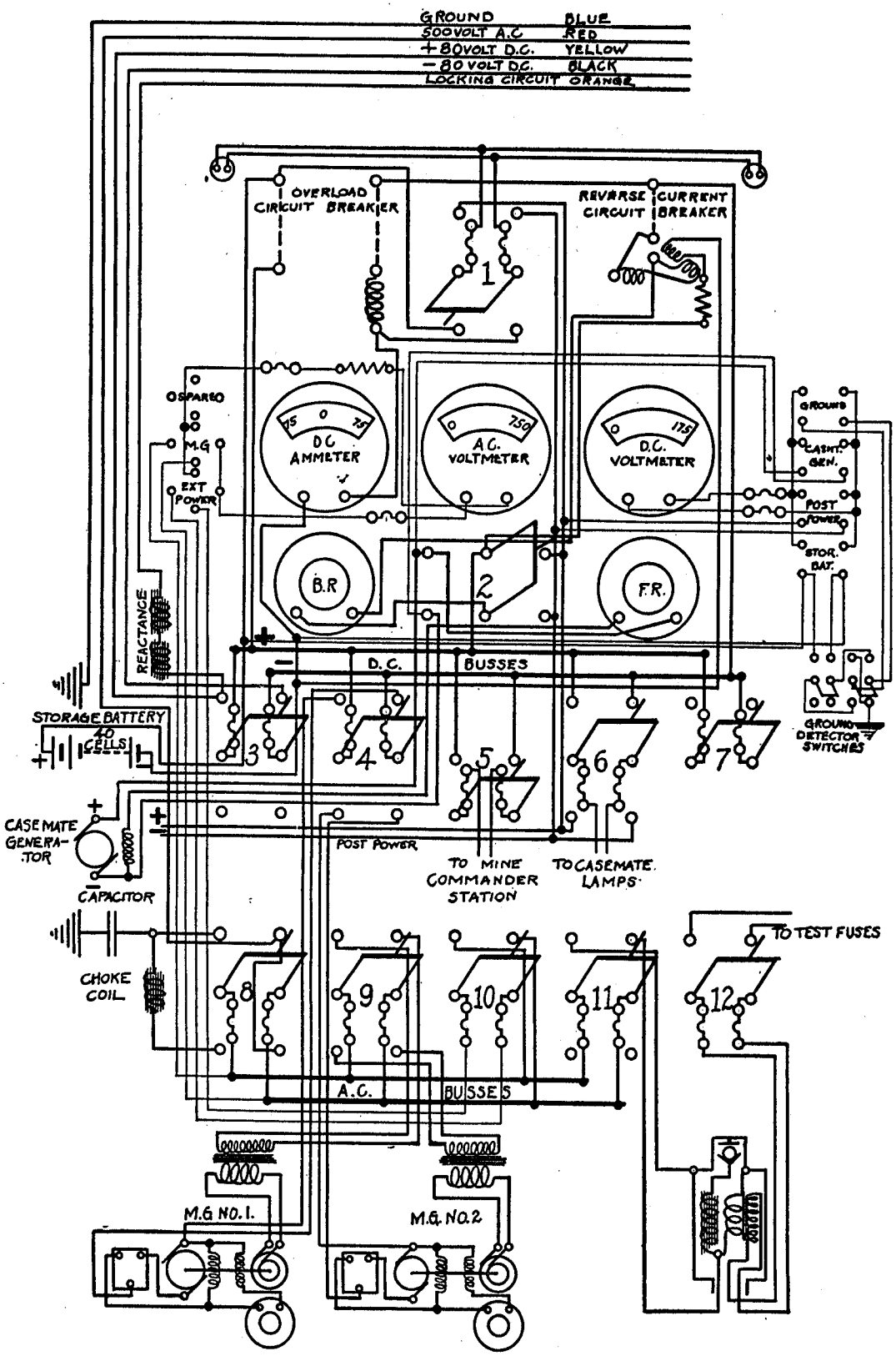


FIGURE 14.—Wiring diagram of power panel

b. Switch No. 1.—Controls the lamps at the top of the power panel; when it is up they are supplied from an external source of power; when it is down they are supplied from the storage battery.

c. Switch No. 2.—The direct-current busses are energized from the casement generator by closing the single-pole circuit breaker and switch No. 2 to the left; from post power by closing the single-pole circuit breaker and switch No. 2 to the right; from the storage battery by closing the double-pole circuit breaker with switch No. 2 open.

d. The direct-current switches supply power as follows:

(1) *No. 3.*—When up it supplies the operating boards through the interrupter panel; when down it is spare.

(2) *No. 4.*—When up it supplies motor-generator No. 1; when down it supplies motor-generator No. 2.

(3) *No. 5.*—When up it supplies the mine commander's station providing the station is not supplied with post power direct; otherwise it is spare.

(4) *No. 6.*—When up it supplies the casemate lamps; or it may be connected so as to discharge the storage battery through a bank of lamps when up. When down it supplies the casemate lamps, but the power is drawn from an external source and not from the direct-current busses.

(5) *No. 7* is spare.

e. The alternating current switches supply power as follows:

(1) *No. 8.*—When up it supplies the operating boards, one pole to the boards and the other to ground through a condenser; when down it does the same, but the side grounded is grounded through a choke coil.

(2) *No. 9.*—When up it energizes the alternating-current busses from motor-generator No. 1; when down from motor-generator No. 2.

(3) *No. 10* is spare.

(4) *No. 11.*—When up it supplies power to the primary of the testing transformer; when down it is spare.

(5) *No. 12.*—When up it supplies power from the secondary of the testing transformer to the test fuzes.

f. Voltmeter receptacles and plugs.—These are properly marked, and are used to obtain the readings of the direct current and alternating current voltages. The direct current receptacles are on the right and the alternating current on the left.

g. With the direct current plug in the first (top) receptacle the voltmeter is connected in series with the two switch keys located

immediately below the bottom receptacle. These keys are used in making a ground test on the storage battery and leads. With the direct current plug in the second receptacle the voltage of the casemate generator is indicated; in the third receptacle the voltage of the external direct current power; in the fourth receptacle the voltage of the storage battery.

h. With the alternating-current plug in the second receptacle, the voltage of the alternating-current power on the busses is indicated; in the third receptacle, the voltage of the external alternating-current power, if supplied. The first receptacle is spare. In general, no external alternating-current power should be led into the casemate, as it would be unsafe owing to the liability of a " cross ". The standard system is perfectly safe, as it is impossible for a mine to be fired when the motor generators are idle.

i. To charge the storage battery from the casement generator, close both the single and double circuit breakers and close switch No. 2 to the left; from an external source of power, close both circuit breakers and switch No. 2 to the right.

j. To test the direct-current voltage.—Insert the direct-current plug in the proper receptacle and read the direct-current voltmeter.

k. To test the alternating-current voltage.—See that switch No. 8 is open; close double-pole circuit breaker to energize direct-current busses; close No. 4 switch up (or down if No. 2 motor generator is to be used); start motor-generator by closing starting switch one step at a time so as to bring machine up to speed gradually; close No. 9 switch up (down if No. 2 motor generator is used); insert the alternating-currrent plug in the proper receptacle and read the alternating-current voltmeter; adjust the voltage to 500 by means of the motor-generator field rheostat.

l. Care and preservation.—The slate panel should never be painted; the ironwork should be painted with asphaltum varnish.

72. Power-panel instruments.—The instruments described below are the standard, but similar instruments of somewhat different characteristics have been supplied to some posts in the past.

a. Double-circuit breaker.—A direct-current, 50-ampere, 250-volt, overload circuit breaker calibrated from 25 to 75 amperes; it is used to protect the storage battery against possible short circuits and the consequent too rapid discharge, which tends to break the plates of the battery. The normal setting is 25 amperes, which is more than sufficient current for normal use; any excess current is due to some trouble which should be corrected instead of setting the circuit breaker to operate on more current.

b. Single-circuit breaker.—A direct-current, 50-ampere, 250-volt, combination overload and reverse current circuit breaker, calibrated from 25 to 75 amperes overload current, and designed to trip on a maximum of 5 amperes reverse current. It protects the storage battery when charging from any source of power, protects the casemate generator against reverse currents from the storage battery, and protects any source of power against possible short circuits on the power panel. If the power charging the storage battery exceeds 25 amperes, which is the normal setting, the storage battery may be damaged from overheating. If the voltage of the charging source becomes less than that of the storage battery, the current reverses and the underload side of the circuit breaker trips the switch; the switch normally trips on 2.5 amperes or less.

c. Ammeter.—A 2-way, 50–0–50, direct-current ammeter connected in series with the storage battery leads; it measures the amperes coming from the storage battery, and the amperes from the source of power to the storage battery when charging. The least reading is 2 amperes.

d. Alternating-current voltmeter.—A 1,000-volt instrument with a least reading of 20 volts. It is used to indicate the voltage at the alternating-current busses.

e. Direct-current voltmeter.—A 150-volt instrument with a least reading of 2 volts. It is used to indicate the voltage of the casemate generator, the post power, and the storage battery.

f. Battery rheostat.—A 7-ohm, 10-ampere rheostat is used with the 5-ampere storage battery, and a 5-ohm, 15-ampere rheostat with the 15-ampere storage battery. The object of this rheostat is to regulate the charging current for the storage battery.

g. Field rheostat.—This is connected in series with the field of the casemate generator for regulating the voltage of this generator.

h. Choke coil.—This coil is placed in series with the ground lead when testing delivery of alternating current to the operating board, to protect the white lamp from too much current. Its resistance is 132 ohms and it allows about 0.3 ampere alternating current to pass through.

i. Reactance.—A special reactance with an impedance of 14,500 ohms and a resistance of about 250 ohms, mounted on the power panel between the positive side of the 80-volt direct current circuit and the 500-volt alternating current circuit. It permits superimposing an 80-volt ~~alternating~~ direct current locking circuit on the alternating current firing circuit in order to hold the armatures of the selectors in the

locked position, and prevents all but a negligible amount of alternating current from flowing to the direct-current circuit.

j. Capacitor.—A 1-kilowatt 440-volt condenser, mounted on the power panel and connected in series with the transformer secondary and ground to prevent a flow of the superimposed direct current to ground through the casemate transformer secondary.

73. Direct current-alternating current motor generator.—*a. Description.*—This consists of an 80-volt direct current shunt motor and a 60-cycle single-phase generator designed to give one-half kilowatt at 80 volts. The usual source of operating current is the storage battery. To insure against breakdown, two of these motor-generators are supplied each casemate.

b. Care.—(1) This machine requires the same care that motors and generators in general do. The oil wells must be kept filled with light dynamo oil, and after an extended period of operation they should be drained and refilled with new oil. Frequent inspections should be made to insure that the oil rings are functioning properly.

(2) The brushes should work freely in their guides with a spring pressure sufficient to insure full contact on the commutator. No lubricant of any kind should be used on the commutator, which should be cleaned by holding a small pad of clean canvas lightly against its surface while running. The outside of the machine should be wiped free of dust and oil, which should also be prevented from accumulating on the lower inner surface of the end pieces. The flexible coupling, if provided, and the exposed parts of the shaft should be kept bright and given a thin coat of light oil. When it is necessary to paint a motor-generator, one coat of steel-colored paint and one of varnish will usually be sufficient.

c. Starting switch (fig. 15).—A 4-point lever switch for starting the motor-generator and accelerating it to full speed. The field is connected to the first point and the armature circuit to the fourth point, with resistances totaling 8 ohms connected between the four points as shown in Figure 15. When the switch blade is in the first point a total resistance of 8 ohms is in the armature circuit, 4 ohms in the armature circuit when the blade is in the second point, 2 ohms when in the third point, and no resistance when in the fourth point. The operation of closing the switch short circuits in turn the 4-ohm, 2-ohm, and 2-ohm resistances.

d. Field rheostat.—A small rheostat mounted on the wall or bench convenient to the motor-generator for regulating the alternating current voltage.

74. Casemate transformer.—*a. Description.*—A "step-up" transformer of the oil-insulated core type; it is rated at 60 cycles, 500 watts, 80 volts primary and 500 volts secondary when carrying full load. It consists of two coils of wire wound around a laminated iron core, and insulated from each other and from the case containing them. The wires that lead from the generator are called primary, and those that lead to the power panel, secondary. The case is filled with transformer oil to keep the core and coils cool, and it also serves as insulation. This transformer is used to "step-up" or increase the voltage from the motor-generator from 80 to 500 volts.

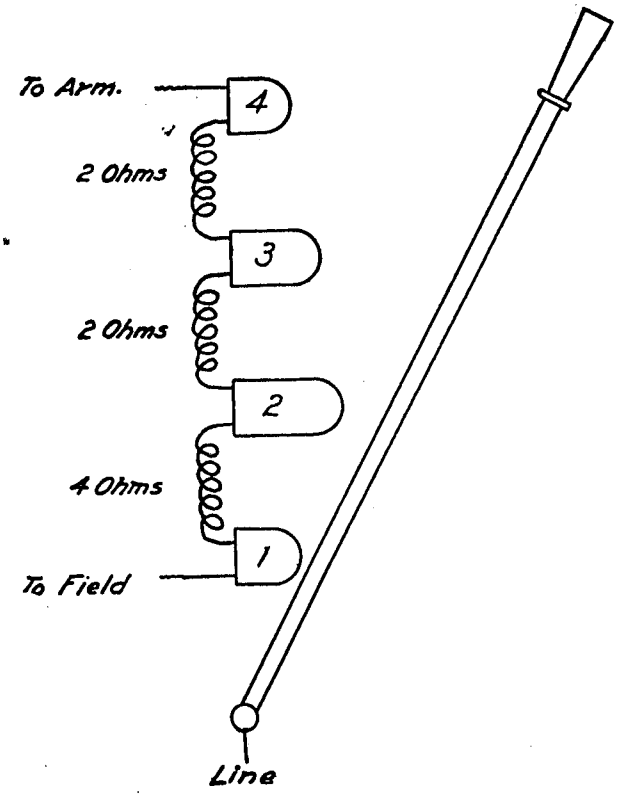


FIGURE 15.—Starting switch

b. Care.—The transformer should be kept filled with transformer oil, and this insulating oil should not touch the primary wires above the coil, otherwise the transformer will leak. When it is necessary to paint the transformer, one coat of steel-colored paint and one of varnish will usually be found sufficient.

c. Transformer oil.—A highly refined petroleum oil. The casemate transformers are filled with this oil to insulate and cool the coils.

75. 80-volt direct-current–120-volt direct-current motor generator (fig. 16).—*a. Description.*—A one-half-horsepower shunt wound motor operating at 80 volts direct current derived from the

storage battery; and a one-fourth kilowatt 120 to 150 volt generator adjustable flat compounded between 0.45 and 2.0 amperes, which delivers 120 volts for the operating circuit. As a unit, this set is mounted on the interrupter panel.

b. Starting.—Close motor-generator tumbler switch on the interrupter panel; turn knob on motor starter slowly to the right as far

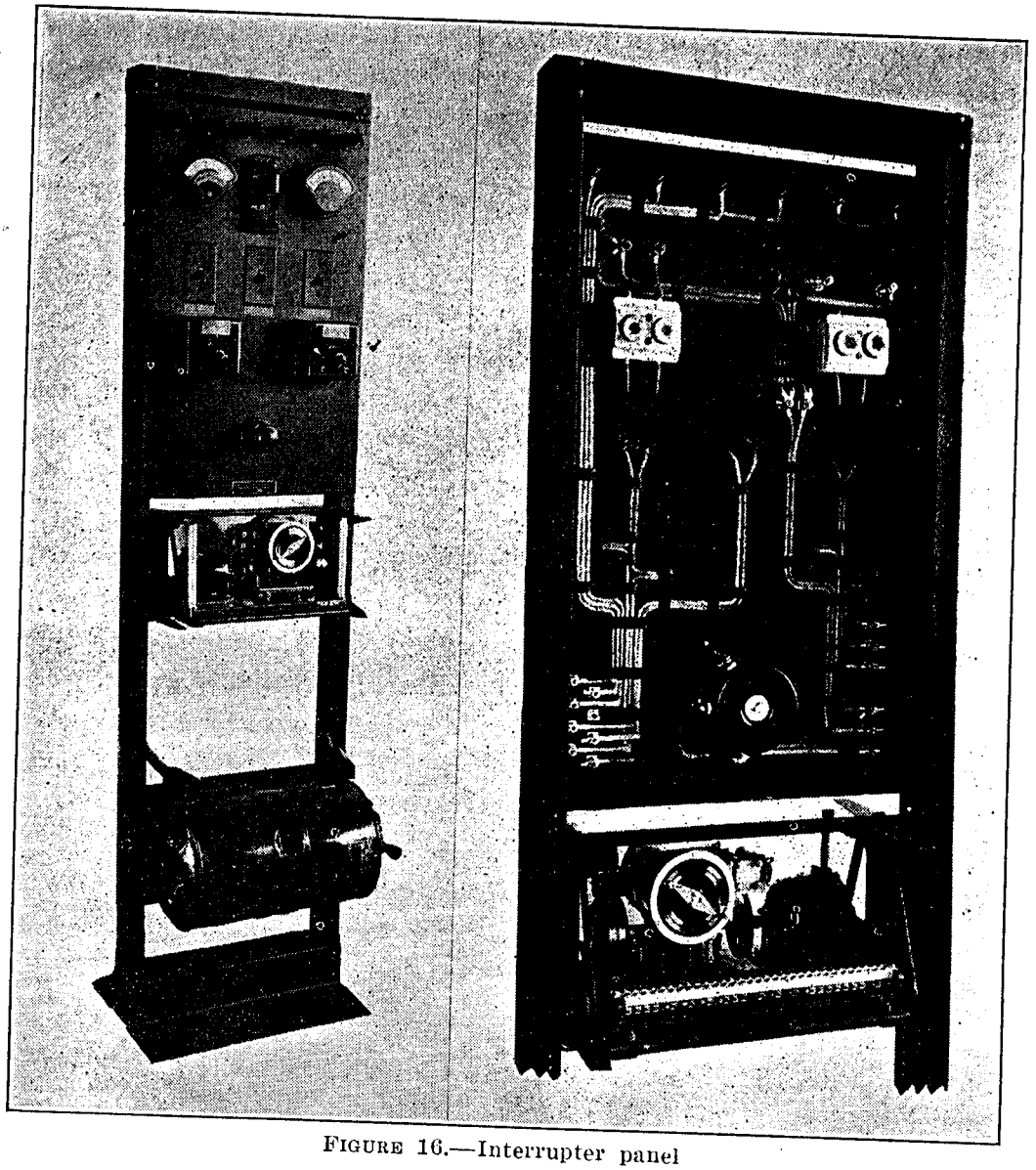


FIGURE 16.—Interrupter panel

as it will go, where it will be held by the action of the no-voltage release magnet. Adjust the voltage to 120 by means of the field rheostat mounted on the interrupter panel.

c. Care.—Lubrication of the two ball bearings is by means of compression grease cups. When the grease is to be changed (about once every 6 months), remove the drain plugs under the bearings

and force fresh cup grease through by means of the grease cups until the fresh grease begins to come out at the drain plug holes. Then replace the drain plugs and set up the grease cups tight. For other instructions covering the care of motor generators see paragraph 73 *b* (2).

76. Interrupter panel (fig. 16).—*a. Description.*—This consists of a relay rack on which are mounted an asbestos ebony panel, an interrupter, and a motor generator. On the asbestos ebony panel are mounted six standard terminals marked "+DC," "−DC," "Ground," "Reset," and two "±"; a Weston Model 269 voltmeter, 0–150 volts; a Weston Model 269 ammeter, 0–3 amperes; a W. E. 2A circuit breaker, three tumbler switches, two fractional horsepower motor starters, and an interpolating rheostat.

b. Principal parts and code numbers.—The following table gives the names and Submarine Mine Depot code numbers of the principal parts of the interrupter panel not listed elsewhere:

Interrupter panel

Name of part	S. M. D. Code No.	Required per panel
Panel, asbestos ebony	4296	1
Terminal posts	4297	6
Name plates for terminal posts	4298	6
Voltmeter, Weston, Model 269, 0–150	4299	1
Ammeter, Weston, Model 269, 0–3	4300	1
Circuit breaker, W. E. 2A	4301	1
Tumbler switch	4302	3
Cover plates for tumbler switches	4303	3
Motor starter, Ward Leonard, 1–80	4304	1
Motor starter, Ward Leonard, 1–110	4305	1
Field rheostat	4306	1
Name plates for switches and panel	4106	4
Terminal board:		
8-stud	4308	1
3-stud	4309	2
2-stud	4310	1
Wire, flameproof No. 14	4311	----------
Flexible conduit, ½-inch	4312	----------
Connector for ½-inch flexible conduit	4313	8
Terminal condulets for ½-inch flexible conduit	4314	2
L-condulets, 1 right and 1 left	4315	2
Motor generator	4320	1
Interrupter	4350	1
Mounting for interrupter	4390	1
Cut-out, porcelain	5528	2

77. Interrupter (fig. 17).—*a. Description.*—(1) A Western Electric 6-type distributor mounted on a W. E. 1A mounting. It consists of a base on which are mounted a 110-volt direct-current motor, a cooling fan, a housing containing a worm drive, a cross

shaft with a contact face on each end, and a governor and three resistance units for regulating the speed of the motor. The speed is regulated by means of a lever which varies the tension of a spring in the governor housing. A row of terminal contacts on the rear of the base engages with a similar row of contacts on the mounting. The motor derives its current from the 120-volt operating circuit. A condenser, with a resistance in series, prevents sparking at the governor contacts.

(2) The function of this machine is to change the 120-volt direct current supplied by the motor-generator into the pulsating, reversing polarity current required to operate the system. The impulses, acting through the operating coils of the two selectors, operate armatures which cause the selector contact arms to be stepped around with

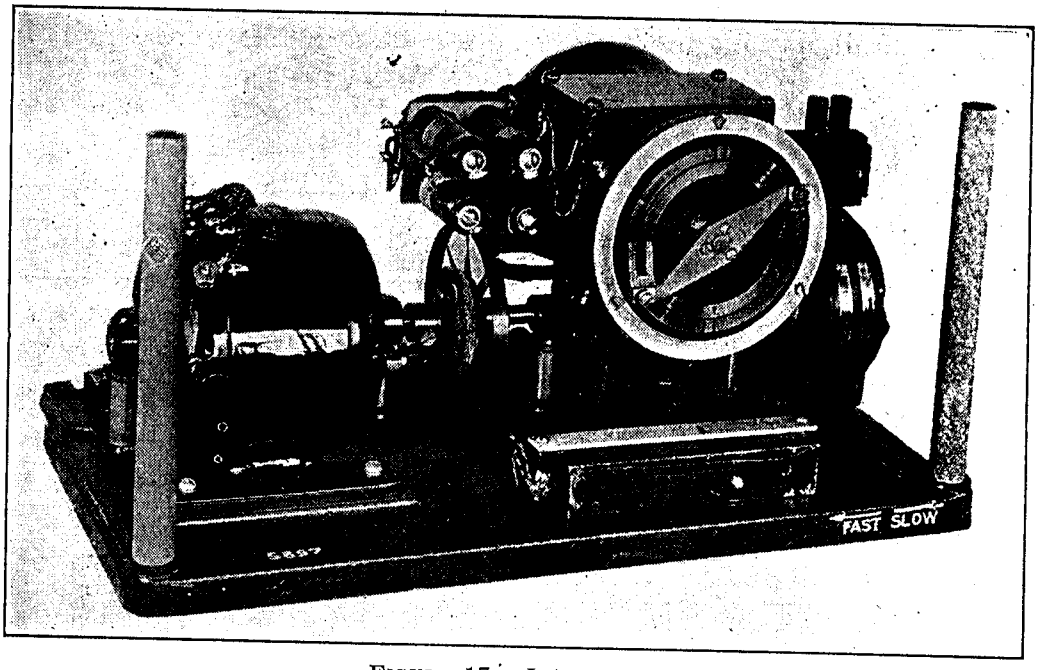


FIGURE 17.—Interrupter

a slight pause on each contact. (Operation of selector is described in paragraph 85 *c*.)

(3) The interrupter contact arms move the contact brushes over the contact faces, the faces being divided into segments with small dead segments between the large live segments. Each step of the selector requires 1 cycle, and with 20 steps in 1 revolution of the selector contact arm, 20 cycles are needed per revolution. As the selector contact arm rotates at the rate of 1 revolution every 3 seconds, or 20 revolutions per minute, the frequency of the pulsations must be at the rate of 400 cycles per minute, which frequency is obtained with the interrupter contact arms operating at 200 revolutions per minute. This speed is maintained by the action of the spring-

controlled governor, which controls the speed by closing and opening a contact which, when closed, short circuits a resistance in series with the armature. The simplest method of verifying the speed is to time the revolutions of the casemate selector contact arm, which should operate at 20 revolutions per minute.

b. Starting.—Close interrupter motor tumbler switch on the interrupter panel; turn knob on motor starter slowly to the right as far as it will go, where it will be held by the action of the no-voltage release magnet.

c. Care and adjustment.—(1) Keep the four grease cups (wick lubricators on each side of the motor and each side of the housing) supplied with the special cup grease furnished with each interrupter.

(2) See that the worm drive in the housing is supplied with a small quantity of Dixon's graphite grease No. 677, furnished for this purpose. Use just enough to come about halfway up on the small worm.

(3) Clean the motor commutator, the contact faces, and the contact rings on the governor with a clean dry cloth.

(4) Adjust the brushes on both contact arms so that they work in synchronism with respect to changing the polarity of the circuit—that is, all four brushes should be leaving their respective contact segments at the same instant.

(5) Except when working on the interrupter, keep it covered with the metal cover.

d. Principal parts and code numbers.—The following table gives the names of the principal parts, the Submarine Mine Depot code number of each part, and the quantity of each part per interrupter:

Interrupter

Name of part	S. M. D. Code No.	Required per interrupter
Interrupter	4350	
Base	4351	1
Motor	4352	1
Brush for motor	4353	2
Brush holder, complete	4354	2
Armature, complete	4355	1
Field coils	4356	2
Flexible coupling	4357	1
Fan	4358	1
Housing	4359	1
Housing cover	4360	1
Housing cover screw	4361	4
Governor, complete	4362	1
Governor contact	4363	2
Grease cups	4364	4

Interrupter—Continued

Name of part	S. M. D. Code No.	Required per interrupter
Resistor, 20-ohm	4365	1
Resistor, 30-ohm	4366	1
Resistor, 45-ohm	4367	1
Resistor, 350-ohm	4368	1
Condenser, 1-mfd	4369	1
Contact face holding ring	4370	2
Contact face holding ring screw	4371	6
Contact face, complete	4372	2
Contact arm	4373	2
Contact arm holding screw	4374	2
Contact brush	4375	4
Contact brush screw	4376	4
Contact brush screw washer	4377	4
Contact brush screw insulation (male and female)	4378	4
Cover, interrupter (2 parts)	4379	1

78. Motor starter (fig. 16).—A fractional horsepower motor starter with a no-voltage release. Two of these are mounted on the interrupter panel, the one on the left for starting the direct current-direct current motor-generator, and the one on the right for starting the interrupter.

79. Field rheostat (fig. 16).—An interpolating rheostat consisting of one 550-ohm 4-inch plate and one 63-ohm 4-inch plate, together with the necessary handles. The resistance of each plate is divided into 11 equal steps and connected so as to give 121 steps. This rheostat is mounted on the interrupter panel in series with the field of the generator of the direct current-direct current motor-generator set, and is used to adjust the generated voltage to 120.

80. Voltmeter, direct current, 150-volt; and ammeter, direct current, 3-ampere (fig. 16).—Mounted on the interrupter panel to indicate the voltage and current generated by the generator of the direct current-direct current motor-generator set. They are standard Weston instruments, Model 269, are of the permanent magnet movable coil type, and are shielded from external magnetic fields. The voltmeter has a resistance of 10,500 ohms. Each instrument has a zero corrector, which is the only adjustment required. In the event of failure of these instruments, they should be sent to the submarine-mine depot for repairs.

81. Circuit breaker (fig. 16).—This is placed in the interrupter circuit to protect the generator of the direct current-direct current set against excessive current due to possible short circuits. It is a sensitive quick-acting single-pole circuit breaker, and has two adjust-

ments. The purpose of one of these adjustments is to regulate the sensitiveness of the latch, and consists of a small machine screw, with lock nut, screwed through a bracket located immediately underneath the hinged armature. The upper end of this screw forms a support for the armature and regulates the height of the outer end as well as the amount of engagement of the latch, or lug, on this end with the end of the hinged breaker arm. When the armature is raised, the breaker arm is released and falls to a horizontal position, breaking the circuit between a spring contact on its inner upper surface and the end of the bracket carrying the screw and jam nut. The other adjustment consists in varying the air gap between the pole piece of the coil and the armature by turning a knurled nut screwed onto the threaded brass stud on the top of the coil. This nut is confined in a bracket above the coil, so that when it is screwed down on the stud the coil is raised, increasing the air gap. By means of this adjustment, the circuit breaker should be set to trip at 1 ampere. The breaker should be tripped by hand frequently to insure that the moving parts are functioning freely.

82. Operating board (fig. 18).—One of these boards is required for each group of 19 mines. It consists of an iron frame 78 inches high and 24 inches wide, to which are attached a signal block, a control panel, and a terminal bar. It should be set up with its face 34 inches from the wall in rear.

83. Signal block.—*a. Description.*—This is shown in the upper half of Figure 18. It consists of an enameled slate block 24 inches wide and 11 inches high upon which are mounted three binding posts, three lamps (red, white, and green), a bell and bell switch, and a 90-ohm noninductive resistor in parallel with the white lamp. The binding posts are marked " Earth," "A. C.," and "D. C.," or "+ D. C.," "A. C.," and "− D. C." The lamps are mounted in order, from left to right facing the signal block, red, white, and green.

b. Red lamp.—This is in the signal circuit (for description of signal circuit see par. 109). It glows and gives warning when the firing circuit is closed at the switching relay (contacts 2 and 6 closed as shown by the dotted line in fig. 42).

c. Bell.—This is connected in parallel with the red lamp, and when the bell switch on the signal block is closed the bell rings each time the red lamp glows; it is used to warn the operator that a mine has been struck and that the switching relay is closed in the firing position.

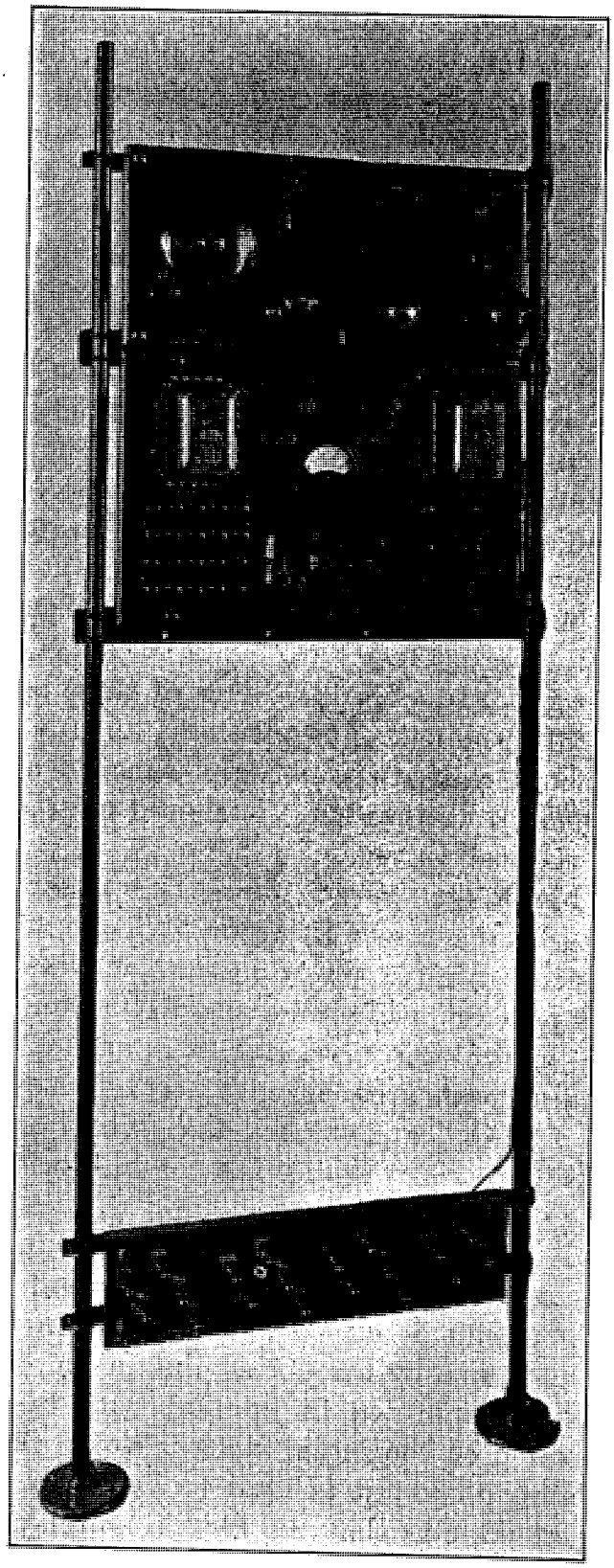


FIGURE 18.—Operating board

d. White lamp.—This is connected across the terminals of a 90-ohm resistor in the firing and alternating current testing circuits; the resistor protects the system against failure should the white lamp burn out. The potential across the terminals of the lamp is equal to the drop in potential across the resistor, which drop is directly proportional to the current flowing in the circuit. With the normal alternating current firing current of 0.2 of an ampere the potential across the lamp is 18 volts and the lamp glows faintly. When the mine has exploded and before the cable grounds no current flows and the lamp goes out. When the cable grounds the maximum current flows and the lamp glows. When the ground is cleared the lamp goes out, thus indicating that the ground has been cleared. This lamp is also used to indicate that alternating current is being delivered to the operating board by closing the testing switch (in the "on" position), when the lamp should glow. For descriptions of the firing and alternating current testing circuits see paragraphs 110 and 112 *a*, respectively.

e. Green lamp.—This lamp is in the individual mine-testing circuit, the signal circuit, and the ground-clearing circuit, which are described in paragraphs 105, 109, and 113, respectively. It glows when the red lamp glows, indicating, as the red lamp does, that the switching relay is in the firing position; when testing mines by the use of manual power (storage-battery power), indicating complete mine-testing circuits; and when clearing a ground in any mine circuit by the use of manual power and the ground-clearing plug with ammeter, indicating that the ground is clear by going out. Two sizes of this lamp are furnished, 16 candlepower and 32 candlepower. Normally, the 16-candlepower lamp should be used; the 32-candlepower lamp is used as explained in paragraph 113.

84. Control panel (fig. 19).—*a. Description.*—One is mounted on each operating board. It consists of an asbestos ebony panel 24 inches wide, 15 inches high, and 1 inch thick, suitably drilled and machined so as to mount a selector, a switching relay, a contact firing relay, a milliammeter alternating current 0–100 M. A., 25 switch keys, a ground clearing jack, and the alternating current firing and testing switches. A 2,500-ohm resistance unit, a 3,800-ohm resistance unit, and an asbestos ebony terminal block are mounted on the back of the panel. In mounting the equipment on the control panel, wires with various colored insulation are used to facilitate tracing the different circuits.

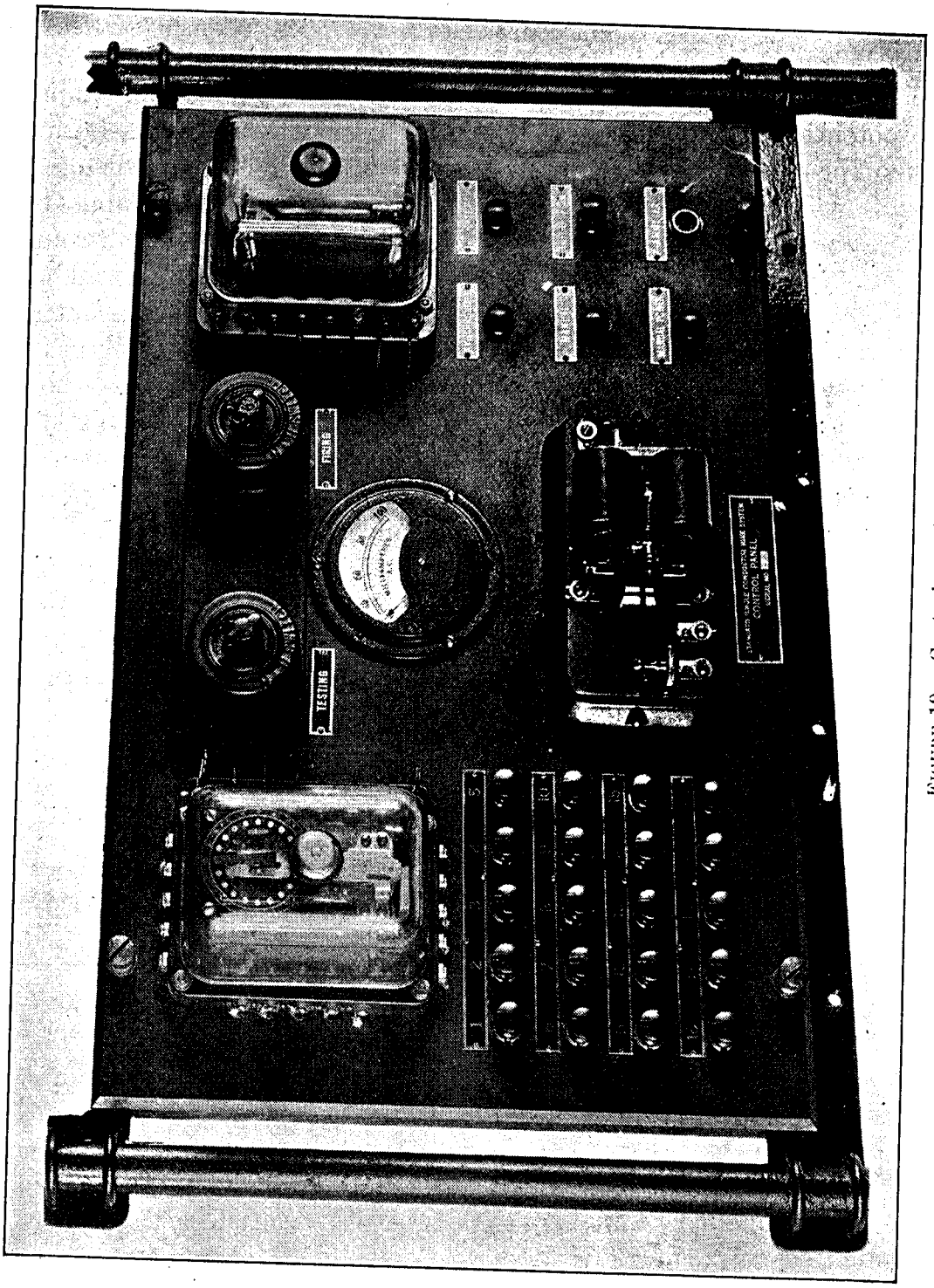


FIGURE 19.—Control panel

b. Principal parts and code numbers.—The following table gives the names and Submarine Mine Depot code numbers of the principal parts of the control panel not listed elsewhere.

Control panel

Name of part	S. M. D. Code No.	Required per panel
Panel, asbestos ebony	4102	----------
Terminal block, asbestos ebony	4103	1
Screw for fastening panel to crossbars	4104	8
Screw, holding, for terminal block	4105	1
Name and number plates	4106	13
Selector	4110	1
Switching relay	4136	1
Contact firing relay	4171	1
Screw, holding, for selector and switching relay	4206	8
Screw, holding, for contact firing relay and milliammeter	4207	5
Firing and testing switches	4208	2
Screw for firing and testing switches	4209	4
Milliammeter, Weston O–100, Model 429	4210	1
W. E. switch key (92–A)	4211	5
W. E. switch key (92–B)	4212	1
W. E. switch key (modified 92–B)	4213	19
Screw, for switch keys	4214	50
Jack, ammeter, W. E. 200	4215	1
Plug, W. E. 3A, without cord	4216	[1] 1
Ammeter, Weston O–1 ampere, Model 517	4217	[1] 1
Terminal screw with 2 nuts and washers	4218	7
Screw, for name and number plates	4219	34
Resistance unit, 2,500 ohms	4220	1
Resistance unit, 3,800 ohms	4221	1
Bracket for resistance units	4222	2
Screw for fastening bracket to panel	4223	4
Screw for securing resistors to bracket with nut and washers	4224	2
Wrench, open end, for selector pole piece nut	4225	[1] 2
Wrench, open end, for selector conical head locking screw nut	4226	[1] 2
Screw driver, offset, for contact arm screws	4227	[1] 2
Tweezers	4228	[1] 2

[1] Per casemate.

FIGURE 19.—Control panel

c. Control panel base with terminal block.—Asbestos ebony, of which this base and terminal block as well as the interrupter panel are made, is manufactured from asbestos fiber and binding cements densely impregnated under heat and pressure. It has greater dielectric strength and greater insulation resistance than quarried materials. It will stand shock and vibration, has a uniform density, is comparatively light in weight, is moisture-proof, and is unaffected by rapid temperature changes. It will not shrink, crack, rot, or rust, is generally unaffected by chemicals, is absolutely free from metal, and can readily be cut, drilled, and machined. *Asbestos ebony must never be painted.* It can be cleaned easily by rubbing with a piece of soft dry cloth.

d. Care.—Keep the panel, instruments, and wiring free from dust and dirt, using a soft brush and a soft cloth. The panel itself is finished with lacquer, and the finish can be maintained to its original appearance by removing the dust and rubbing with a soft cloth. It must not be painted, and oil or polish of any kind must not be used.

85. Selector.—*a. Description.*—A D86522 selector; one is mounted on the control panel and one in the distribution box for each group of 19 mines. An assembled view is shown in Figure 20, and a disassembled view in Figure 21. This selector is a modification of the Western Electric 60-A selector.

b. Principal parts and code numbers.—The following table gives the names of the principal parts, the Submarine Mine Depot code number of each part, and the quantity of each part per selector.

Selector

Name of part	S. M. D. Code No.	Required per selector
Selector, complete	4110	
Base, complete with terminals	4111	1
Screw, for attaching selector to base	4112	4
Screw, terminal, large	4113	8
Screw, terminal, small	4114	15
Frame, complete with pole pieces and magnet	4115	1
Nut, for pole pieces	4116	2
Screw, for magnet	4117	2
Operating assembly, complete	4118	1
Screw, for operating assembly	4119	3
Armature assembly	4120	1
Rocker arm with operating pawl	4121	1
Spring, for operating pawl	4122	1
Pawl, holding	4123	1
Spring, for holding pawl	4124	1
Screw, locking, conical head, with nut	4125	1
Ratchet wheel, with shaft	4126	1
Contact arm	4127	1
Screw, for contact arm	4128	2
Commutator, complete with wiring	4129	1
Bracket, supporting, for commutator	4130	1
Screw, for commutator	4131	4
Armature spring	4132	1
Coil, operating	4153	2
Cover, glass	4154	1
Screw, for cover	4155	1
Washer, felt, for cover screw	4156	1

c. Operation.—The operation of the selector is as follows:

(1) Positive impulses on L_1 (fig. 31) are power impulses, and negative impulses on L_1 are retracting impulses. When a positive impulse enters the operating coils at L_1 the direction of the magnetic flux is such that the armature is attracted to the pole piece of the

right-hand coil. This motion of the armature moves the armature arm to the left, the armature arm carrying with it the rocker arm. The operating pawl, being pivoted to the end of the rocker arm, is carried to the left and engages a notch in the ratchet wheel, moving the ratchet wheel in a counterclockwise direction. The engagement of the operating pawl with the ratchet wheel is made certain by the pawl spring which holds the end of the pawl against the ratchet wheel. The movement of the operating pawl to the left is stopped by the armature striking the pole piece, and the locking screw forces the pawl into a notch of the ratchet wheel, stopping and locking the ratchet wheel. The ratchet wheel is prevented from moving in a clockwise direction (opposite to operating direction) by the holding pawl, which engages a notch of the ratchet wheel each time the operating pawl reaches its extreme left position. The holding pawl is held against the ratchet wheel, ready to drop into a notch, by the holding pawl spring. The ratchet wheel is fastened rigidly to the ratchet wheel shaft, and the contact arm is fastened rigidly to the upper end of this shaft by two set screws. This results in any motion of the ratchet wheel being transmitted to the contact arm, and as the operating pawl moves the ratchet wheel in a counterclockwise direction, the contact arm is carried in the same direction over the commutator contacts. Each motion of the operating pawl to the left moves the contact arm through one-twentieth of a revolution, or the distance between the centers of two contacts.

(2) When a negative impulse enters the operating coils at L_1 the direction of the magnetic flux is such that the armature is attracted to the pole piece of the left-hand coil. This motion of the armature moves the armature arm to the right, carrying with it the rocker arm and operating pawl. During this motion, the ratchet wheel, and therefore the contact arm, remain stationary, the contact arm resting on a commutator contact until the next positive impulse causes the contact arm to move to the next contact. These impulses of the alternating polarity cause the contact arm to be stepped completely around in 20 steps with a slight pause on each contact.

(3) That part of any firing or mine circuit, or the synchronizer circuit which passes through the selector is from a terminal screw on the base, numbered from 1 to 20, by wire to the corresponding commutator contact, to the contact arm as it rests on that particular contact, to the ratchet wheel shaft, frame, and screw for attaching selector to base, thence by wire to terminal No. 21. That part of the operating circuit through the selector is from terminal L_1 on the base by wire to the right-hand operating coil, through this coil, by

wire to the left-hand operating coil, through the left-hand coil, thence by wire to terminal L_2 on the base.

(4) The object of the armature spring is to assist in holding the armature in the locked position when the selector is stopped.

d. Starting.—Start the interrupter running, close the interrupter switch on the interrupter panel, and pull the interrupter key on the control panel to the "out" position. Trip the switching relay (for operation of relay see par. 86 *c*) by pressing the mine key corresponding to the contact on which the contact arm of the casemate

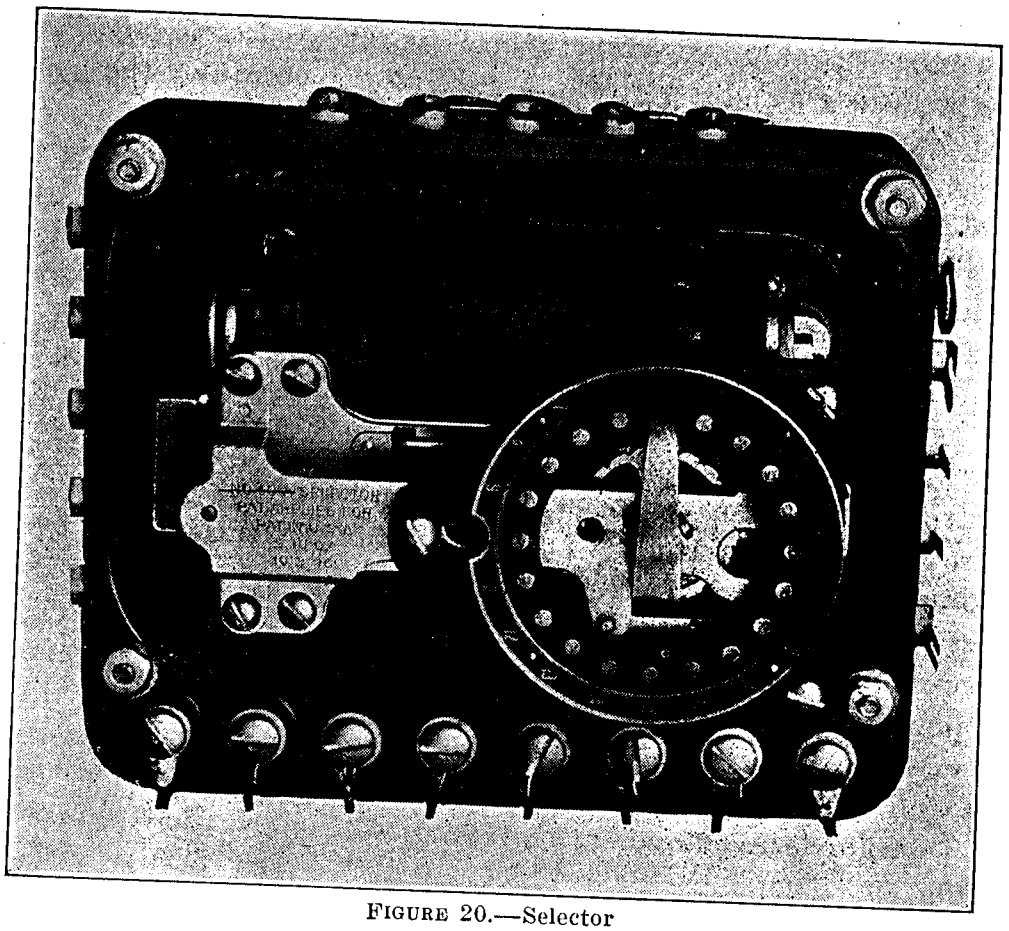


FIGURE 20.—Selector

selector is resting, press in the interrupter key, and then press the reset key, and the selector will start operating. This sequence of operations is important and should always be followed. The circuits are so arranged that by following this sequence the first power impulse impressed on both selectors will be a full impulse, so that both selectors positively will start together, and if they were in synchronism when the system was stopped, they will start in synchronism. If it is attempted to start the selectors by pressing in the interrupter key without first tripping the switching relay, occasionally the operating circuit will be closed just as the interrupter

cams are opening the circuit, giving an incomplete power impulse which will throw the selectors out of synchronism.

e. Stopping.—Press any mine key and hold it in until the proper contact is made, which will be within three seconds. The stopping is indicated not only by the stopping of the casemate selector but also by the lighting of the red lamp and the green lamp, and the ringing of the bell if the bell switch is closed. The normal method of stopping the selectors is to press mine key No. 20, as no mine is then left in the circuit. The interrupter key should not be used for stopping the selectors, as the stopping may then take place at the beginning or end of an impulse, resulting in a "ragged" impulse

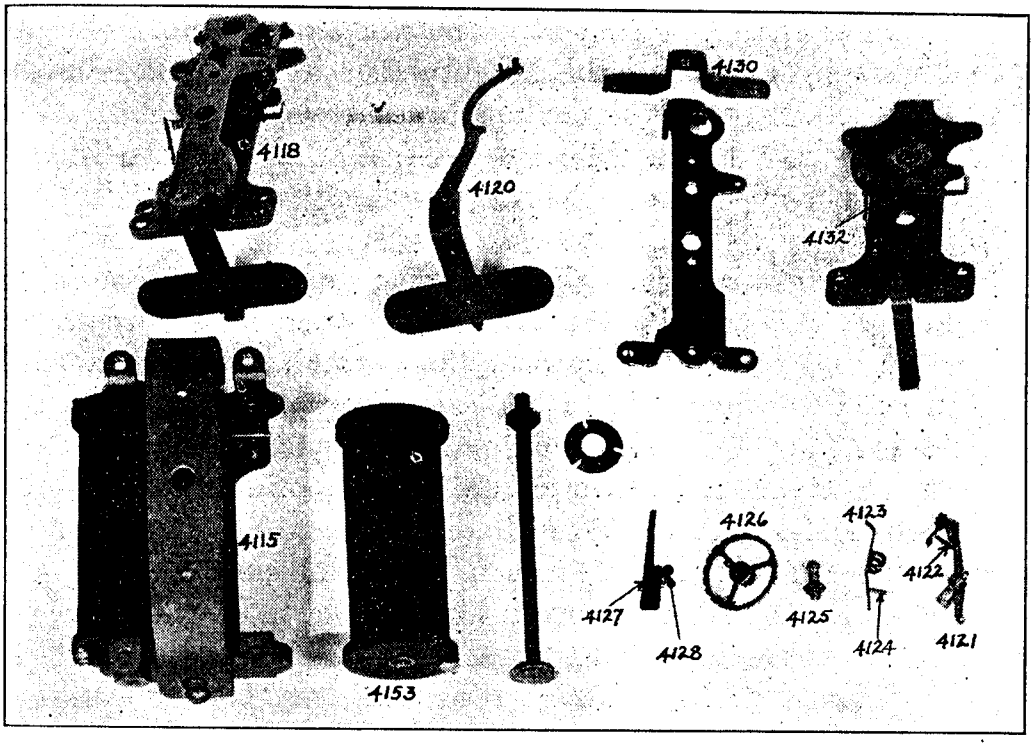


FIGURE 21.—Selector, disassembled

which may throw the selectors out of synchronism. On the other hand, when the selectors are stopped by pressing a mine key, the spring contacts of the switching relay are tripped, opening the operating circuit during the period when a retracting impulse is being impressed thereon. The consequence is that when the operating circuit is next closed, the selectors will receive a power impulse first, and if this circuit is closed as directed in *d* above by resetting the switching relay *after* the interrupter key is pressed in, the first power impulse so impressed will be a complete one.

f. Manual operation and synchronizing.—(1) Pull the interrupter key out. Press the manual power key and, holding it in with one

hand, alternately press and release the manual key with the other hand; this causes both selectors to operate. Holding in on the manual power key and alternately pressing and releasing the synchronizer key causes the casemate selector only to operate.

(2) To synchronize when there is no open mine circuit, press the reset key to be sure the contact springs of the switching relay are in the operating circuit position. The contact arms of both selectors then are stepped around by alternately pressing and releasing the manual key while holding in the manual power key and observing the milliammeter as the casemate selector contact arm rests on each mine contact. When the milliammeter needle drops to approximately 18 milliamperes, it indicates that the distribution box selector contact arm is on No. 20 contact. The casemate selector is stepped around next by operating the synchronizer key with the manual power key held in, until its contact brush rests on No. 20 contact. Both selectors now are at their respective No. 20 contacts, which is indicated by the milliammeter needle returning to its normal reading of approximately 33 milliamperes.

(3) To synchronize when there are one or more open mine circuits, make a note of the numbers of the open mine circuits and restore the respective mine keys to the normal, or firing, position. Then proceed to synchronize as in (2) above. Restoring the open circuit mine keys to the normal position removes the 2,500-ohm balancing resistance from each circuit, and the milliammeter pointer will throw to the left to 7.5 milliamperes as the distribution box selector contact arm passes over each open mine circuit except when the casemate selector contact arm is on No. 20 contact. In the latter case, step the casemate selector contact arm ahead one step by means of the synchronizer key. After synchronizing, balance the open mine circuits by rotating the keys 180° and then pressing them in. If notation of the numbers of the keys was not made, step the selectors around slowly, and for each milliammeter reading of 7.5 milliamperes switch the balancing resistance into the circuit. Continue in this manner until the circuit is balanced.

(4) While it is possible that the two selectors may be out of step by any number of steps from 1 to 19, when they get out of synchronism under ordinary operating conditions they are not likely to be out by more than one step in either direction. For this reason, when the operation of the system is to be stopped in order to synchronize, it is advisable to press mine key No. 18. This means that the casemate selector contact arm will stop on contact No. 18 and the distribution box selector contact arm probably will stop on either con-

tact No. 17 or No. 19. It then will be necessary to step the selectors around by manual operation only either three steps or one step until the distribution box selector contact arm rests on its No. 20 contact, which is indicated by the milliammeter pointer dropping to about 18 milliamperes.

g. Care and adjustment.—In the following description of the adjustment, care, and repair of the selector, mention is made of the various parts as viewed from above the armature end of the selector.

(1) *To disassemble selector.*—To disassemble for cleaning and replacement of parts, proceed as follows:

(*a*) With the armature in contact with the left-hand pole piece, rotate the contact arm counterclockwise to No. 20 contact.

(*b*) Remove the three screws holding the commutator to the top plate. Raise the end of the contact arm to clear the graduated ring, and move the commutator back so that the screw holding the commutator-supporting bracket can be unscrewed and the bracket removed. Then the commutator is tipped up and pushed forward over the contact arm and the end of the operating assembly, taking care that the conductors are not given any sharp bends.

(*c*) The operating assembly is held in position by three screws and a dowel. Remove these screws and the assembly can be removed as a unit by lifting straight up.

(*d*) Unscrew the jam nuts on the threaded ends of the pole pieces, and after the screws holding the permanent magnet have been loosened, the pole pieces can be removed by unscrewing.

(*e*) Unsolder the connections to the operating coils and remove by slipping them out of the frame sidewise. End motion of the operating coils is limited by a cupped washer interposed between the end of the coil and the frame, and the coils are prevented from rotating on the cores by a lug turned up on the inside of the frame on a line with the threaded hole into which the pole pieces are screwed, engaging a notch in the edge of the bobbin on one end of each coil.

(*f*) The operating assembly can be taken apart, after removing the two holding screws and the contact arm, by prying apart at the point where the dowel pin is

located. When doing this, however, the rocker arm should be held down into the bearing in the base plate to prevent its jumping out and putting an undue strain on the holding pawl spring.

(*g*) The ratchet wheel is removed next by lifting it out of its bearing in the base. Lift the rocker arm straight up and the holding pawl will slip off the rocker arm shaft. Unhook the holding pawl spring, using a pair of small tweezers. Before removing the armature assembly, disengage the armature spring from its bracket.

The foregoing provides for a complete disassembly, which will be necessary if a coil or some component part of the operating assembly is to be replaced.

(2) *Assembly, adjustment, and care.*

(*a*) Before the assembly is begun, wipe all parts dry and clean, paying particular attention to all bearing surfaces, the pawls, and the ratchet wheel. After assembly, drop 2 drops of clock oil into each bearing.

(*b*) In assembling the coils into the frame, the only precaution that should be taken is that of careful handling. The two coils are similar, and the notch in the end of each coil, slipping over the lug on the frame, lines the coils up so that, after the spring washers are slipped into place, the pole pieces can be inserted into the coils and screwed into the frame until the underside of the pole face is against the end piece of the frame. Tighten the magnet holding screws and screw on the jam nuts.

(*c*) Fasten the base of the operating assembly in a small vise. Hook the eye of the holding pawl spring into its anchorage and place the pawl in the position on the base with its bearing holes centered over the rocker arm shaft bearing.

(*d*) Mount the armature assembly with its shaft in the lower bearing, connect the armature spring to its bracket, and then place the rocker arm into position with its shaft fully seated in its bearing and its upper end between the two studs on the end of the armature arm.

(*e*) Put the ratchet wheel in place, and holding both pawls away from the ratchet wheel, push it down firmly into its bearing in the base and release the pawls, which then should rest on the rim of the ratchet wheel.

(*f*) Push the top plate into place by first placing the ratchet wheel shaft into its bearing; second, push dowel on front end into its hole, then the rocker arm shaft and finally the armature assembly shaft. None of these operations is complete until the armature shaft has been entered into its bearing in the top plate, after which this plate will snap down into place and be secured there by the two holding screws. The operating assembly then is mounted and secured in place by the three holding screws.

(*g*) At this stage of the assembly, the following adjustments should be made: Loosen the jam nut on the conical-head locking screw and give this screw several turns in a counterclockwise direction so as to move the head of the screw to the left. Bring the armature up against the right-hand pole piece. This motion of the armature, transmitted to the operating pawl on the rocker arm by the outer lug on the end of armature arm rotates the ratchet wheel in a counterclockwise direction. When the armature is up against the right-hand pole piece, the holding pawl should be seated firmly in a notch on the ratchet wheel and the operating pawl should not be in contact with the conical head of the locking screw. If the notch is back of the holding pawl, screw the pole piece in until the pawl drops into the notch. If the notch is beyond the pawl, back the wheel up by screwing the pole piece out until the notch and the end of the pawl are properly engaged. In making this adjustment, the ratchet wheel must be made to follow the operating pawl back by rotating it clockwise by hand. Insert a screw driver in the slotted end of the pole piece and tighten the jam nut.

(*h*) Adjust the movement of the operating pawl in the other direction by bringing the armature up against the left-hand pole piece and adjusting the pole piece until the operating pawl is in the notch with a clearance between the radial side of the notch and the pawl equal to the thickness of the pawl, and then tighten the jam nut. Operate the selector slowly by hand to obtain a complete revolution of the ratchet wheel and note the action of the holding pawl, which should freely snap

into each notch with a clearance of not more than 0.003 inch with the armature against the pole piece.

(*i*) The tightening of the jam nuts may have changed the initial adjustment so that this adjustment may have to be repeated several times. When this adjustment has been attained, bring the armature up against the right-hand pole piece and screw the conical-head locking screw in until it makes contact with the operating pawl, and then tighten the jam nut. The purpose of this locking screw is not to act as a stop for the operating pawl, but to lock it into the bottom of the ratchet wheel notch at the end of its travel and thus prevent the overrunning of the ratchet wheel. When properly made, there should be no discernible motion of the ratchet wheel when a slight pressure in either direction is applied on the rim of the wheel.

(*j*) Insert a small wooden wedge between the armature and the left-hand pole piece to hold the wheel in the locked position and slip the contact arm into place on the ratchet wheel shaft, pushing it down until there is a minimum clearance between its hub and the top plate, and pointing it in the approximate direction of No. 20 contact. Then turn it on the shaft until the center line of the top of the contact arm is parallel to the left-hand or straight side of the top plate. Hold securely in this position and tighten the two set screws. These screws which are made of steel have cupped ends, and the ratchet wheel shaft, being of bronze, will not require much pressure to seat them firmly.

(*k*) With the contact arm still in this position, pull the commutator back so that the commutator bracket can be fastened into place by its holding screw; the end of the contact arm will have to be raised when moving the commutator into place. Then fasten the commutator by its three screws and adjust the tension of the contact arm by prying up slightly on the rounded end if the tension is not great enough, or by springing the front end up if the tension is too great. When this adjustment is made properly the contact arm can be observed to ride up on each contact, and the selector should operate with no noticeable increase of effort.

The foregoing methods of disassembly, assembly, and adjustment are performed easily if precision, care, and patience are exercised. Several sizes of screw drivers and wrenches and a small pair of tweezers are supplied with the apparatus. Use the screw driver that fits the slot in the head of the screw, and the wrenches on the nuts. The selector, while of a rather rugged construction, is nevertheless a delicate instrument and should be treated as such. All parts are formed and shaped in manufacture and initial assembly, and can be reassembled and adjusted without the use of force or the bending or springing of any of the parts. The glass cover should be in place at all times, except when working on the selector, as a protection from dust and moisture.

h. Speed of rotation of selector contact arm.—(1) The speed of rotation of the contact arm is such that if a hostile vessel of the highest speed and the minimum length capable of attaining such speed hits a mine in a group set for contact firing *just after* the contact arm of the selector has left the contact for that mine the contact arm will return to the same mine contact after making a complete revolution before the vessel has passed entirely over the mine and the mine righted itself. The combination of conditions thus presented imposes the maximum difficulty in the execution of contact firing, and the probability of occurrence of this combination of conditions is low.

(2) The type of vessel fulfilling the conditions stated as to speed and size is represented by a few classes of destroyers approximately 300 feet long with a maximum speed of 36 knots per hour. This speed is equivalent to 60.8 feet per second. A destroyer 300 feet long moving at this speed and hitting a mine at the bow would not clear the mine until 4.93 seconds. Therefore, if the selector contact arm makes a complete revolution once in every three seconds, and a 36-knot destroyer hits a mine just after the contact arm has left that particular mine contact, the destroyer will move approximately 180 feet before the mine fires, and the explosion will get the destroyer just aft of amidships.

(3) The selectors and accessories can be operated at this tactical speed of 20 revolutions per minute with dependable reliability, and while they can be operated at a higher tactical speed if necessary, yet such increase is unnecessary, and is undesirable, both because it shortens the serviceable life of the apparatus and because, with a material increase in speed, a point would be reached where maintenance of synchronism can not absolutely be depended on.

86. Switching relay.—*a. Description.*—This is a 216–E relay and is shown in Figure 22; one is mounted on each control panel (fig. 19). The single-conductor cable from the distribution box of the group of mines is connected to this relay which opens the 120-volt direct current operating circuit and closes the 500-volt alternating current firing, the 80-volt direct current locking, and 80-volt direct current signaling circuits. Only one of these relays is required for each group of 19 mines.

b. Principal parts and code numbers.—The following table gives the names of the principal parts, the Submarine Mine Depot code numbers of each part and the quantity of each part per relay:

Switching relay

Name of part	S. M. D. Code No.	Required per relay
Relay, complete	4136	
Base, complete with terminals	4137	1
Screw, for attaching relay to base	4112	4
Screw, terminal	4113	8
Frame, complete with pole pieces and magnet	4115	1
Nut, for pole pieces	4116	2
Screw, for magnet	4117	2
Contact assembly	4138	1
Screw, for contact assembly	4119	3
Armature assembly	4139	1
Contact spring, long (contact 1 or 7)	4140	2
Contact spring, long (contact 2)	4141	1
Contact spring, medium (contact 3, 5, or 6)	4142	3
Contact spring, short (contact 4)	4143	1
Contact spring spacer	4144	1
Contact spring spacer screw	4145	1
Stop spring	4146	4
Phenol fiber insulator, small	4147	7
Phenol fiber insulator, large	4148	3
Hard rubber bushing	4149	2
Clamping plate	4150	2
Screw, clamping plate	4151	2
Nut, clamping plate screw	4152	2
Coil, operating	4153	2
Cover, glass	4154	1
Screw, for cover	4155	1
Washer, felt, for cover screw	4156	1

c. Operation.—The operation of this relay is as follows:

(1) When a positive impulse enters the operating coils at L_1 (fig. 31), the direction of the magnetic flux is such that the armature is attracted to the right-hand coil. This motion of the armature moves the armature arm to the left, closing the operating circuit at the relay (closes spring contacts 3–1), and opening the firing, locking, and signaling circuits at the relay (opens spring contacts 1–4, 7–5, and 2–6) as shown in Figure 31.

(2) When a negative impulse enters the operating coil at L_1, the direction of the magnetic flux is such that the armature is attracted to the left-hand coil. This motion of the armature moves the armature arm to the right, closing the firing, locking, and signaling circuits at the relay (closes spring contacts 1–4, 7–5, and 2–6) and opening the operating circuit at the relay (opens spring contacts 3–1).

(3) The adjustment of the contact spring is such that contacts 7–5 (locking circuit) close before 1–4 (alternating current firing cir-

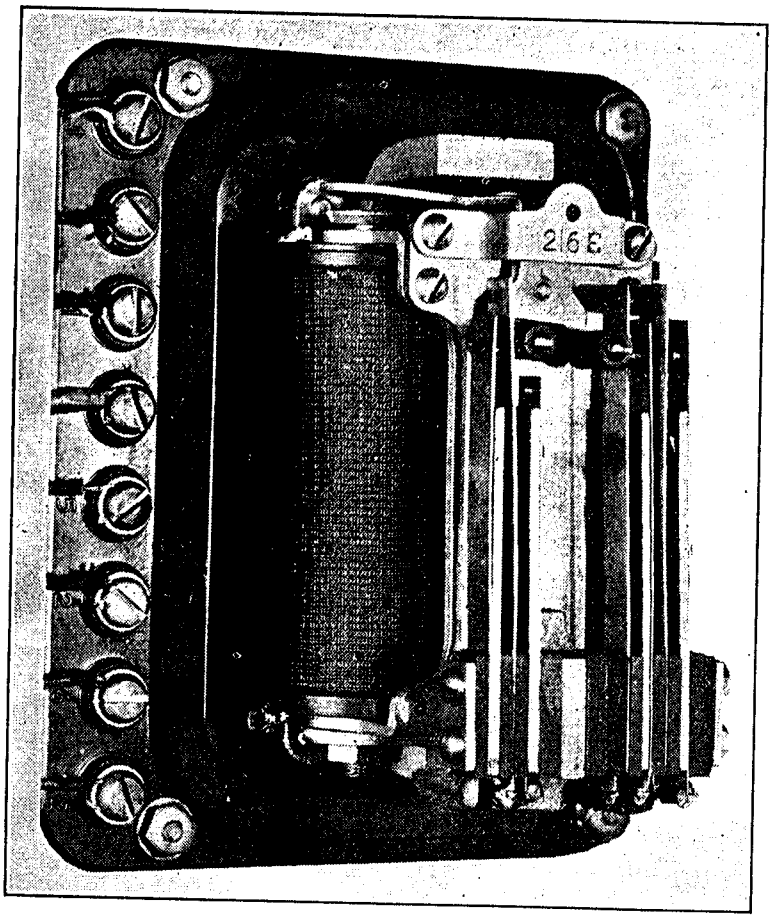


FIGURE 22.—Switching relay

cuit) make contact, and 7–5 do not open until after contacts 1–4 have opened. Contacts 7–5 ground the negative side of the 80-volt direct current locking circuit in order to complete that circuit. The positive side of this circuit is connected on the power panel to the secondary of the casemate transformer through a reactance (par. 72 *i*), and the transformer ground is made through a capacitor (par. 72 *j*). The purpose of these connections is to superimpose on the alternating current firing circuit an 80-volt direct current locking circuit to hold the armatures of the selectors in the locked position.

d. Resetting.—By "resetting the relay" is meant tripping the switching relay contact springs so as to open the firing circuit and close the operating circuit in order to start the selectors operating. This is accomplished by pressing the reset key on the control panel. In order to restart the selectors, it is necessary to press this key after each mine has been fired, or after the selectors have been stopped by pressing a mine key.

e. Adjustment and care.—The adjustments of this relay consist of the proper timing of the break of the contacts, correct spacing, and the required amount of "follow" after the contacts have been made. These are mostly dependent upon the design and construction and should not require readjustment for a long time. The "follow" given the contacts causes a slight rubbing between them, insuring a good electrical contact. The operating coils are removed and replaced as on the selector. The instructions as to the use of the proper tools when working on the selector are also applicable to this relay. The glass cover should be in place at all times except when the relay is being worked upon.

87. Contact-firing relay.—*a. Description.*—This is a 24–B relay with latch and is shown in Figure 23; one is mounted on each control panel. (Fig. 19.) This relay functions only during contact firing, its object being to complete a local circuit through the operating coils of the switching relay when a mine is tipped, thus causing the switching relay to open the operating circuit and close the firing, locking, and signaling circuits. The relay is adjusted so that when a mine is tipped the increased current flowing through the coils is sufficient to move the armature forward into contact with the long contact screw, thus completing the necessary circuit to cause the switching relay to function. An armature latch is so constructed that when the armature is not completing the local circuit through the switching relay—that is, the armature contact spring is not making contact with the long contact screw—the latch is up; but when the armature is drawn to the right by the increased current so that the contact spring on the armature makes contact with the long contact screw, the latch drops down and holds the armature in the contact (completed local circuit) position. This latch is necessary in order that the local circuit through the switching relay will not be broken before the armature of the switching relay completes its throw. After each contact firing of a mine this latch must be raised by hand to release the armature and break the local circuit.

b. Principal parts and code numbers.—The following table gives the names of the principal parts, the Submarine Mine Depot code number of each part, and the quantity of each part per relay:

Contact-firing relay

Name of part	S. M. D. Code No.	Required per relay
Relay, complete	4166	
Sub-base	4167	1
Base, complete with terminals	4168	1
Screw, with nut, for attaching base to sub-base	4169	4
Screw, terminal, with washer	4170	5
Spindle with head	4171	1
Spindle bracket	4172	1
Screw, for spindle bracket	4173	2
Contact bracket	4174	1
Contact screw, short	4175	1
Contact screw, long	4176	1
Check nut for contact screw	4177	2
Contact post with base	4178	1
Armature assembly	4179	1
Armature latch	4180	1
Helical spring	4181	1
Coil, operating	4182	2
Core, operating coil	4183	2
Yoke assembly	4184	1
Screw, for yoke	4185	2
Adjusting nut	4186	1
Adjusting nut bracket	4187	1
Screw with nut, for adjusting nut bracket	4188	1
Screw, for adjusting nut bracket	4189	2
Binding post	4190	5
Screw, for binding post	4191	5

c. Care and adjustment.—The methods to follow in the replacement of parts on this relay are evident on inspection, except the manner of breaking the connection between the two coils. The tubing covering this wire has a longitudinal slot near its center sealed with shellac. Break this shellac seal and pull out the soldered joint, unsolder, and the coils may be separated. In connecting the coils, the ends of the wires are pulled taut through this hole, twisted together, and soldered. After the excess wire has been cut off the joint is pushed into the tubing and the slot sealed with shellac. Should it be necessary to get at the winding the shell can be removed by pulling it off over the rear end of the bobbin. When working on the coils it should be borne in mind that the conductor is solid and therefore not flexible, and will not stand a great amount of bending before breaking. In adjusting for operation the contact screw which acts as a back stop for the armature should be set so that the

latch remains up (unlatched position) when the armature is held against this contact by the helical spring. The long contact screw is then adjusted for a gap of 0.025 inch between its contact and the spring contact on the armature. The coils are moved back for the maximum air gap between the pole tip and the armature. The final adjustment for the value of the current at which the relay will act is made by increasing or decreasing the tension on the helical spring. The relay should be kept dry and free from dust at all times.

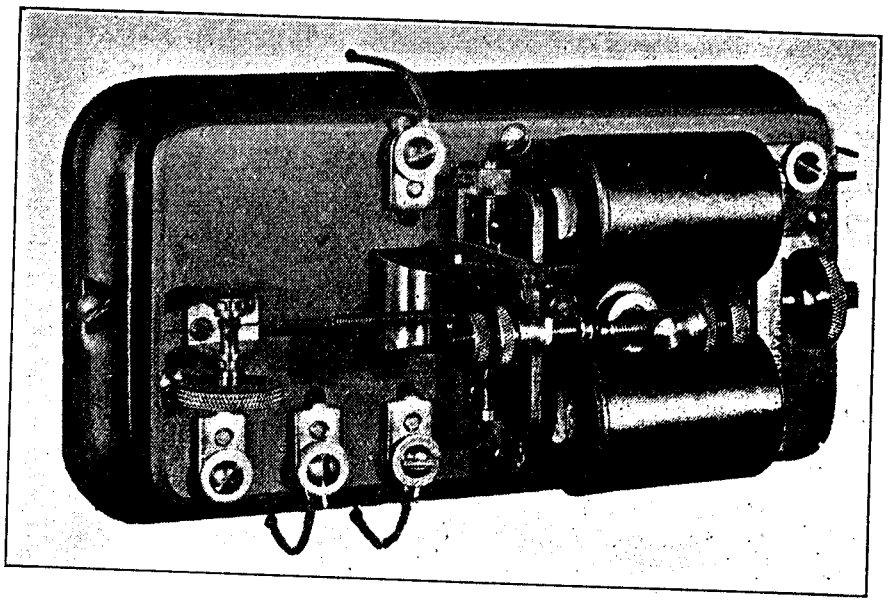


FIGURE 23.—Contact firing relay

88. Milliammeter, alternating current, 0–100 M. A. (fig. 19).—*a. Description.*—This is an ordinary Weston 429 commercial milliammeter, which is placed in the 120-volt direct current operating circuit on the control panel. The functions of this instrument are—

(1) To indicate milliampere readings of mines after planting.

(2) To show the amount of direct current on the operating circuit.

(3) To indicate whether the selectors are in or out of synchronism.

(4) When out of synchronism, to indicate when the contact arm of either selector is on contact No. 20.

(5) To indicate that a mine has been fired, and to show which mine has been fired.

b. Current values.—Whenever current values are given in this description of the standard single-conductor mine system, as indicated by this milliammeter, they must be considered as relative values only, as they do not represent the actual currents flowing under all conditions or in all the various circuits for the following reasons:

(1) Any given installation will differ from all other similar installations in the length of conductor and slight variations in equipment.

(2) The machine operating voltage is 120, whereas the manual operating voltage is 80.

(3) The milliammeter will not indicate the actual current flowing when the selectors are operating, as the making and breaking of the operating circuit at the interrupter causes the pointer to indicate a current value between the actual current of 53 milliamperes and zero. This is due to the tendency of the pointer to move to a reading of 53 milliamperes when the circuit is closed at the interrupter, and the tendency to move to zero when the circuit is opened at the interrupter. The current action on the pointer being stronger than the spring action, the pointer indicates a current flow greater than an average of 53 and zero, or approximately 38 milliamperes.

(4) The current flow as indicated by the milliammeter is not the current flowing through a mine circuit, as the current divides at the switching relay, a small amount going to operate the casemate selector and the greater amount going to the mine field. The current again divides at the distribution box selector, a small amount going through the operating coils of the distribution box selector and the greater amount being impressed successively on each mine circuit.

c. Care and adjustment.—The milliammeter operates on the electromagnetic or moving iron principle, in which is utilized the repulsion action between a fixed and a movable piece of iron placed within a field coil. The movable element is of a very light construction and its motion is damped by an air damper. A zero correction is mounted in the center of the name plate. This instrument is accurate within 1 per cent of the full scale values over the working range of the scale, and has a resistance of 125 ohms. If this ammeter becomes unserviceable, from whatever cause, it should be replaced by a spare, and authority obtained to turn it in to the Submarine Mine Depot for repairs.

89. Switch and mine keys.—*a. Switch keys.*—These are modified 92–A and 92–B commercial switch keys with six terminals each which may be connected so as to make any combination of single-pole or double-pole, single-throw or double-throw switches. The construction of the two keys is similar except for the buttons. Key 92–A is a nonlocking key; when pressed in it immediately returns to the "out" or open position when released. Key 92–B is a locking key; when pushed in or pulled out it locks in either position.

b. Mine keys.—(1) Mine keys Nos. 1 to 19 are 92–A keys modified into a combination of the 92–A and 92–B keys with a pointer on

the face of each button; when this pointer points up to the number of the key, it functions as a nonlocking 92–A key; when the button is rotated 180° (pointer pointing down) and then pressed in, it locks in that position and the key becomes a 92–B locking key. The contacts have been changed so that there are two single-pole, single-break switches, one of which is operative in the nonlocking position and the other in the locking position of the button. The purpose of this modification is to insert into the operating circuit a 2,500-ohm resistance (mounted on back of control panel) to balance the circuit when the distribution box selector is on an open mine circuit, and thus prevent a "throw" of the milliammeter pointer each time the distribution box selector contact arm passes a contact of an open mine circuit. The operating circuit with this resistance inserted is called the mine compensating circuit.

(2) After a mine has been fired, rotate the button for that particular mine 180° and press it in. This not only inserts the 2,500-ohm resistance into the mine circuit, but also enables the operator to see at a glance which mines have been fired.

c. Care and adjustment.—The clearance and follow through of the contacts have been adjusted in the factory and should require no further adjustment. The button is held in position by a semicircular brass spring locking ring fitting into an annular groove on the button. In the center of this ring a hole has been punched outwardly, and the upturned edges of this hole engage in a slot in the body of the key, limiting the motion of the key to the travel of the edges of the hole in the slot. To remove a button, depress the locking ring with the blade of a small screw driver and pull out the button. Defective keys should be replaced by new ones.

90. Ground-clearing jack.—A Western Electric 200 jack; one is mounted on each control panel (fig. 19). It accommodates the plug of the ground clearing ammeter.

91. Ground-clearing plug with ammeter.—A Western Electric 3A plug with a Weston 517 ammeter, alternating current 0–1 amperes, attached (fig. 24). It is an ordinary commercial ammeter of the electromagnetic type, one being required for each casemate. It is unmounted, so that the plug may be inserted into the ground clearing jack on any control panel for the purpose of clearing a ground occurring on any individual mine circuit.

92. Clearing a ground.—With the selectors in synchronism and their contact arms on the contacts of the mine circuit to be cleared, insert the ground clearing plug attached to the ammeter into the ground clearing jack on the control panel. The ammeter pointer will

drop close to zero when the ½-ampere tubular fuze in that particular mine circuit has ruptured.

93. Testing switch.—A 5-ampere, 600-volt, single-pole, porcelain switch 2⅝ inches in diameter, consisting of a base, top, and handle. It is mounted on the control panel to the left of the firing switch and is marked "Testing." When in the "on" position, the alternating current circuit is connected directly to ground so as to test, by the white lamp glowing, the delivery of alternating current to the control panel without going through the firing circuit. When in the "off" position, the alternating current testing circuit is open. Defective switches should be replaced by new ones.

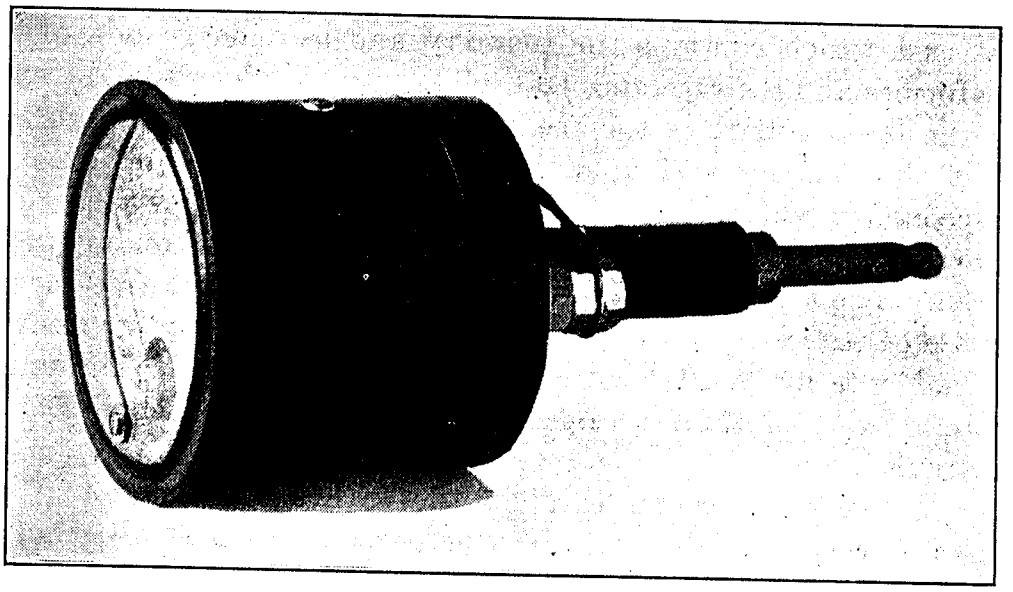


FIGURE 24.—Ground clearing plug with ammeter

94. Firing switch.—This is similar to the testing switch described in paragraph 93; it is mounted on the control panel to the right of the testing switch, and is marked "Firing." This switch is used to throw the alternating current on the firing circuit for firing the mines; no mine can be fired unless this switch is in the "on" position. When in the "off" position the firing circuit is open. Defective switches should be replaced by new ones.

95. Resistance units, 2,500 ohms, 3,800 ohms, and 7,200 ohms.—These are coil resistance units. The 2,500-ohm unit is in the mine compensating circuit (fig. 45) and is mounted on the back of the control panel. The 3,800 and 7,200 ohm units are in the synchronizer indicating circuit (fig. 37), the 3,800-ohm unit being mounted on the back of the control panel and the 7,200-ohm unit in the selector box.

96. Mine transformer (fig. 25).—*a. Types.*—Four types of mine transformers have been supplied to the service—A, B, C, and D. The various types may be distinguished by their serial numbers, as follows:

Type A, serial numbers, 450,000 to 578,000.
Type B, serial numbers, 594,000 to 871,000.
Type C, serial numbers, 1,327,000 to 1,327,800.
Type D, serial numbers greater than 1,327,800.

Only type D transformers will be used with the standard single-conductor mine system, and the following description covers this type:

b. Description.—(1) This transformer consists of a cylindrical brass case which contains the primary and secondary coils of the transformer and the reactance coil. The transformer case is screwed into the brass collar, or the reenforce, and the cap containing the circuit closer is screwed upon its top. The fuzes are attached to the secondary coil and are fired when proper voltage is applied to the primary. The primary leads are black and the secondary leads are red. The terminal "P′" of the primary coil is left free for the purpose of testing, but when preparing the transformer for use this terminal is securely attached to the binding post "T." The upper terminal "R′" of the reactance coil is attached to the ball seat of the circuit closer.

(2) The normal circuit through the transformer is from "P," which is connected to the single-conductor cable from the distribution box, through the primary coil whose resistance is approximately 2,400 ohms, to the transformer case at "T," and to earth. However, in the case of contact firing, when the mine is struck and tipped so as to close the circuit closer, a parallel circuit is completed through the reactance coil whose resistance is approximately 130 ohms, to the ball seat of the circuit closer, through the ball and plate (or ball and springs) to the transformer case, and to earth. In this case the joint resistance of the primary and reactance coils is approximately 120 ohms.

(3) The reactance coil will allow the passage of only a small amount of alternating current when the ball is displaced, so that mines may be fired whether the ball is displaced or not.

(4) Two fuzes are connected in multiple across the ends of the secondary terminals, two being used so as to be reasonably certain of having at least one good fuze. The terminals are about 10 inches long to allow ample margin for inserting the fuzes in the primary charge of trotol in the fuze can.

(5) This transformer is of the step-down type, with a maximum output of 8.5 watts at 500 volts primary at 60 cycles, with a secondary current of approximately 1.3 amperes at 6.5 volts.

(6) The mine circuit when normal is such that 80 volts direct current should give approximately 33 milliamperes, but a mine may

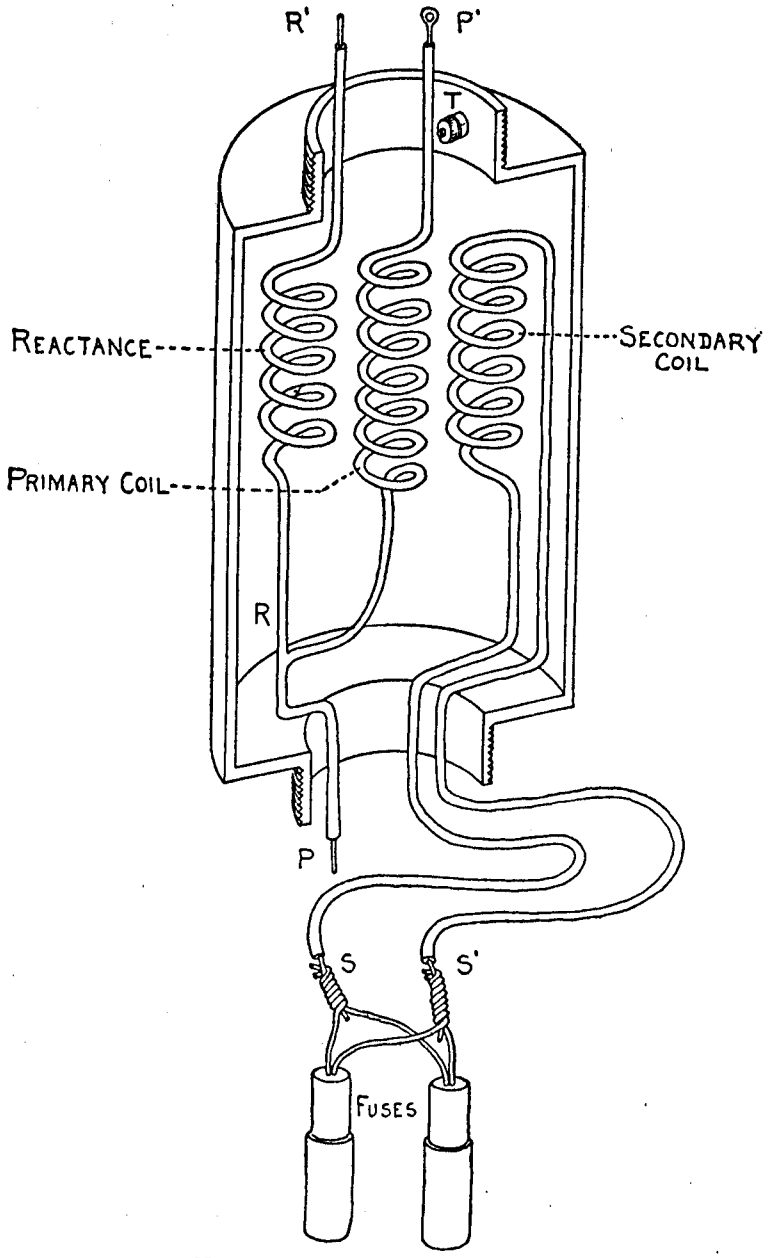


FIGURE 25.—Mine transformer

be fired even when the circuit is so defective that 80 volts direct current give 120 milliamperes. One hundred and fifty volts direct current may be applied to the primary without danger of explosion. An explosion can not be produced unless alternating current is on the control panel, and so long as the firing switch on the control panel is

open ("off" position) there is no danger from the accidental closing of switches or from short circuits in the mine, except in the case of a deteriorated fuze.

c. Mine transformer wire.—This wire is supplied for repair purposes for use in the wiring external to the coils of mine transformers. The conductor is equivalent to No. 16 B. & S. gage, and is rubber insulated and cotton braided. Two types are supplied which are identical except for the color of the cotton braid; black braid is used for the primary wire and red braid for the secondary wire.

d. End plate clamp wrench (fig. 26).—This consists of a circular collar, threaded and split, which fits over the threads of the end plate of the transformer and is tightened by means of a bolt and nut. It has handles on two opposite sides and is 23 inches long.

e. Circuit closer, old model.—This is shown at the top in Figure 62. The circuit closer proper consists of a spring plate and distance ring, while the complete circuit closer consists of the cap, spring

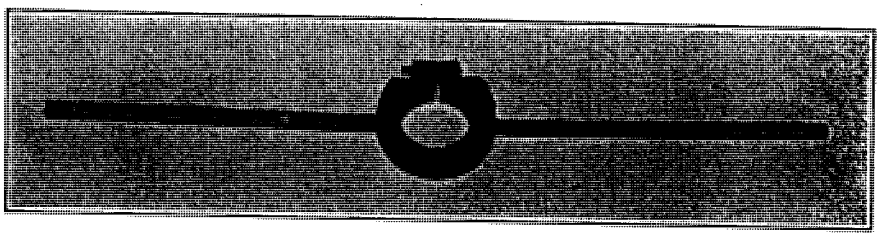


FIGURE 26.—End plate clamp wrench

plate, distance ring, steel ball, and ball seat. To assemble, with the transformer in an upright position screw the ball seat onto the center stud in the neck of the transformer; place the steel ball in its seat; set the distance ring in place on the ball seat; put the spring plate in position on the distance ring; and then slip the cap over this assembly and screw it firmly into place. In service, coat the threads with ruberoid.

f. Circuit closer, Model 1926.—This is shown at the top in Figures 63 and 64. The circuit closer proper consists of a cup, contact plate, contact-plate spring, and distance ring. The contact-plate spring (large end first), contact plate, and distance ring are assembled into the cup, in the order named, in manufacture, the whole being held together by soldering the distance ring to the cup at three places along the lower edge. To assemble, with the transformer in an upright position screw the ball seat home, place the steel ball in its seat, set the assembled cup in place on the ball seat, and then slip the cup over this assembly and screw it firmly into place. In service, coat the threads with ruberoid.

g. Testing mine transformer.—(1) With a voltmeter and battery hook-up similar to that described in paragraph 97, test the transformer for—

(*a*) Good circuit between red wires.
(*b*) Poor circuit through black wire.
(*c*) Good circuit between lower end of black wire and center stud in neck of transformer.
(*d*) No circuit between black and red wires.
(*e*) No circuit between any wire and the case.

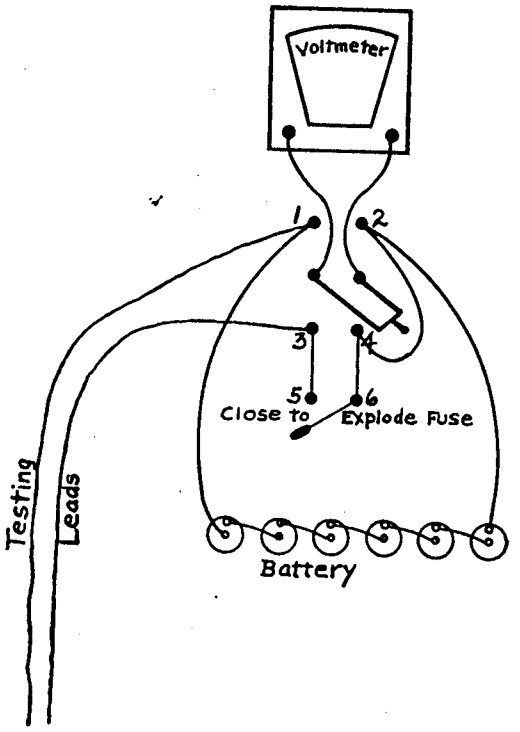


FIGURE 27.—Hook-up for testing transformers, fuzes, and mines

(2) After the above tests have been completed, the upper end of the black wire is bared for about one-half inch and secured to the binding post in the neck of the transformer.

97. Hook-up for testing transformers, fuzes, and mines.—*a.* A convenient voltmeter and battery arrangement for testing transformers, testing fuzes for continuity of circuit and resistance, exploding fuzes, and testing mines in the loading-room tank, is shown in Figure 27.

b. The voltmeter, double-pole double-throw switch, and single-pole single-throw switch may be mounted in a convenient place on the wall of the loading room, and the dry cells placed in a dry box on a shelf near the floor, while the wiring may be either exposed on the wall or run between the walls. The two testing wires should

be long enough to reach to the workbench, to the testing tank in the loading room, and through a window or door to an iron box outside the building, or a fuze testing hole or box set in the ground.

c. Referring to Figure 27, when the double-pole switch is closed up (terminals 1 and 2) the voltmeter only is in series with the dry cells, thus indicating, by a reading of the voltmeter, that the voltmeter and dry cells are in serviceable condition.

d. When the double-pole switch is closed down (terminals 3 and 4) the two testing wires and the voltmeter are placed in series with the dry cells, this being the hook-up when testing mine transformers, assembled mines in the tank, and fuzes for continuity of circuit and resistance.

e. To explode a fuze, connect it to the ends of the two testing wires (be sure that both switches are open while this is being done), place the fuze in the fuze-testing hole or box set in the ground, and then close the single-pole switch (terminals 5 and 6); the fuze should explode if serviceable. Closing the single-pole switch shorts the voltmeter out of the circuit regardless of the position of the double-pole switch.

f. A label, such as "Close to explode fuze" should be placed just under the single-pole switch.

g. The greatest care should be exercised in handling and exploding fuzes. When connecting fuzes to the testing wires or disconnecting therefrom, for whatever purpose, always be sure that both switches are open and remain open until all personnel have cleared away from the fuzes.

98. Mine fuze.—*a. Description.*—This is a regular commercial water-proof electric fuze. It is 3 inches long and approximately 0.275 inch in diameter. It is loaded with 30.8 grains of explosive mixture consisting of fulminate of mercury and chlorate of potash; or a mixture of equivalent strength consisting of tetryl, fulminate of mercury, and chlorate of potash. The fuze wires, which are 4 feet long, are of enameled copper covered with cotton impregnated with tar compound. In order that this fuze may fire immediately, a current of 0.365 ampere, or more, is necessary.

b. Package.—(1) These fuzes are packed 50 to a standard 2-quart, tin, friction-top paint can. Each can bears a printed label on the side showing the manufacturer's name and the contents. The lid is sealed with colored Duco, both to seal the can against moisture and to prevent it from being opened without detection. The entire outside surface of the can is also coated with Duco to prevent rusting of the can.

(2) This special package has been adopted to retard deterioration in storage and is sealed and coated with Duco in manufacture. The seals must not be broken until ready to use the fuzes therein.

(3) *In transfers of accountability, each can, with the seal unbroken, will be accepted as containing 50 fuzes.*

c. Storage and care.—(1) Fuzes may be stored in any place which is available, provided it is cool, dry, secure from entrance by unauthorized persons, and not subjected to a temperature greater than 100° F.

(2) Fuzes must not be stored with other explosives except primers.

(3) Fuzes will not be disassembled for any purpose, as such action by inexperienced persons is liable to result in explosion. The greatest care will be exercised at all times when handling fuzes.

d. Inspection.—This will be limited to seeing that the requirements of storage and care are strictly observed.

e. Testing.—Mine fuzes which have been kept in storage for a long time occasionally deteriorate in such a way that the heating element is so corroded as greatly to increase its resistance, while still maintaining continuity of circuit. In order to preclude the possibility of accident from this cause, all submarine mine fuzes, before use, will, in addition to the test for continuity of circuit, be tested for resistance with the bridge megger. Any fuze whose resistance, including the 4-foot leads, exceeds 1.6 ohms will be discarded and destroyed.

99. Selector box (figs. 28 and 29).—*a. Description.*—(1) This is a water-tight box for housing the selector in the mine field. It is made of Government composition brass and built to withstand a pressure of at least 150 pounds per square inch. The bottom flange of the box has four holes for fastening the box to the inside bottom of a standard 19-conductor distribution box, while the top flange is drilled and tapped to receive the cover holding screws. A rubber gasket is used between the box and cover. On the machined surface of both the box and cover, inside the row of cover-holding screw holes, are two concentric grooves, the two grooves in the box being opposite the two grooves in the cover when the cover is in place. Tightening the cover-holding screws forces part of the rubber gasket into these grooves and forms two rings of rubber which make a water-tight connection between the box and cover. The selector, nineteen ½-ampere tubular fuzes, a 7,200-ohm resistance, and the necessary wiring are fastened to the inside of the cover (fig. 28), so that by unscrewing the cover-holding screws and turning the cover upside down, allowing it to rest on the box, all mechanism and wiring are conveniently accessible.

(2) The letter "C" is stamped on the top edge of the cover above one water-tight connector, and the other connectors are numbered from 10 to 19 clockwise, and from 9 to 1 counterclockwise, from the "C" connector, looking down on the box.

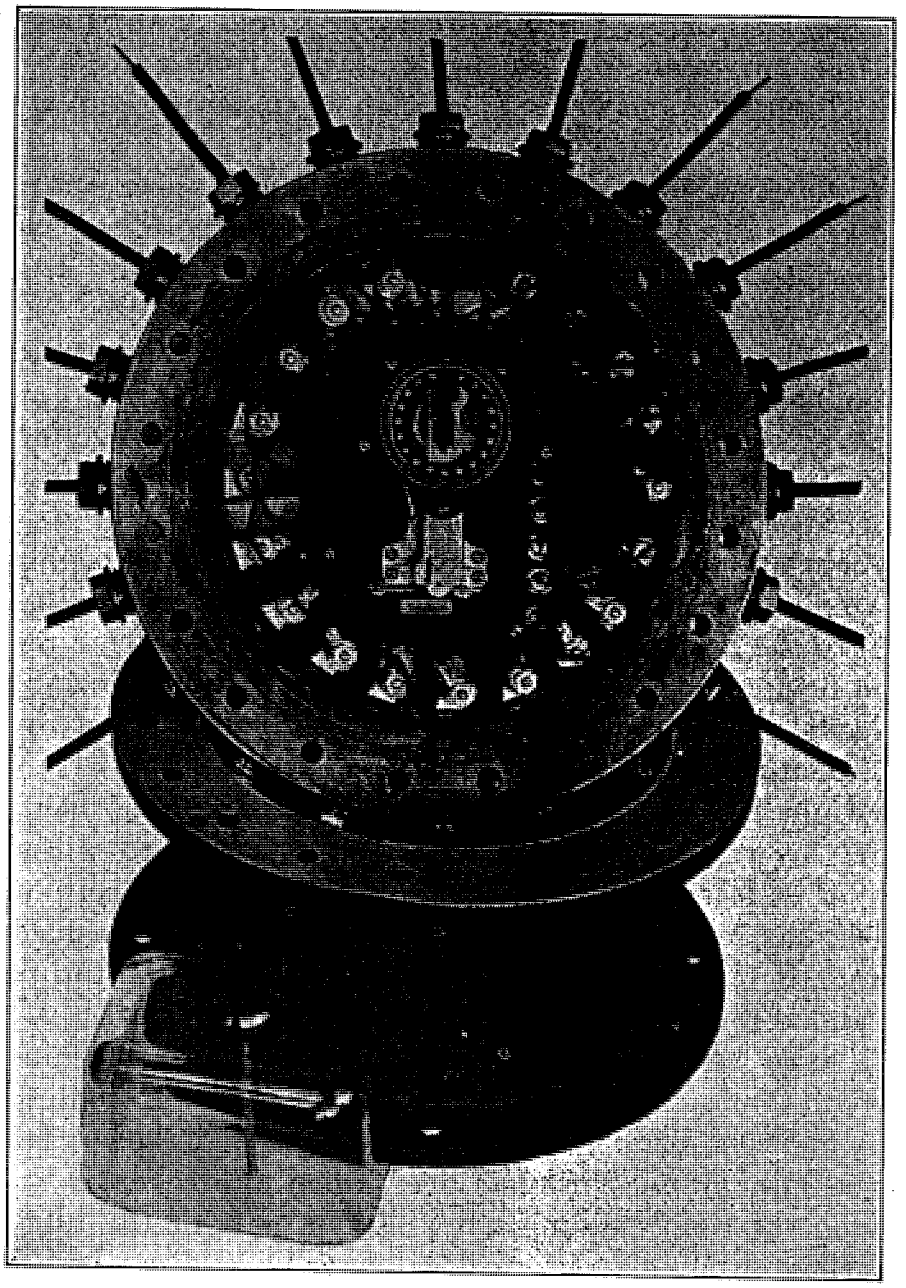


FIGURE 28.—Selector box with selector

b. Principal parts and code numbers.—The following table gives the names of the various parts of the selector box and accessories, the Submarine Mine Depot code number of each part, and the quantity of each part per selector box:

Selector box and accessories

Name of part	S. M. D. Code No.	Required per box
Selector box, complete	4501	----------
Selector box body	4502	1
Selector box cover	4503	1
Cover screw (collar cap screw)	4504	20
Bushing, bakelite or phenol fiber	4505	20
Washer, bakelite or phenol fiber	4506	20
Washer, bronze	4507	20
Washer, bronze	4507–A	20
Contact screw (machine, fil. head)	4508	20
Screw for fastening selector to cover	4508	4
Nut, hexagonal, for securing fuzes to contact screw	4509	40
Follower, bronze	4510	20
Gasket, rubber, for cover	4511	1
Wrench, socket, for cover screw	4512	1
Tubular fuze	4513	19
Lugs, large	4514	27
Lugs, small	4515	15
Washer, for fastening selector to cover	4516	4
Resistance unit, 7,200 ohms	4517	1
Bracket for resistance unit	4518	1
Screw for resistor bracket	4519	1
Screw for resistor	4520	1
Nut for resistor screw	4521	1
Rubber packing	4522	20
Brass gland	4523	20
Washer, brass, for conductor	4524	20
Screw for fastening selector box to distribution box	4525	4
Cover lifter	4526	1
Wire, 19-strand, No. 30, tinned copper, rubber covered	4527	----------
Wrench, for follower	4528	1

c. Assembly.—(1) When working on any of the equipment attached to the selector box cover, the cover should be turned upside down and allowed to rest on the box. Prior to planting, the selector box should be given a thorough inspection and test in the casemate. All screws and nuts on the selector and on the wiring connections should be tightened, and all wiring examined for kinks and pinches.

(2) Test the selector box for operation connected to a test bank of 19 mine transformers, and if it functions properly lead a 40-watt electric lamp into the bottom of the box, support the cover on four cover screws (screwed a short distance into the upper surface of the box flange) so as not to crush the lamp, and allow the lamp to burn for about six hours in order to dry out any moisture in the box and prevent condensation after the box is planted.

(3) After the box has been dried out thoroughly, clean the grooves in the contact surfaces and wipe the surfaces clean. Screw two cover screws, diametrically opposite each other, into the box from the underside of the flange so as to project about one-fourth inch

above the surface of the flange and serve as temporary guide bolts. Lay a new gasket on the flange of the box and examine to see that the holes in the gasket and the flange coincide. Then lower the cover carefully into place with the index marks on the cover and the box lined up. Before removing the guide bolts, screw several cover-holding screws into place, then remove guides and complete the assembly of the screws into the box. When the screws have been screwed down so that their flanges are in contact with the cover, commence tightening, using the special socket wrench, and giving each screw in succession around the box a partial turn. Continue around the box until all the screws are firmly and equally set up.

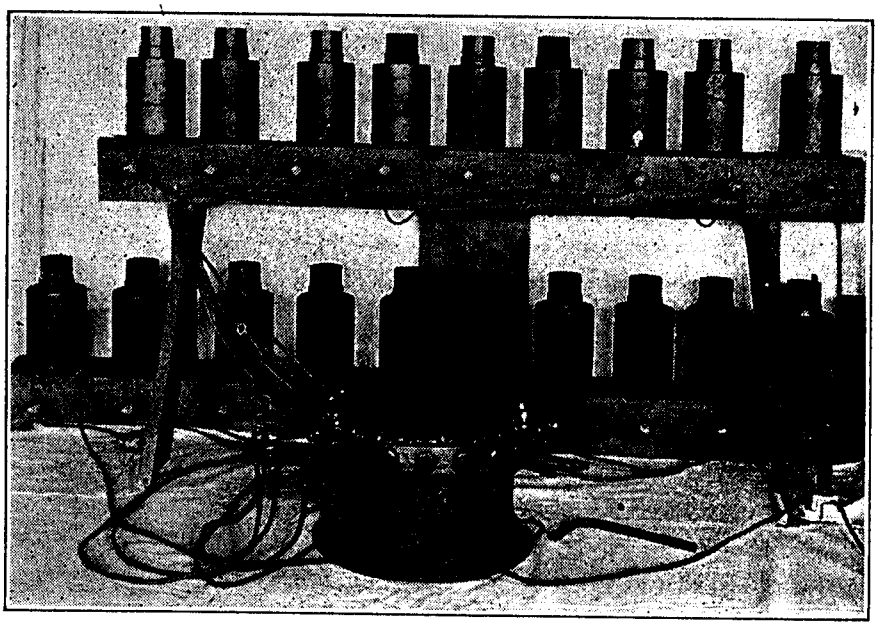


FIGURE 29.—Selector box connected for test

(4) Reconnect to the test bank of mine transformers and give the selector a final test. Then fasten the box into the distribution box with the water-tight connector marked "C" opposite the wide cable slot. Screw the four holding bolts firmly into place.

d. Fitting to 19-conductor distribution box.—The selector box is mounted in the center of the distribution box (fig. 30), to which it is securely attached by four ⅜-inch–16 round-head screws. If holes have not already been drilled into the bottom of the distribution box for this purpose, the box is accurately centered in position in the distribution box with the water-tight connector marked "C" in line with the wide cable slot, and the outlines of the four holes in the bottom flange of the selector box scribed on the floor of the distribution box. Remove the selector box, prickpunch the center of the scribing and, using a breast or electric drill, bore a five-sixteenth-

inch through hole at each of the four points; then with a 3/8-inch–16 tap, thread each hole all the way through. Replace the box and center it over the holes, and if the work has been done properly the holding screws can easily be entered and screwed down, using a large screw driver.

e. Gasket.—The molded or cut gaskets supplied for the selector box cover are one-sixteenth-inch thick and made of rubber with a cloth insertion. Gaskets should be stored in a cool, dry, dark place. If, while in storage, the rubber becomes soft and tacky, or dry and brittle, with numerous surface cracks, the gaskets should be considered unserviceable and requisition made for a new supply. Only

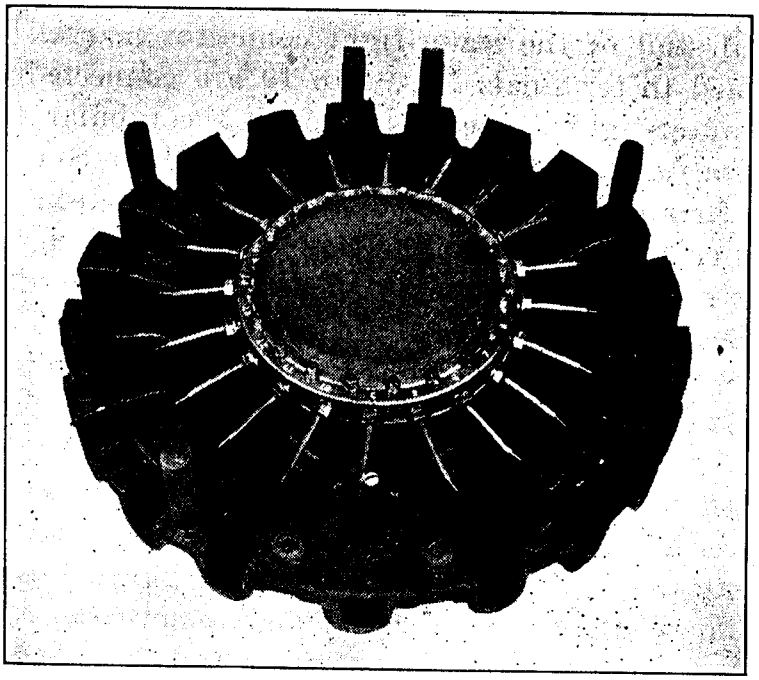


FIGURE 30.—Selector box mounted in distribution box

new live rubber gaskets should be used, one for each time the box is sealed.

f. Wiring (fig. 28).—Because of the inaccessibility of the terminals of the selector when it is mounted in the selector box, all the wiring is attached to the selector before mounting it in the box. The leads for terminals Nos. 1 to 6 are of the same length and fitted with a slotted terminal at one end and a hook terminal at the other. The slotted terminals are connected to the selector terminals with the leads pointing perpendicular to the selector. The leads for terminals Nos. 7 to 19 are similar with a small hook terminal on one end and a larger hook terminal on the other. The end with the smaller terminal is attached to the selector

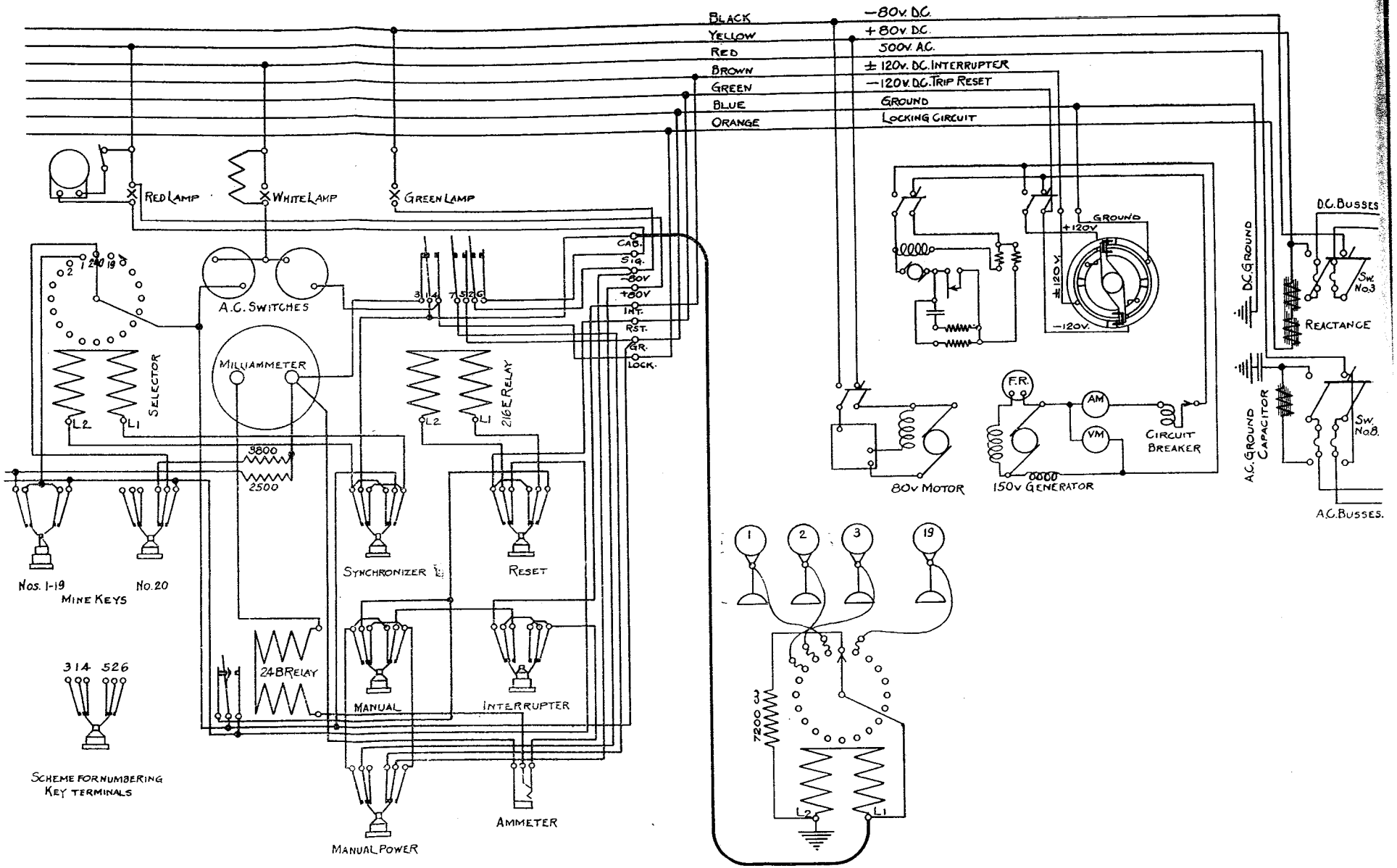
with the conductor leading straight up from the base. Care should be taken that the conductors lead away from the selector as stated, to preclude the possibility of their terminals coming into contact. All contact screws must be firmly set up. The one other lead has terminals similar to the leads for Nos. 1 to 6, but is considerably longer than these. The slotted terminal is connected to L_1 pointing as do Nos. 1 to 6. A parallel connection at the selector end of this lead fitted with a small hook terminal is connected to terminal No. 21. Contact No. 20 is permanently connected through a 7,200-ohm resistance to terminal L_2 which is grounded to the selector box cover through the adjacent selector holding screw. After the selector has been mounted in the box, the lead from L_1 is connected directly to the terminal stud of the water-tight connector marked "C." The leads attached to terminals Nos. 1 to 19 are connected to the like numbered water-tight connectors through the tubular fuzes.

g. Tubular fuze.—(1) This is an ordinary heat coil designed to rupture under a current of one-half ampere. Nineteen of these are mounted in each selector box, one being placed in each mine circuit between the selector and the mine. The fuze is attached to the contact screw between the hexagonal nut nearest the bakelite washer and the brass washer nearest the end of the screw, as shown in Figure 28. Be sure that both nuts are set up firmly so that the fuze will not slip out.

(2) Blown tubular fuzes should be replaced by new ones. All tubular fuzes must be tested for continuity of circuit before assembling into the selector box. To remove a blown fuze, loosen the clamping nut on the top of the coil and remove the selector lead. Then loosen the nut on the contact screw and the tubular fuze can be pulled out. To replace, fasten the tubular fuze to the contact screw and then connect the conductor to it.

h. Water-tight connector.—The water-tight connector has no adjustments. The inner hexagonal nut on the stud should be tightened frequently and the threads and the seat in the outer portion kept clean. Prior to planting, the head of the screw in the bakelite bushing should be cleaned to a bright surface, using a piece of fine sandpaper and a stick, as it is the surface with which the conductor of the cable makes electrical contact. After cleaning, all traces of the sandpaper should be blown out.

i. Cover lifter.—A bronze screw one-half inch in diameter and 2 inches long. Due to the great pressure exerted by the cover-holding screws between the box and its cover, this screw is necessary to separate the cover from the box without damaging the box or cover



Selector— A positive impulse on terminal L_1 is a power impulse, selector steps ahead

2/6 E Relay. A pos. impulse on ter L_1 closes contacts 3-1 and opens 1-4, 7-5 and 2-6. A neg. impulse on L_1 opens 3-1 and closes 1-4, 7-5 and 2-6.

FIGURE 31.—Schematic wiring diagram of mine system

after all the cover-holding screws have been removed. Remove all cover-holding screws, screw the cover lifter into the cover-holding screw hole between Nos. 1 and 19 connectors (which is threaded to receive the cover lifter) until it presses against the surface of the top flange of the box, then apply pressure to the cover lifter by means of the cover-holding screw socket wrench until the cover separates from the box.

SECTION X

CIRCUITS

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Schematic of complete mine system	100
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To start the system operating	116

100. Schematic of complete mine system.—Figure 31 is a schematic diagram of the complete standard single-conductor mine system, showing all circuits.

101. Circuits of distribution-box selector and mine field (fig. 32).—There are parts of three circuits in parallel as follows:

a. Operating circuit.—Through the operating coils of the selector to ground.

b. Supervising circuit.—Through the contact arm of the selector to a mine contact on the selector, to a one-half ampere tubular fuze, to a mine circuit. The supervising circuit is successively impressed on each mine circuit by the rotation of the selector contact arm.

c. Synchronism indicating circuit.—Through the contact arm of the selector, to the No. 20 contact, through the 7,200-ohm resistor, to ground. The function of the resistor is to indicate to the operator in the casemate when the contact arm of the distribution box selector is resting on contact No. 20.

102. Operating circuit.—Reference in this manual to the *operating circuit* means the circuit or combination of circuits by which the selectors are operated under various conditions as distinguished from the firing circuit. It may mean the circuit for machine operation of the selectors, the circuit for manual operation of the selectors, or either of these circuits in combination with the synchronizer indicating and mine compensating circuits.

103. Selector-operating circuits.—*a. Circuit for machine operation of selectors.*—This circuit is shown in Figure 33. The normal (machine) operating current is approximately 53 milliamperes at 120 volts, which is supplied by the generator of the 80-volt direct

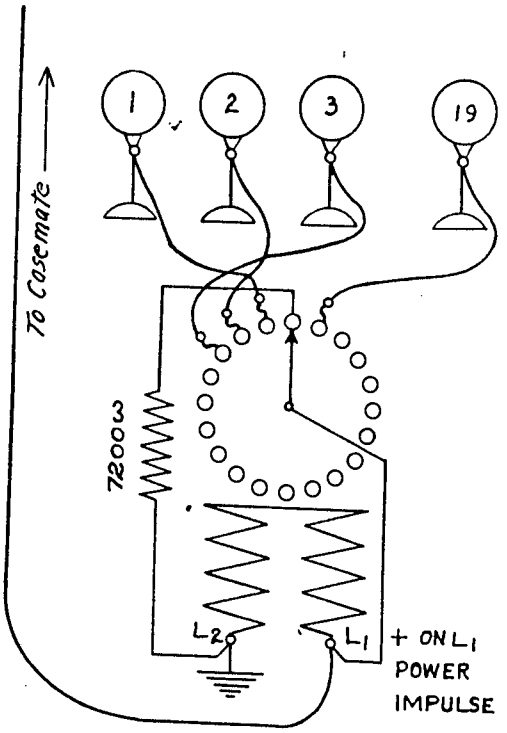

FIGURE 32.—Circuits of distribution-box selector and mine field

current–120-volt direct current motor-generator through the motor-driven pole changer or interrupter for continuous operation. The interrupter key, which is a switch key connected as a double-pole, double-throw switch for either machine or manual operation must be pushed to the "in" position for machine operation. Pulling this key out opens the 120-volt machine operating circuit and throws the 80-volt manual operating circuit onto the system.

b. Circuit for manual operation of selectors (fig. 34).—The manual operating current is approximately 33 milliamperes at 80 volts which is supplied by the storage battery. The interrupter key must be pulled to the "out" position for manual operation. Pulling this key out opens the 120-volt machine operating circuit and throws the

80-volt manual operating circuit on to the selectors. The manual power key is a switch key connected as a double-pole, single-throw switch. Pressing this key, with the interrupter key in the "out" position, places power from the storage battery on the supervising circuit, which permits manual operation and synchronization. The manual key is a switch key connected as a pole changer. Alternately pressing and releasing this key, with the interrupter key pulled to the "out" position and the manual power key held in, sends impulses of alternating polarity (storage battery power)

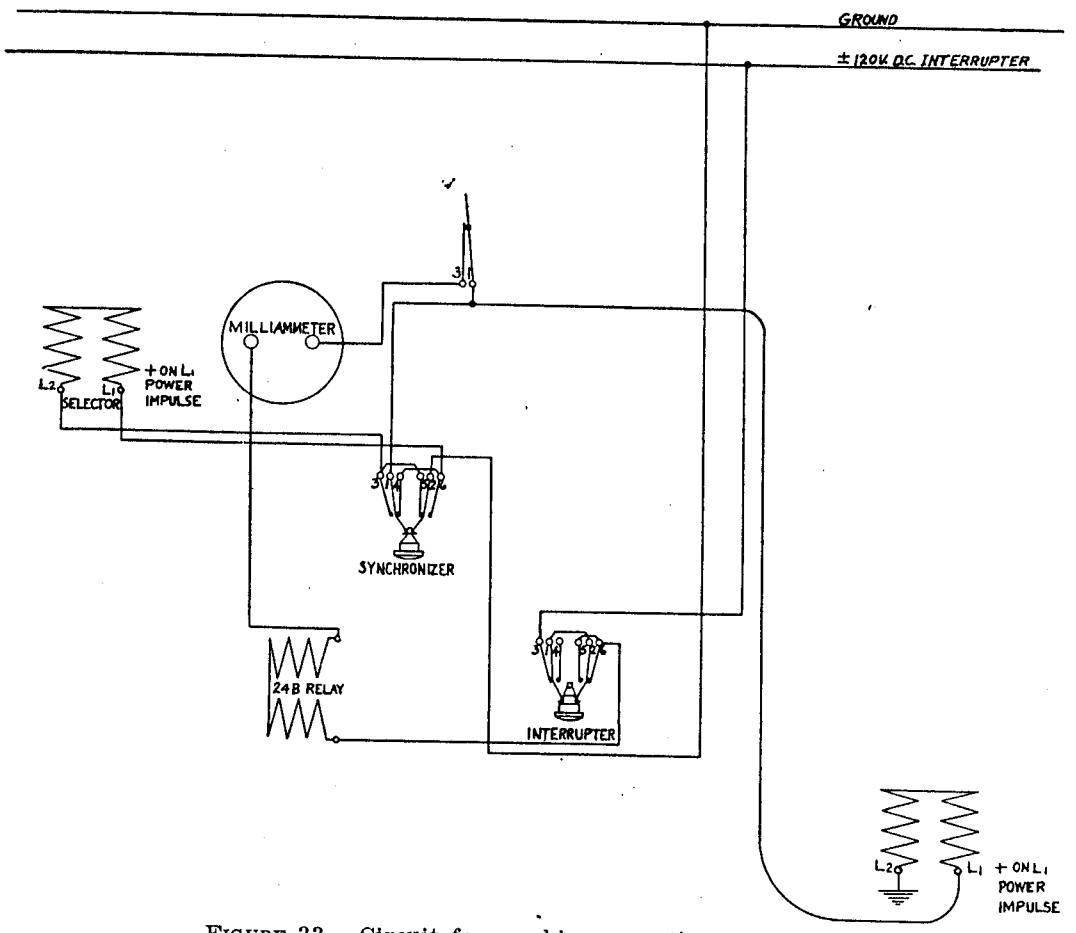

FIGURE 33.—Circuit for machine operation of selectors

through the operating coils of both selectors. Each push of the key sends a retracting impulse (negative polarity) through the circuit, while each time the key is released a power impulse (positive polarity) is sent through the circuit which moves the contact arm of each selector from one contact to the next.

104. Connections of synchronizer key to casemate selector (fig. 35).—This is a switch key connected as a pole changer. It operates only the casemate selector. Alternately pressing and releasing this key with the manual power key held in, sends impulses of alter-

nating polarity through the operating coils of the casemate selector. Each push of the key sends a retracting impulse through the operating coils, while each time the key is released a power impulse is sent through the operating coils which moves the contact arm from one contact to the next. Pressing this key during machine operation when the selectors are synchronized will throw the selectors out of synchronism.

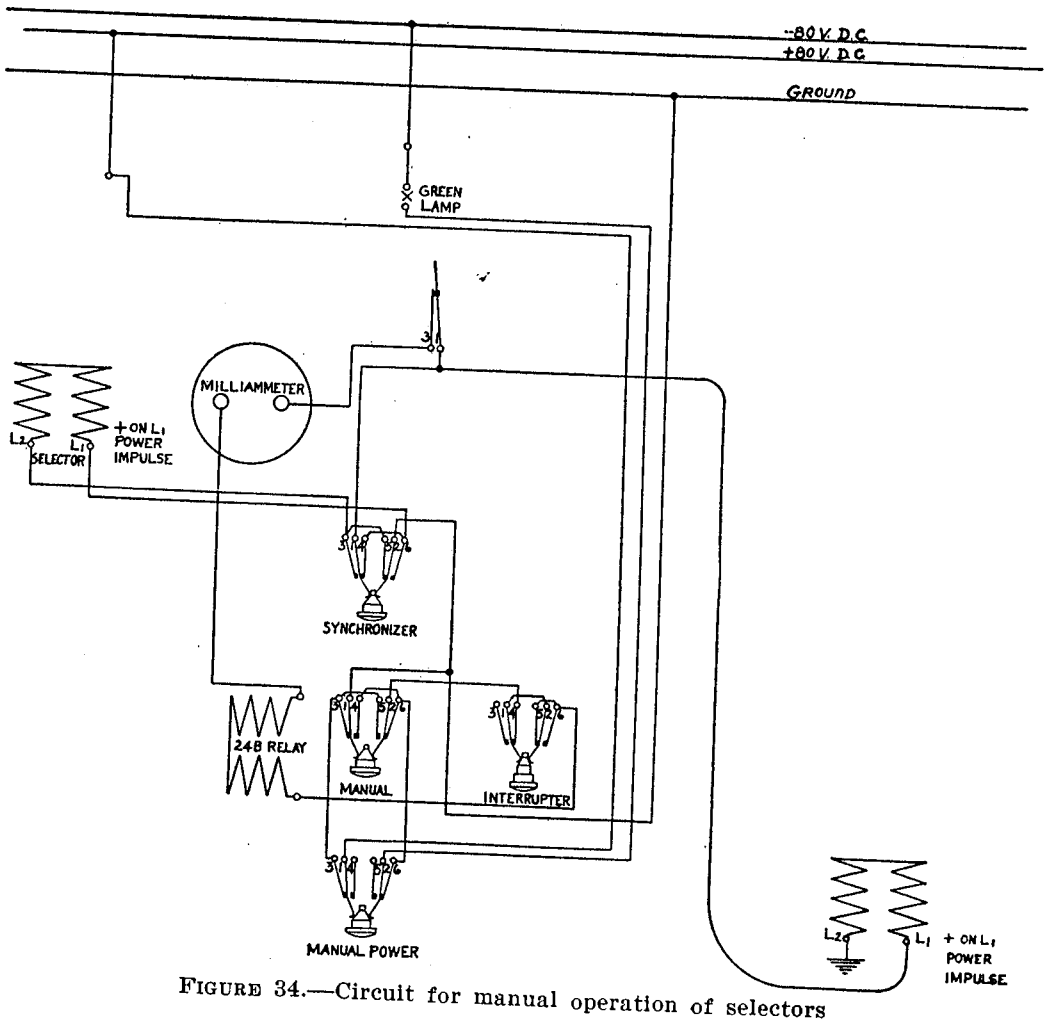

FIGURE 34.—Circuit for manual operation of selectors

105. Individual mine-testing circuit.—*a.* A complete mine circuit for testing purposes is shown in Figure 36. The selector being synchronized, the contact arms of both selectors are stepped around by manual operation and the milliammeter reading noted as the contact arm rests on each mine contact. For a normal condition of the circuits these readings should average about 33 milliamperes, but they may vary by several milliamperes due to the variation in the resistances of the mine circuits as a result of the different lengths of cable and to the allowable manufacturer's variance of plus or minus 5 per cent in the resistance of the mine transformer primary.

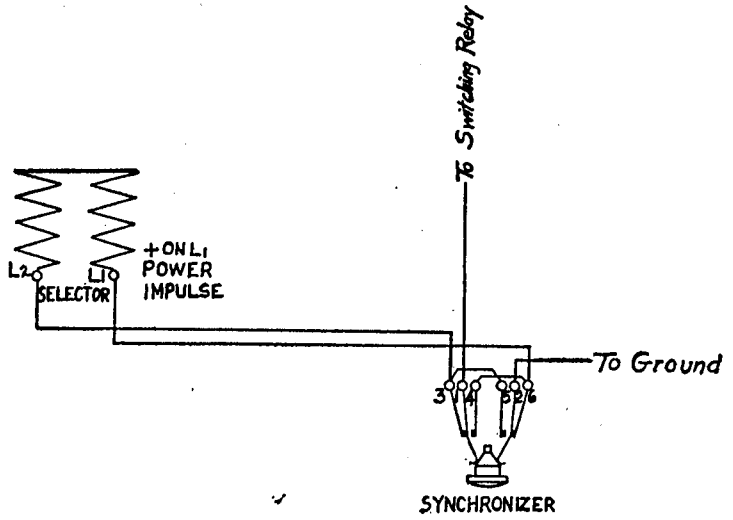

FIGURE 35.—Connections of synchronizer key to casemate selector

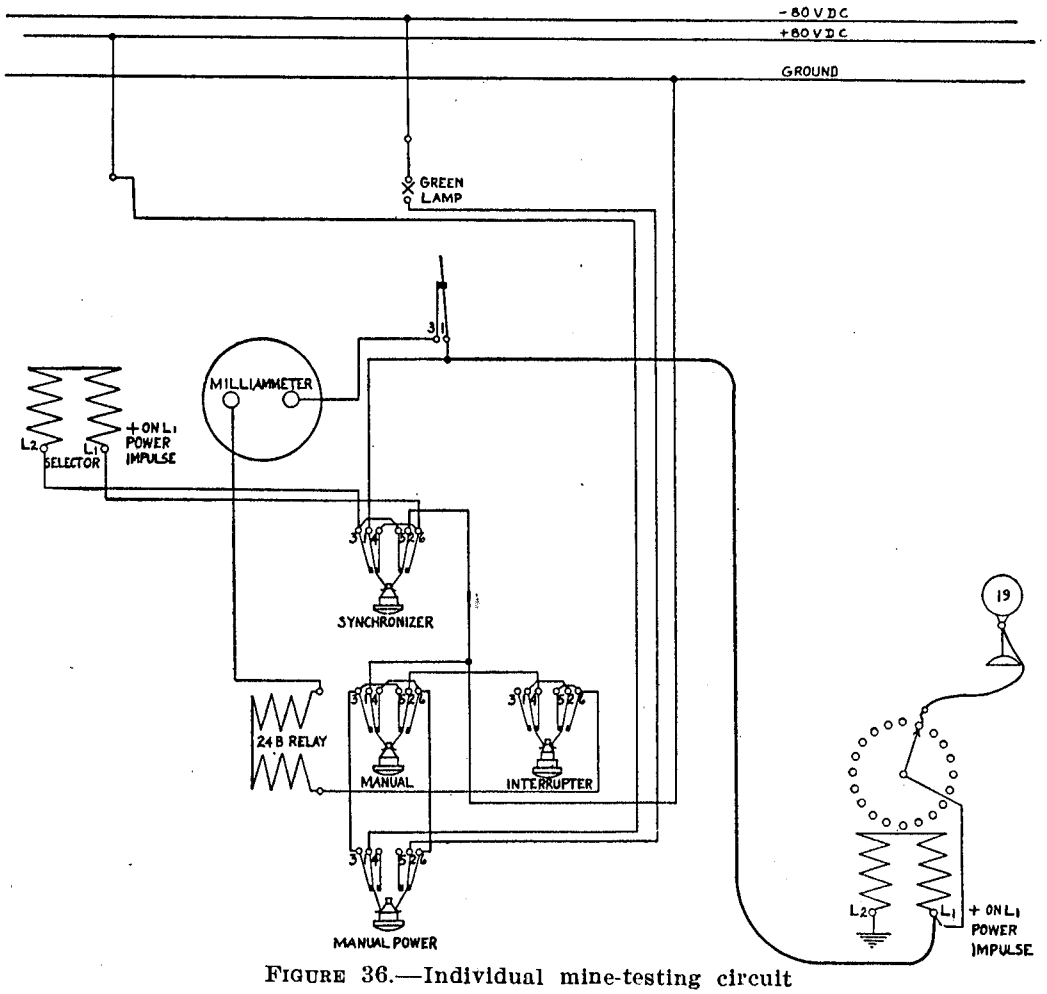

FIGURE 36.—Individual mine-testing circuit

b. An open mine circuit is indicated by a milliammeter reading of 7.5 milliamperes which is the current flowing through the operating coils of the two selectors.

c. A grounded mine circuit is indicated by an increase in the amount of current flowing and the amount of the increase is a measure of the resistance of the ground.

d. An open mine circuit is balanced by rotating the button of the corresponding mine key 180° and pressing it into the locked position, which inserts a resistance of 2,500 ohms in parallel with the casemate selector coils and reduces the resistance of the circuit to normal so that the milliammeter will indicate the average reading. (Par. 89 *b.*)

e. If the ground is such as to interfere with the operation of the selectors, it should be cleared as described in paragraph 113, and the resulting open circuit balanced as described in *d* above.

106. Synchronizer-indicating circuit.—*a. In synchronism* (fig. 37).—(1) In this case the contact arms of the two selectors are always on the corresponding numbered contacts of their respective selectors at the same instant; i. e., when the casemate selector contact arm is on contact No. 1, the direct current selector contact arm is on contact No. 1, etc.

(2) When the contact arm of each selector rests on a mine contact, Nos. 1 to 19, inclusive, the contact arm of the casemate selector is always on an open circuit providing the mine compensating circuit for that particular mine is open, while the contact arm of the distribution box selector completes a mine circuit. If the mine circuit is open and the mine key has been pressed into the locked position, the casemate selector contact arm completes the mine compensating circuit (par. 114) when the distribution box selector contact arm is on the open-mine circuit.

(3) When the contact arm of each selector rests on its No. 20 contact (fig. 37), a circuit is formed which contains two resistances in parallel (the 7,200-ohm resistance in the selector box and the 3,800-ohm resistance in the casemate) whose joint resistance is approximately equal to the resistance of the 2,400-ohm primary winding of a mine transformer. The result is that when the system is operating the milliammeter will continue to indicate approximately the same current flow (53 milliamperes for machine operation and 33 for manual operation) regardless of whether the contact arms rest on No. 20 contacts or on mine contacts, so long as the two selectors are in sychronism.

b. Out of synchronism (fig. 38).—(1) In this case the casemate selector and the distribution box selector are out of step with each

other, which means that the contact arms of the two selectors are on differently numbered contacts at any instant. This condition is indicated by the milliammeter pointer "throwing" to the right and left, or to the left and right, of the normal 53 milliampere reading during machine operation. When this happens, stop the operation of the system and synchronize as described in paragraph 85 *f*.

(2) If at any time there is doubt as to the significance of the movements of the milliammeter pointer, manual operation should be resorted to so that each separate movement of the pointer may be

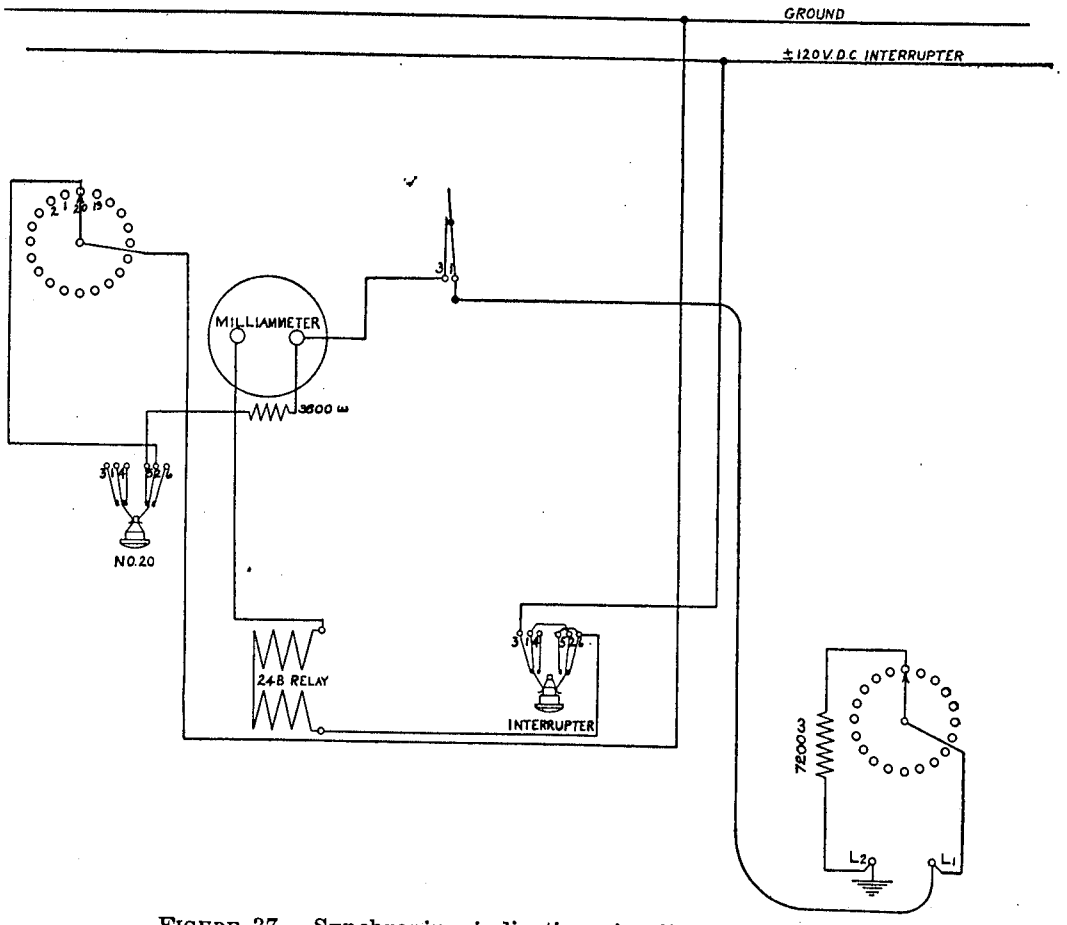

FIGURE 37.—Synchronizer-indicating circuit—in synchronism

noted. The movements of the milliammeter pointer under the different operating conditions must be carefully studied so that the significance of the movements may be properly interpreted.

107. Relay actuating circuits.—*a. Observation fire.*—Twenty switch keys are mine keys for observation firing; they are connected in parallel in the circuit between the commutator mine contacts of the casemate selector and a common lead to the operating coils of the switching relay. Pressing any mine key and holding it in until the selector contact arm reaches that particular contact completes a

circuit (fig. 39) from the 120-volt source of power and trips the spring contacts of the switching relay, opening the operating circuit and closing the firing, locking, and signal circuits, during the period when a retracting impulse is being impressed thereon (negative on L_1). This locks both selector contact arms on the mine contacts corresponding to the key pressed. The observation firing circuit functions only when the polarity of the tracer braid wire of the overhead twisted pair of wires marked ±120 V. direct current in Figure 31 is negative, inasmuch as when this wire is negative the ground wire

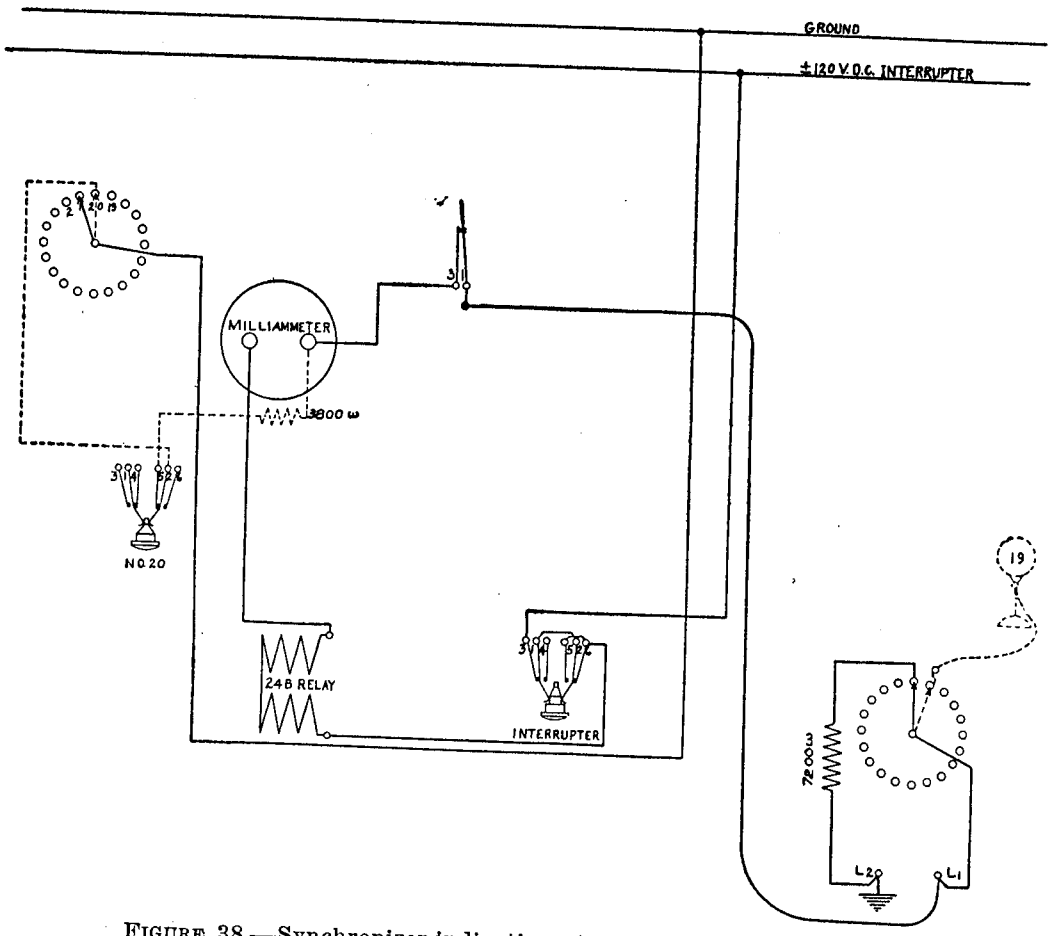

FIGURE 38.—Synchronizer-indicating circuit—out of synchronism

is positive, and a positive ground is necessary to complete the circuit. Referring to Figure 39, it will be seen that terminal 3 on the reset key is always negative, so that when the reset key is not pressed in the current impressed on the switching relay at L_1 is always negative. The consequence is that the switching relay functions to open the operating circuit only when a positive impulse is impressed on the relay at L_2, which is accomplished at pressing a mine key. Pressing the reset key to close the operating circuit causes the negative current to be impressed on the switching relay at L_2, which

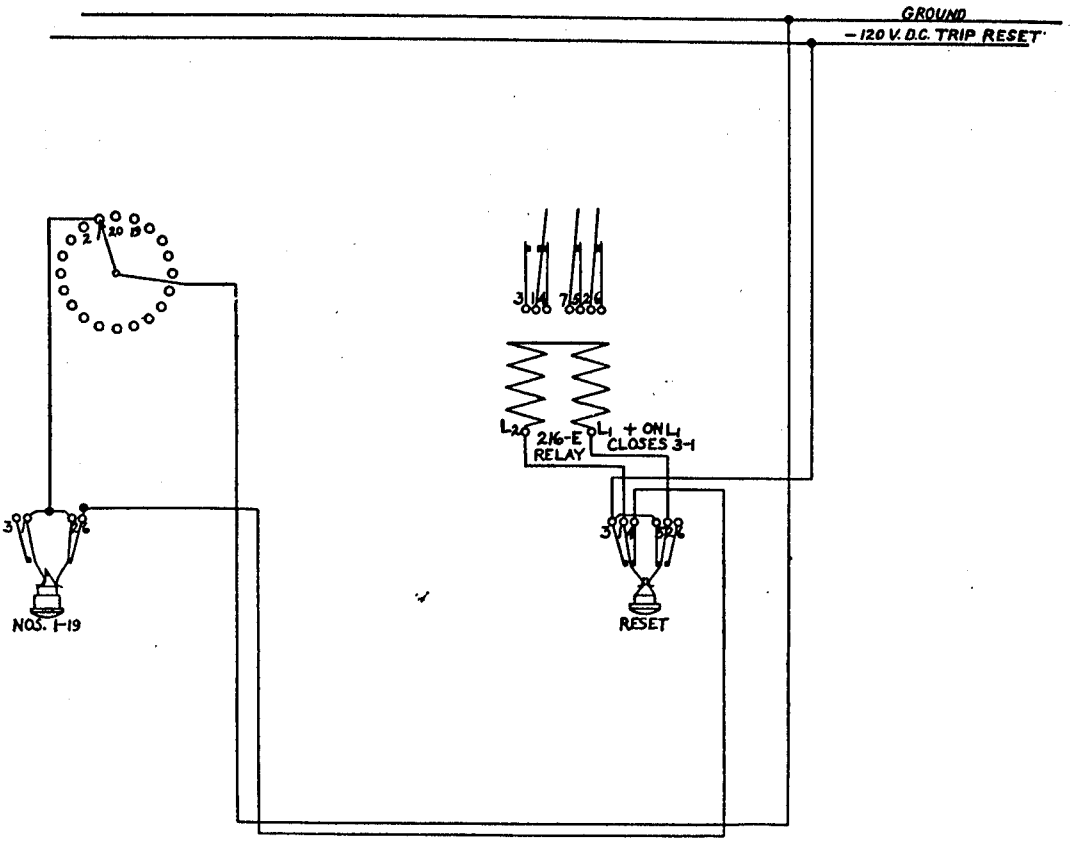

FIGURE 39.—Relay-actuating circuit—observation fire

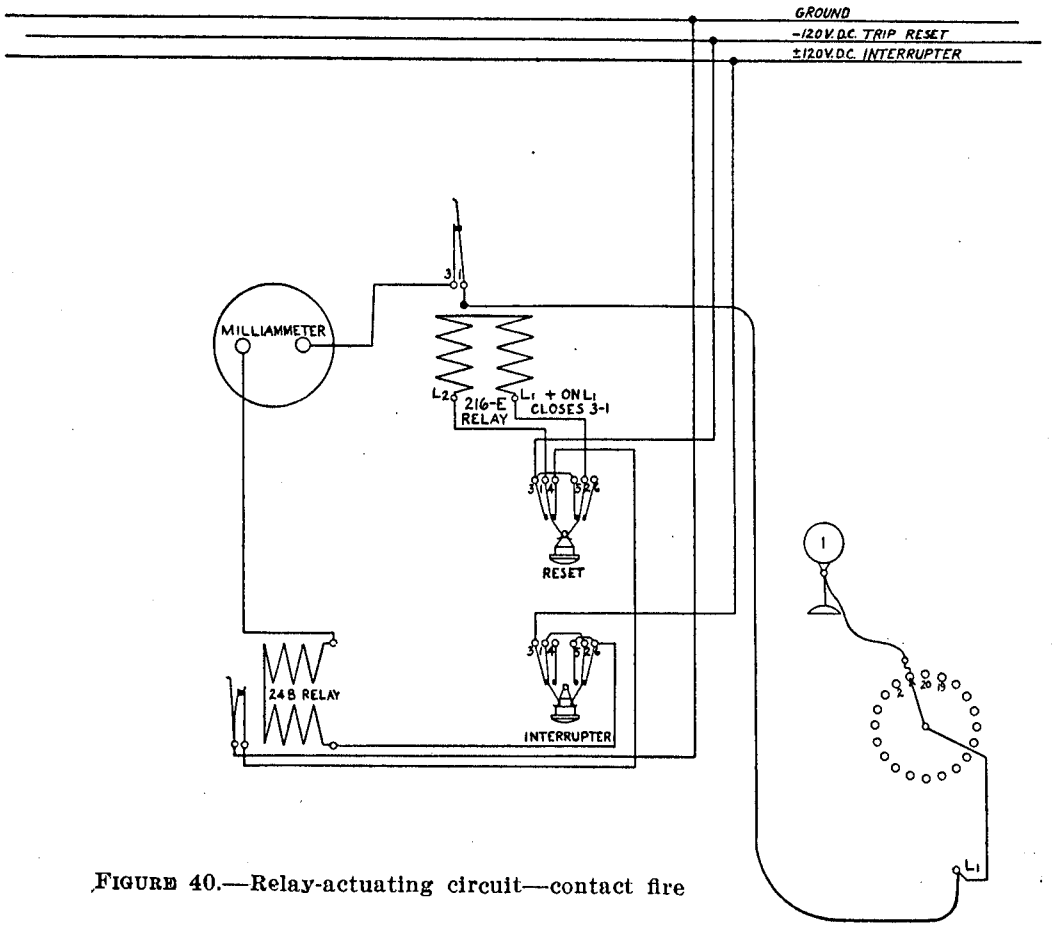

FIGURE 40.—Relay-actuating circuit—contact fire

means that the switching relay functions, so as to close the operating circuit, only when a positive impulse is impressed on the relay at L_1. As this positive impulse comes from the ground wire, the tracer braid wire is negative at that instant.

b. Contact fire.—The increased flow of current through the circuit closer of the tipped mine causes the contact firing relay to function (fig. 40), which completes a circuit through the operating coils of

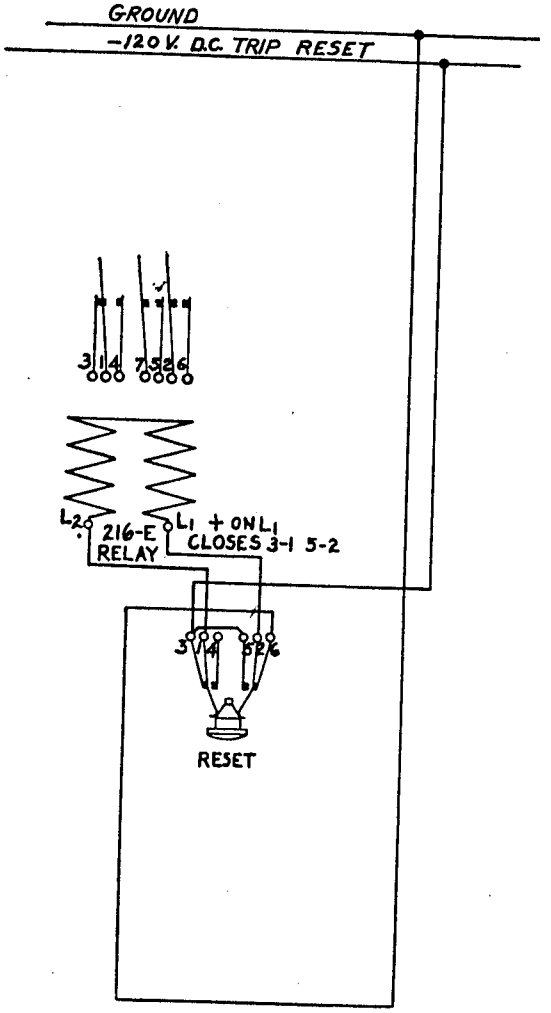

FIGURE 41.—Relay-actuating circuit—reset

the switching relay. This flow of current trips the contact springs of the relay, opening the operating circuit and closing the firing, locking, and signal circuits as in observation firing.

c. Reset.—The reset key is a switch key connected as a pole-changer (fig. 41). Pressing it completes a circuit, from the 120-volt source of power, through the operating coils of the switching relay. This trips the spring contacts of the relay so as to open the firing, locking, and signal circuits and close the operating circuit, providing the spring contacts are not already in that position. If

the interrupter key is set for machine operation and the interrupter is running, pressing the reset key immediately starts the system operating.

108. Switching relay contacts.—*a. Operating circuit to firing circuit* (fig. 42).—When spring contacts 1 and 3 make contact, the operating circuit is closed and the firing circuit is open; when spring

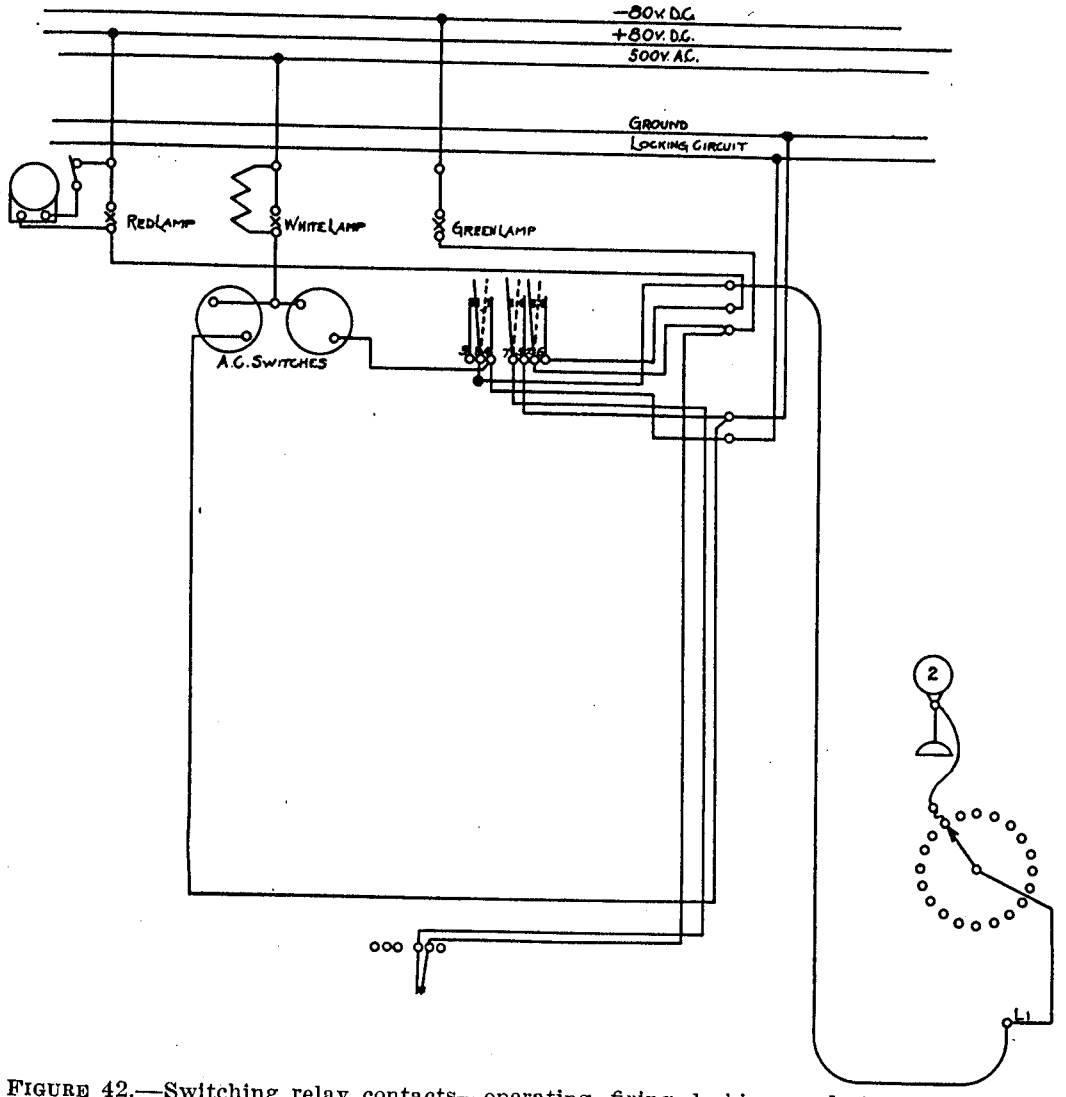

FIGURE 42.—Switching relay contacts—operating, firing, locking, and signal positions

contacts 1 and 4 make contact, the firing circuit is closed and the operating circuit is open.

b. Closing signal and locking circuits (fig. 42).—When spring contacts 2–6 and 7–5 are closed, the signal and locking circuits are completed. The mechanical construction of the switching relay and the adjustment of the relay spring contacts are such that when contacts 1–3 are closed (completing the operating circuit), all the

other contacts are open, and when contacts 1–3 are open, contacts 7–5 and 2–6 close before the firing circuit contacts 1–4 close.

109. Signal circuit (fig. 42).—This circuit is from the positive direct current bus on the power panel to switch No. 3 closed up, to the earth operating board terminal on the power panel, to the overhead positive (yellow) direct current lead, to the earth or +direct current terminal on the signal block, through the red lamp and bell in parallel to the signal terminal on the terminal block of the control panel, through the switching relay (contacts 2 and 6 closed) to the negative direct current terminal on the terminal block, through the green lamp to the negative direct current post on the signal block, to the overhead negative (black) direct current lead, to the earth operating board terminal on the power panel, to switch No. 3 and to the negative direct current bus on the power panel.

110. Firing circuit.—*a.* The complete firing circuit includes the alternating current firing circuit and the direct current locking circuit, both of which must be simultaneously imposed on the selectors and mine transformers to insure safe operation of the system.

b. The alternating current firing circuit is shown in Figure 42. When spring contacts 1 and 4 are thrown in contact by action of the switching relay, the firing circuit is closed at the relay, and if the firing switch is closed the firing circuit is then completed. When spring contacts 1 and 3 are thrown in contact by action of the relay, the firing circuit is opened at the relay.

c. The alternating current firing circuit is from an alternating current bus on the power panel to switch No. 8 closed up, to the operating board terminal on the power panel, to the overhead alternating current (red) lead, to the alternating current terminal on the signal block, through the white lamp and 90-ohm resistor in parallel to the firing switch in the "on" (closed) position, through the switching relay (contacts 1 and 4 closed) to the cable terminal on the terminal block of the control panel, to the cable terminal bar on the operating board, through the single-conductor cable to the distribution box selector, through this selector and single-conductor cable to a mine transformer primary coil, to the mine case, to ground, and to the alternating current ground terminal on the power panel.

111. Locking circuit (fig. 43).—The purpose of this circuit is to superimpose on the alternating firing current an 80-volt direct locking current to lock both selector contact arms on the mine contacts on which they are stopped. (See par. 86 *c* (3).)

112. Firing testing circuits.—*a. Alternating-current testing circuit.*—This is shown in Figure 42. It is the same as the alternat-

ing-current firing circuit up to the alternating-current switch, thence through the testing switch in the "on" (closed) position, to the ground terminal on the terminal block of the control panel, to the overhead (blue) ground wire, to the direct-current ground on the power panel, to the alternating-current ground on the power panel, to switch No. 8 closed down, and to the other alternating-current bus on the power panel.

b. Locking testing circuit.—Reference Figure 31, this circuit is as follows: +DC bus bar on power panel, through switch No. 3 closed up, reactance on power panel to 500-volt alternating current

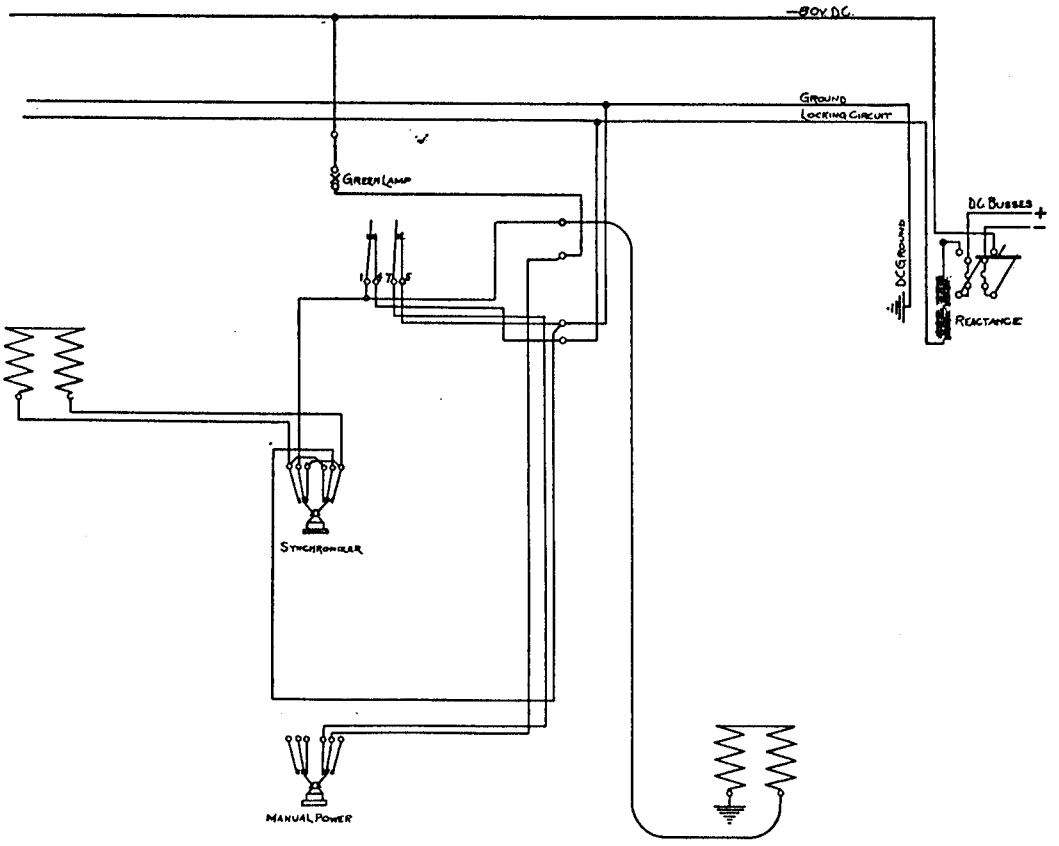

FIGURE 43.—Locking circuit

line (red), through white lamp and 90-ohm resistance on operating board signal block to testing switch, through testing switch closed to ground, through ground (blue) to contact 5 on switching relay, thence with switching relay tripped to right, to contact 7 on switching relay, to −80-volt direct current terminal block on control panel, through green lamp on signal block, through −80-volt direct current line (black), to upper right jaw of switch No. 3 on power panel, to −DC bus bar on power panel.

113. Ground-clearing circuit (fig. 44).—This circuit is completed by inserting into the ground clearing jack on the control

panel the ground clearing plug attached to the ground clearing ammeter. This short circuits the resistances of the milliammeter and of the coil of the contact firing relay in the operating circuit and increases the flow of current sufficiently to rupture the one-half ampere tubular fuze in any mine circuit when it is desired to clear that circuit. The fact that the tubular fuze has ruptured will be indicated by the needle of the short-circuiting ammeter dropping to zero. When a ground or other defect in any mine circuit increases

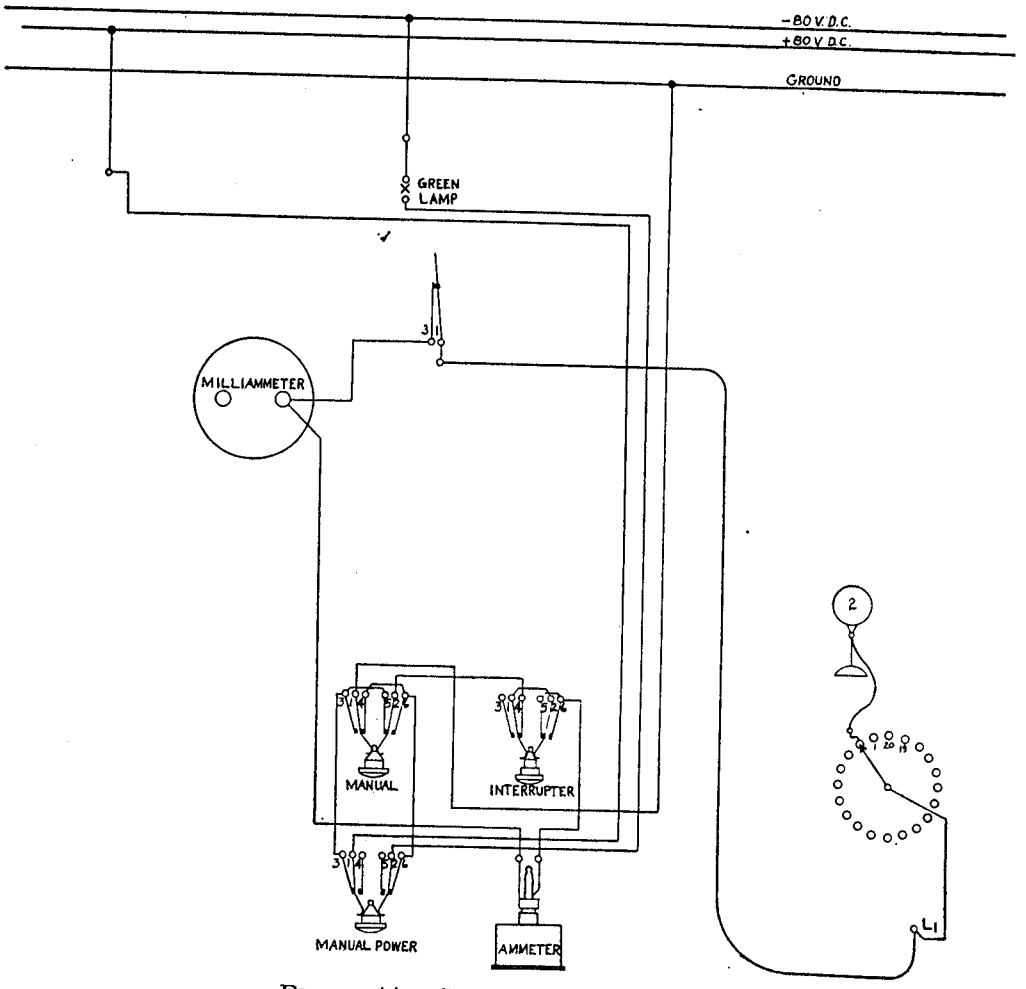

FIGURE 44.—Ground-clearing circuit

the current to such an extent that the distribution box selector will not operate, the distribution box selector contact arm will be locked on the contact of the defective mine circuit. To clear this circuit it is only necessary to plug in on the ground-clearing circuit (ground clearing jack on control panel) with the ground-clearing plug and ammeter, regardless of the contact on which the casemate selector contact arm rests. Manual power (80-volt direct current) should be used for ground-clearing purposes, but if in any case this should

prove insufficient for the purpose, substitute a 32-candlepower green lamp for the 16-candlepower lamp; then if this does not give enough current to clear the ground, the 120-volt direct current should be used, the interrupter being stopped, in order to get continuous current, by opening the interrupter motor switch on the interrupter panel.

114. Mine-compensating circuit (fig. 45).—The purpose of this circuit is to insert into the operating circuit a 2,500-ohm resist-

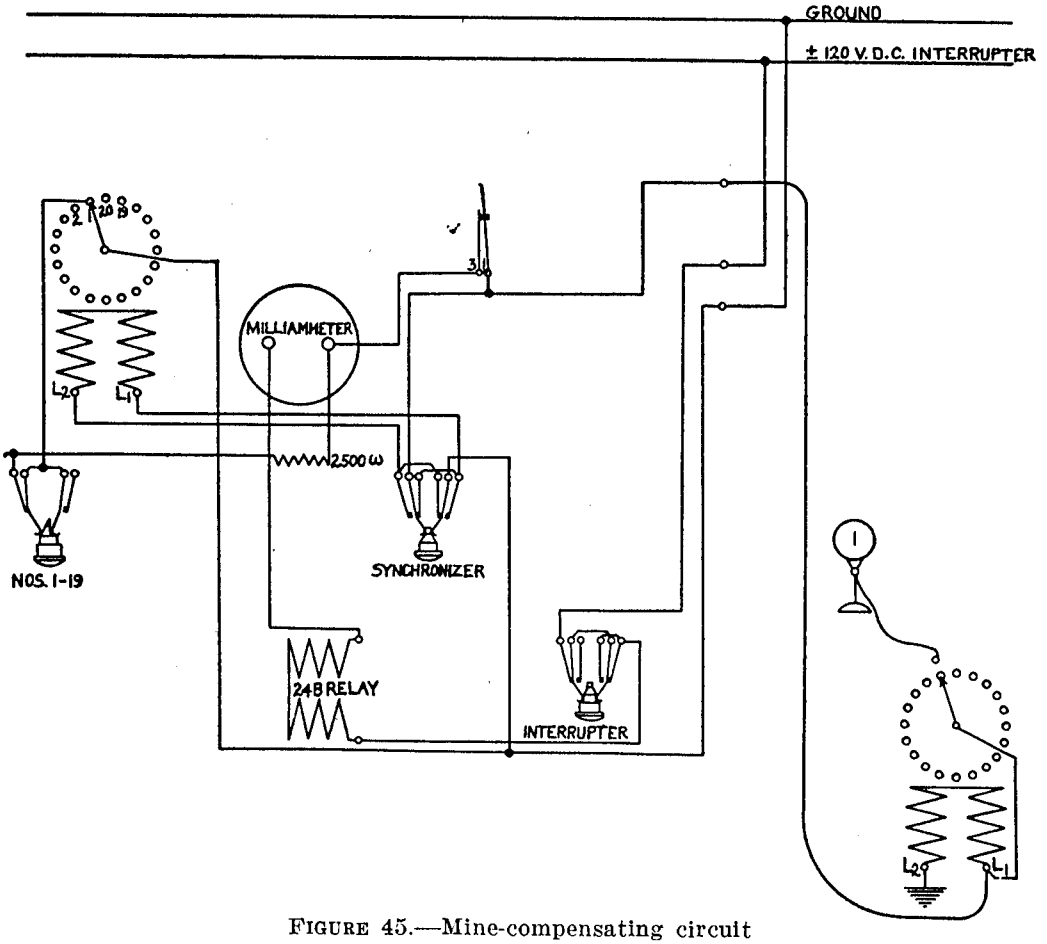

FIGURE 45.—Mine-compensating circuit

ance to take the place of the resistance of the primary winding of a mine transformer when the distribution box selector contact arm is on an open mine circuit, and thus cause the milliammeter to indicate the normal reading. This is accomplished as described in paragraph 89 *b*.

115. Interrupter-panel circuits.—There are two distinct and separate circuits on this panel, the 80-volt storage battery circuit for driving the motor of the direct current-direct current motor-generator set, and the 120-volt circuit for driving the interrupter motor

and for operating the system. In the 80-volt circuit there are a fuze cut-out, tumbler switch, motor starter, and a 3-stud terminal board. In the 120-volt circuit there are a fuze cut-out, tumbler switch, motor starter, field rheostat, voltmeter, ammeter, circuit breaker, an 8-stud terminal block, a 3-stud terminal block, and a 2-stud terminal block.

116. To start the system operating.—*a.* With all switches and circuit breakers on the power panel open, and all switches on the interrupter panel open, energize the direct-current busses by closing the double-pole circuit breaker.

b. Close switch No. 3 up, which supplies 80-volt direct current from the storage battery to the interrupter panel and to the operating boards.

c. Close the motor-generator switch on the interrupter panel, which closes the 80-volt direct-current circuit to the motor-generator motor starter.

d. Start the 80-volt direct current to 120-volt direct-current motor generator by means of the motor starter under the motor-generator switch on the interrupter panel, and regulate the voltage of the generator to 120 by means of the field rheostat on the interrupter panel.

e. Close the interrupter motor switch on the interrupter panel, which closes the 120-volt direct-current circuit to the interrupter motor starter.

f. Start the interrupter by means of the motor starter under the interrupter motor switch on the interrupter panel.

g. Close the interrupter power switch on the interrupter panel, which places the pulsating 120-volt direct current on the operating boards.

h. Start the selectors operating as described in paragraph 85 *d*.

i. When stopping the operation of the system for the day, for each control panel which is operating stop the selectors by pressing No. 20 mine key; then pull out the interrupter button and press the reset key.

j. On the interrupter panel, snap off in turn the interrupter power, interrupter motor, and motor-generator tumbler switches, and cut in all resistance on the field rheostat by turning both knobs to the right as far as they will go.

k. On the power panel, open No. 3 switch and trip the double-pole circuit breaker.

SECTION XI

TEST OF MINES AND APPARATUS

	Paragraph
Making and recording tests	117
Precautions	118
Test of the direct current voltage	119
Test of the alternating current voltage	120
Test of switching relay, red and green lamps, and bell	121
Test of delivery of firing current to operating board	122
Test of the alternating current power	123
Test of the mines	124
Test of grounds	125
Air test of cable	126
Dry test of mine circuits	127
Wet test of mine circuits	128
Maintenance test	129

117. Making and recording tests.—*a.* After the mines have been planted, the tests described in paragraphs 119 to 125, inclusive, are made daily, or more often if necessary, and the results recorded in the Record of Casemate Tests.

b. The weekly maintenance test prescribed in paragraph 129 will also be recorded in the Record of Casemate Tests.

c. The form for Record of Casemate Tests is described and illustrated in paragraph 264 *d.*

118. Precautions.—The following precautions should always be observed:

a. Never start the direct current-alternating current motor generator during the planting of mines, nor when any friendly vessel is in the vicinity of the mine field.

b. Before starting the direct current-alternating current motor generator for testing it, see that the firing circuit is open at the switching relay on each operating board by pressing the reset key while the system is operating; that all firing switches are open (in "off" position); and that the No. 8 switch on the power panel is open.

c. Make no test of mine circuits using casemate direct current power except when all boats are clear of the mine field.

119. Test of the direct-current voltage.—Plug in at the proper receptacle on the right of the power panel and read the direct current voltmeter.

120. Test of the alternating-current voltage.—*a. Precaution.—First see that the firing circuits are open at the switching relays on all operating boards by pressing the reset keys while the*

system is operating; that all firing switches are open; and that switch No. 8 on the power panel is open.

b. Close switch No. 4 up (or down, depending upon which motor generator is to be used); close the starting switch of the motor generator, and when the motor generator has attained its full speed close switch No. 9 up (or down, depending upon which motor generator is being used). Plug in at proper receptacle on the left of the power panel and read the alternating current voltmeter; bring this voltage to 500 by means of the generator field rheostat of the motor generator.

c. It may sometimes be necessary to regulate the alternating current voltage above 500 in case of an exceptionally long shore cable, or where a leak is known to exist between the shore and the distribution box.

121. Test of switching relay, red and green lamps, and bell.—See that the bell switch is closed (should be kept closed at all times). Close switch No. 3 on the power panel and start the system operating as described in paragraph 116. Press any mine key and hold it in until the proper contact is made. The switching relay should trip, the red lamp and green lamp should glow, and the bell should ring.

122. Test of delivery of firing current to operating board.—*a. Test of delivery of alternating current to operating board.—See that the firing circuits are open at the switching relays on all operating boards by pressing the reset keys while the system is operating, and that all firing switches are open.* Close switches 4 and 9 up (or down) and 8 down, and close the testing switch ("on" position) on the control panel. The white lamp should glow. This circuit is shown in Figure 42. In this test it is imperative to see that the firing circuit is open at all switching relays and that all firing switches are open ("off" position).

b. Test of delivery of locking current to operating board.—See that the firing circuits are open at the switching relays on all operating boards *except the one under test*, by pressing the reset keys while the system is operating. On the operating board under test trip the switching relay by pressing No. 20 mine key. Have all firing switches open, including that on the operating board under test. The direct current-alternating current motor-generator should not be running. Close switch No. 3 on power panel up, and close testing switch on control panel. The white lamp should glow dimly. If it is uncertain whether the white lamp glows, remove the 90-ohm resistance at one of the jaws on signal block, when the white lamp

should glow more brightly. For circuit see paragraph 112 *b*. The red lamp will also glow when the switching relay is tripped, but this fact has no bearing on the test of the locking circuit.

123. Test of the alternating-current power.—Connect two fuzes in multiple across the fuze leads from the power panel. Put the fuzes in a hole or box set in the ground, or similar place, outside the casemate, so there will be no danger from flying fragments. See that all switches on the power panel are open, that the firing circuits are open at the switching relays on all operating boards, and that all firing switches are open. Energize the direct current busses of the power panel. Close switch No. 4 up (or down), and close the starting switch; close switch No. 9 up (or down). Close switch No. 12 up, which connects the mine transformer secondary to the fuzes; and finally, close switch No. 11 up, which throws the alternating current power on the mine transformer primary; the fuzes should explode. If fuzes are not available for this test, a low-voltage lamp or a short piece of fine wire may be heated to incandescence.

124. Test of the mines.—After the group has been planted, the distribution box lowered, and the mine field cleared, test each mine separately as follows:

a. See that the selectors are synchronized, then step the contact arms of both selectors around by manual operation and note the reading of the milliammeter on the control panel as the selector contact arm rests on each mine contact (fig. 36). Each of these readings should be from 20 to 40 milliamperes depending upon the length of the cable. A leak in a mine circuit will be indicated by a much higher reading for that particular mine, and also by an increased brightness of the green lamp on the signal block as the selector contact arm rests on that particular mine contact during manual operation.

b. If the increased current caused by a leak in any mine circuit is sufficient to trip the contact firing relay, the contact arms of both selectors will be locked on the contacts of that particular mine circuit, and it will then be necessary to increase the tension on the helical spring (par. 87 *c*) in order to prevent, if possible, the tripping of the contact firing relay. However, the tension on the spring must not be so great as to prevent the relay from tripping on a maximum of 0.2 ampere, as a greater tension will not permit the mine to fire when tipped. If this relay trips after the maximum allowable tension has been placed on the helical spring (relay must

trip on a maximum of 0.2 ampere) it will be necessary to clear the ground by means of the ground clearing circuit described in paragraph 113.

125. Test of grounds.—*a.* Separate grounds will be made for the alternating current power and the direct current power on the power panel. The word "separate" as here used means actual connection to earth without metallic contact of the earth leads. A convenient method of making a ground is to connect to the armor of a cable running to salt water, a bond being made in case the armor of the cable in the casemate does not reach water before a joint is made. If a cable armor is used for one ground, the other ground lead must go to earth without contact with that armor. This may be accomplished by using the conductors of a cable the ends of which are grounded to an earth plate in salt water.

b. Neither of the grounds made should have more than 10 ohms resistance. To verify this, disconnect both grounds on the floor side and connect a megger, or other resistance measuring instrument, to the two grounds. If the combined resistance is more than 10 ohms, make a good third ground and measure the resistance of each of the first two grounds in conjunction with the third ground.

126. Air test of cable.—*a. Casemate terminal hut cable.*—This should be tested a sufficient length of time prior to planting so as to permit of repair or replacement, when necessary, without delaying other work.

b. Shore cable.—This consists in testing the insulation of the shore cable after it has been laid. When the casemate operator has notified the distribution box boat to prepare the cable end for insulation test, the end of the single-conductor shore cable is dried and held in the air, and a megger test taken in the casemate. For instructions covering the use of the megger, see paragraph 18, TR 1160–15. In case multiple cable is used, the conductors should be carefully separated, dried, and held in the air.

127. Dry test of mine circuits.—This consists in taking milliammeter readings on the mines after all of the mines of the group have been planted and permanently connected to the selector box, with the shore cable temporarily connected thereto, and with the distribution box on the distribution-box boat. When notified by the distribution-box boat that they are ready for the test, the selectors are synchronized and stepped around by manual operation and the milliammeter readings recorded for each mine circuit. *While testing mines from the casemate always be sure the mine field is clear.*

128. Wet test of mine circuits.—This consists in taking milliammeter readings on each mine circuit at least one hour after the distribution box has been lowered, by manual operation of the selectors as described in paragraph 127 for the dry test.

129. Maintenance test.—*a.* At least once a week the casemate equipment will be operated separately through each operating board and its corresponding selector box for at least one-half hour. This is known as the "maintenance test," its object being to insure that all casemate equipment and the assembled selector boxes are in serviceable condition at all times.

b. A convenient way of caring for the assembled selector boxes is to place each box with its cover secured in place, on a low bench in rear of its operating board, allowing it to remain there at all times when not being worked on or in use in the mine field. Have each box rest on a metal plate on top of the bench with the plate permanently connected to the casemate ground; this provides a convenient place for the box when conducting the weekly maintenance test.

c. (1) Build up a multiple testing cable locally by bundling together 19 insulated conductors long enough to reach from the testing bank of mine transformers to the farthest operating board.

(2) Connect the 19 conductors of one end of the built-up testing cable to the 19 mine transformers of the testing bank by permanent insulated joints.

(3) Fasten a testing clip permanently to each conductor at the other end of the testing cable, and mark the 19 clips to correspond to the numbers of the transformers to which the other ends of the conductors are fastened. This marking may be done either by stamping the clips or by attaching brass cable tags properly stamped.

(4) Run a wire from the casemate ground to the metallic ground strips upon which the testing transformers rest.

(5) Run a wire from the "C" connector of the selector box to the cable terminal on the terminal block of the control panel. A piece of loading wire with a clip at each end will serve the purpose.

d. The maintenance test will be made substantially as follows:

(1) Connect 19 testing clips of the testing cable to the correspondingly numbered selector box loading wire terminals of the selector box in rear of No. 1 operating board, and connect the "C" connector of the selector box to the cable terminal on the terminal block of the control panel.

(2) Start the system operating (par. 116), see that the selectors are synchronized, and trip the switching relay by pressing mine key

No. 1; then start the selectors operating again and trip the switching relay by pressing mine key No. 2; and continue on until every mine key from Nos. 1 to 20, inclusive, has been tested and operates satisfactorily. Similarly, test the system for contact firing operation by tipping each testing mine transformer at least once. Finally, start the selectors operating and allow them to operate continuously until the expiration of at least one-half hour from the time the tests were started.

(3) Record the results of this test, together with the tests prescribed in paragraphs 119, 120, 122, and 123, in the Record of Casemate Tests. (See pars. 117 and 264 *d*.)

(4) Upon the completion of the test of No. 1 operating board and its selector box, test No. 2 operating board and its selector box, and continue on until every operating board and every selector box has been tested and found to operate satisfactorily.

(5) If any defects are disclosed, they must be corrected at once, if possible, and the tests repeated until satisfactory operation is obtained.

e. The construction of a testing cable may be obviated by carrying each selector box to be tested to a workbench near the testing transformers and using only short leads of loading wire. As the test of each selector box is completed, return it to its position in rear of its operating board.

SECTION XII

DUTIES IN THE CASEMATE

	Paragraph
Duties in the casemate when planting mines	130
Delayed contact fire	131
Contact fire	132
Observation fire	133

130. Duties in the casemate when planting mines.—*a*. Immediately on entering the casemate for duty in connection with planting mines, and *before* the distribution box boat has taken up the cable end, the following tests should be made by the casemate electrician:

(1) Of the direct current voltage (par. 119).
(2) Of the alternating current voltage (par. 120).
(3) Of switching relay, red and green lamps, and bell (par. 121).
(4) Of delivery of alternating current to operating board (par. 122).

(5) Of the alternating current power (par. 123).

b. Connect a boat telephone to the cable at the operating board to be used and have a man stationed at this telephone ready to receive calls from the distribution box boat.

c. Upon call from the distribution box boat for the air test, a megger is connected to the single-conductor shore cable (or one good conductor of the multiple cable, if used) at the cable terminal bar on the operating board, and a test made and recorded (par. 126).

d. (1) After all of the mines of the group have been planted and connected to the selector box, *and the mine field is clear*, a dry test of the mine circuits and an operating board test of the selectors are made. Upon notification from the distribution box boat that they are ready for these tests wait 2 minutes (to give distribution box boat time to disconnect telephone and temporarily connect shore cable to selector box), then test each mine circuit by manual operation (par. 127), and finally give the selectors an operating test (machine operation), allowing them to operate until the expiration of 10 minutes from the time the distribution box boat reported they were ready for the tests. This allows a total of 8 minutes for synchronization, the dry test, and the operating test. This time may be varied to suit circumstances. At the end of the specified length of time, come back on the telephone and report the results of the test to the distribution box boat.

(2) Communication with the distribution box boat may be had by means of the distribution box boat radio set, if available.

(3) During submine target practice when less than 19 mines are planted, balance each open mine circuit by switching in the 2500-ohm balancing resistance as described in paragraph 105 *d*.

131. Delayed contact fire.—*a.* Unless the selectors are already operating, start direct current-direct current motor generator.

b. Start interrupter, and close interrupter power switch on interrupter panel.

c. On control panels for which delayed contact fire is ordered, see that interrupter key is pressed in, and then press reset key to start the selectors.

d. Check synchronism.

e. See that all firing switches are open.

f. See that alternating current plug on power panel is in center receptacle.

g. Close switch No. 4 on power panel (up or down).

h. Close the proper M. G. starting switch and accelerate the direct current–alternating current motor generator to full speed.

i. Close switch No. 9 on power panel (up or down).

j. Close switch No. 8 on power panel.

k. Stand by for a mine to signal being struck. When a bell rings, start stop watch, note on which control panel red light glows, and close the firing switch on this control panel at the proper time.

l. After the mine has fired, as soon as the ground clears, start the selectors for this group operating again, and stand by.

m. At the command ***CUT OFF A. C.,*** open in succession, switches No. 8, No. 9, No. 4 on power panel, and report to assistant plotter ***A. C. Off.***

n. At the command ***CUT OFF D. C.,*** stop all selectors on No. 20 position, open interrupter power switch on interrupter panel, stop interrupter and direct current–direct current motor-generator, open all switches on power panel, and report to the assistant plotter ***D. C. Off.***

132. Contact fire.—Proceed as for delayed contact fire, except that after closing switch No. 8 on power panel, close the firing switches on all control panels of groups of mines for which contact fire is ordered, and when a mine is struck and fires, report to the assistant plotter ***Group (such number)—Mine (such number)—Fired.***

133. Observation fire.—*a.* At the command ***COMMENCE TRACKING*** start the selectors if they are not already operating, and with the alternating current plug in the center receptacle on the power panel, at the command ***OBSERVATION FIRE:***

(1) Close switch No. 4 up (or down).

(2) Start the direct current-alternating current motor generator by means of the starting switch and accelerate it to full speed.

(3) Close switch No. 9 up (or down).

b. At the command ***GROUP 3:*** Close switch No. 8 up and take position at the appropriate operating board, ready to press a mine key.

c. At the command ***NO. 9 MINE, READY:***

(1) Press No. 9 firing key and hold it in until the selector stops on No. 9 contact.

(2) Stand ready to close the firing switch at the command ***FIRE.***

d. After the mine has fired, as soon as the ground is cleared, open the firing switch, start the selectors again and verify synchronism, unless the commands ***CUT OFF A. C.*** or ***CUT OFF D. C.*** are received, in which case proceed as under delayed contact fire.

SECTION XIII

TELEPHONES

	Paragraph
Fire-control telephone	134
Operation of fire-control telephone	135
Boat telephone, Model 1917 (figs. 47 and 48)	136
Boat telephone, Model 1909	137

134. Fire-control telephone.—*a. Description.*—This is a common-battery artillery type telephone, the energy to operate the telephone being supplied by a central storage battery located in the switchboard room. The instruments are furnished in two separate parts, the telephone proper and the talking set. Two forms of the telephone proper are used in the casemate—the wall telephone and the plotter's telephone, and two forms of talking set—the head set and the hand set.

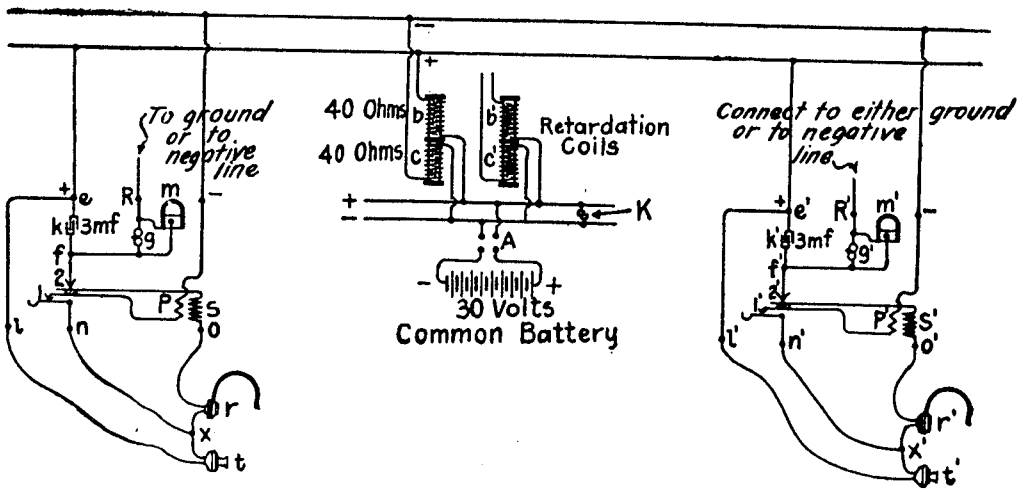

FIGURE 46.—Common battery telephone circuits

b. Circuits.—The operation of the entire system requires three circuits:

(1) The primary circuit (talking).
(2) The secondary circuit (hearing).
(3) The ringing circuit (call bell).

The details of the above circuits are indicated and may be easily traced in Figure 46.

c. Primary circuit.—This circuit passes through the transmitter, the induction coil, the retardation coil, and the hook switch.

(1) *Transmitter.*—This causes the strength of the current in the primary circuit to fluctuate whenever sound waves fall upon its diaphragm.

(2) *Induction coil.*—The function of the induction coil is to change the direct current of the talking (primary) circuit into the alternating current of the hearing (secondary) circuit.

(3) *Retardation coil.*—This prevents the talking or ringing on one line from being heard on the other lines in the fire command.

(4) *Hook switch.*—The hook switch, when down, breaks the local circuit, thus preventing the storage battery from running down; in this position it also breaks the secondary circuit and allows the bells to be rung.

d. Secondary circuit.—This circuit passes through the receiver, the induction coil, the condenser, the transmitter, and the hook switch of both the local and distant telephones.

(1) *Receiver.*—The object of the receiver is to reproduce sound waves when its coils are energized by the alternating current in the hearing circuit.

(2) *Condenser.*—The function of the condenser is to prevent the primary circuit direct current from going out on the line, but to allow the passage of the alternating ringing current.

e. Ringing circuit.—The generator, the bell, and the condenser are in this circuit. By turning the generator crank the armature is revolved and an alternating current is generated, which rings the bells. The output is approximately one-half ampere at 75 to 90 volts.

135. Operation of fire-control telephone.—*a. Tests and troubles.*—(1) Upon arriving at the station, each operator should test his instrument. If it is not in working order, he should report the fact to the chief of section. Telephones ordinarily will be repaired by an electrician sergeant.

(2) The principal troubles that occur in the service generally may be traced to the following causes:

(*a*) *No power on the line.*—This condition may be detected by there being no tap of the bell or click in the receiver, by not receiving a shock upon touching the line terminals with moistened fingers or by the easy turning of the generator when the condenser is short circuited. No power on the line may be due to an open circuit, a short circuit, or to both an open and a short circuit.

(*b*) *Broken cord and poor switch contacts.*—These conditions usually produce irregular operation, since the circuits may be complete one instant and broken the next instant by a slight jar or movement of the cord.

(*c*) *Heating of transmitters.*—This condition exists when the hook switches are left up for an hour or more at a time, which results in the heating of the carbon grains until they lose their resiliency and become packed. A transmitter never regains its original efficiency after once having become packed. For this reason, hooks should be kept down as much as possible.

(*d*) *Poor generator contacts.*—These manifest themselves by the easy turning of the generator crank and the failure of the bells to ring.

(*e*) *Pierced condensers.*—When a condenser becomes pierced, the transmission is not seriously impaired, but the generator turns very hard and irregularly, due to the direct current that passes through its armature. The storage battery discharges continuously through the bell, thus causing it to operate uncertainly.

b. Use.—(1) In selecting operators, men should be procured who speak slowly and clearly and who are not excitable. They should have a sufficient knowledge of their instruments to correct minor defects.

(2) In sending messages, the following rules should be observed:

(*a*) Speak into the transmitter, with the lips about 1 inch from the transmitter.

(*b*) Use a moderate tone of voice and speak slowly and distinctly.

(*c*) Never shout or raise the pitch of the voice.

(*d*) Send numerals singly; thus, 2370 is sent "two, three, seven, zero." Never use the letter "O" for zero. In sending an azimuth, or any number involving a decimal, the decimal point is called "point"; 327.14 is sent "three, two, seven, point, one, four." An exact hundred is sent as such; thus, 300 is sent "three hundred," 4800 is sent as "four, eight hundred." This also applies to the sending of an exact thousand, 2000 being sent as "two thousand."

(*e*) If it is necessary to repeat, use more care as to distinctness but do not raise the voice. A single number not understood may be accentuated by counting up to and emphasizing it; thus, if the figure four were not understood, say "four," with emphasis, "one, two, three, four."

c. Care.—Never leave the station with the hook up; keep the nuts on the terminal posts tight and the cords clear of tangles; report at once any troubles you are unable to correct.

136. Boat telephone, Model 1917 (figs. 47 and 48).—*a. Description.*—This is a local battery telephone, and consists of an apparatus box and a hand set. It is intended primarily for use in communicating between the distribution-box boat and the casemate over the shore cable, and can be used either as a local battery telephone or for sending telegraphic signals.

b. Battery.—A single commercial 4½-volt dry battery is furnished for this purpose.

c. Connecting telephone.—A complete boat telephone, consisting of an apparatus box and a hand set, is used at each end of the line. At the distribution-box boat the line terminal on the apparatus box, marked "L," is connected to the conductor of the shore cable, and the ground terminal, marked "G," to the cable armor or an earth plate. At the casemate the line terminal is connected to the conductor of the shore cable, and the ground terminal to earth.

d. Telegraph signals.—In case injury to the cable makes it difficult to transmit messages telephonically, the usual telegraph signals may be sent in the form of a high-pitched hum somewhat similar to radio telegraphic signals. The telegraphic signals can also be used to advantage to attract the attention of the called station. These signals may be sent by releasing the talking key in the hand set handle and operating the telegraph key. This operation automatically disconnects the "talking" windings in the buzzer coil and connects the signaling windings.

e. Installation of battery (see wiring diagram and schematic circuits in cover of the apparatus box).—Remove the phenol fiber plate attached to the lower half of the case by removing the four holding screws. A number of wires is attached to the underside of this plate, some of which are also attached to the terminal posts and jack in the lower half of the metal case. In removing and replacing

the plate, care should be taken that none of these wires is injured. Upon removing the fiber plate there will be found six wires with free terminals, these six wires being braided in color as follows:

2 red and white.
2 red.
1 orange.
1 blue.

The two red and white wires and the two red wires are merely the opposite ends of two jumpers which were originally used to connect three dry cells in series. There is no further use for these two jumpers

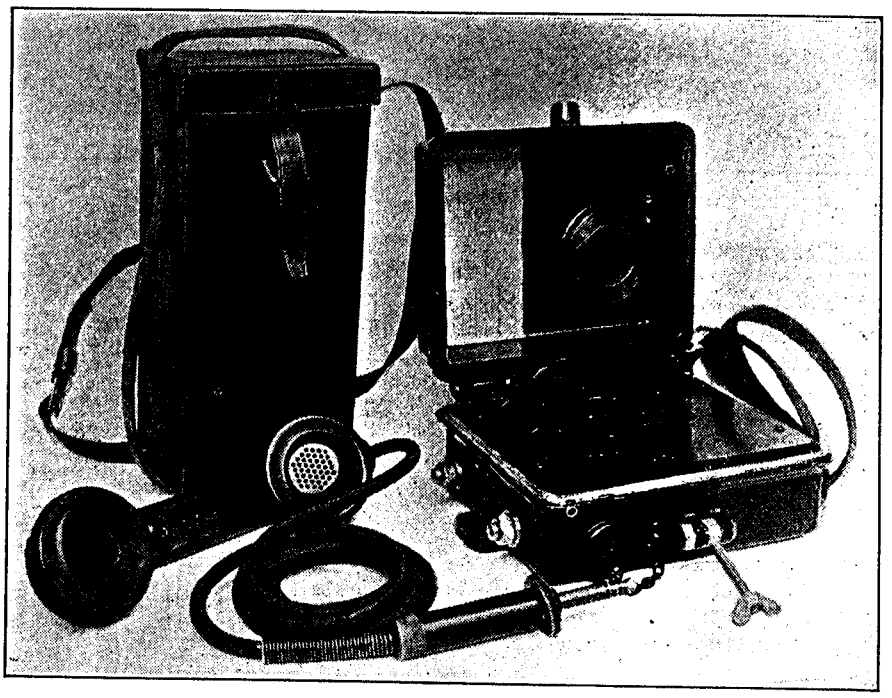

FIGURE 47.—Boat telephone, Model 1917, assembly

and they should be disregarded if they have not been removed There then remains the orange wire which should be connected to the positive terminal of the 4½-volt battery; and the blue wire which should be connected to the negative terminal of the battery. The battery then should be placed in the compartment in the lower half of the metal case. Replace the phenol fiber plate, exercising care in replacing the wires so as not to injure them.

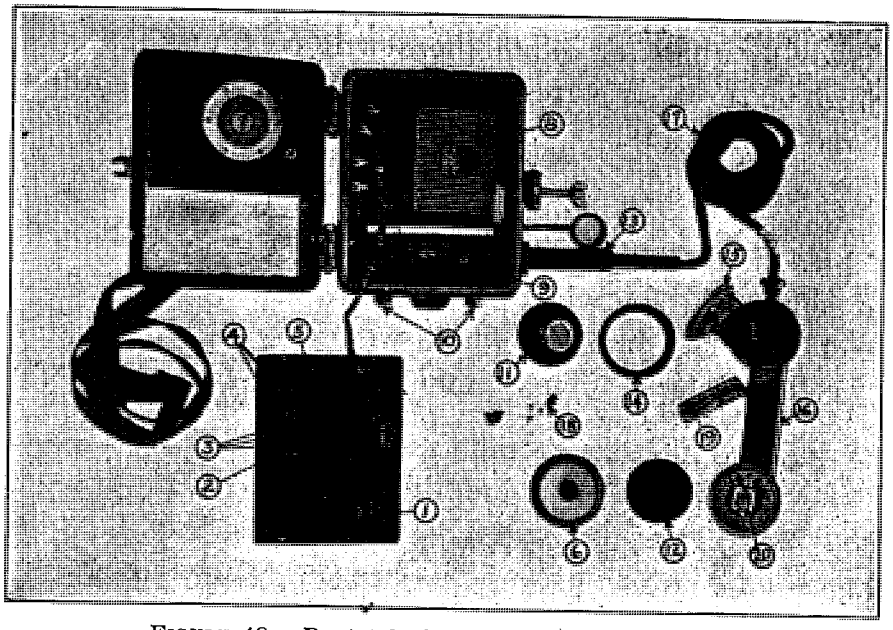

FIGURE 48.—Boat telephone, Model 1917, details

1. Telegraph key.
2. Tools—2 screw drivers and holder.
3. Condensers, 0.25 M. F. each.
4. Induction coil and buzzer assembly.
5. 12,000-ohm resistance.
6. Receiver cap.
7. Leather diaphragm for telegraph key.
8. Battery, 4½ volts.
9. Jack for hand-set plug.
10. Line and ground terminal posts.
11. Transmitter cap.
12. Receiver diaphragm.
13. Hand-set plug.
14. Transmitter cap ring.
15. Transmitter assembly.
16. Hand-set case.
17. Hand-set cord.
18. Screws for talking-key cover.
19. Talking key.
20. Receiver magnets.

f. Operation.—(1) Connect the terminals of the metal case to the line and ground; insert the plug into the jack, screwing home the ring cover on the plug. Call the distant station by means of the telegraph key; the calling signal at the distant station is a penetrating, high-pitched hum. The talking-key button on the handle of the hand set must be pressed down while talking into the transmitter, but the button should not be pressed down while signaling with the telegraph key.

(2) Satisfactory telephonic communication may be expected even with the conductor grounded, with the conductor connected to a mine, over a broken conductor, and frequently when the telephone at one end is connected to one conductor of the multiple cable and the distant telephone connected to another conductor.

(3) In operating this telephone care should be exercised not to make excessive use of the telegraphic key for calling, and communication by telegraphic code should not be used except in emergency and for instruction. Such sparing use of the telegraphic key is advised because considerably more energy is drawn from the

battery when using the signal circuit than when using the talking circuit, so that unnecessary use of the signal circuit results in premature exhaustion of the battery.

g. Repair and adjustment of boat telephones.—Should any repair or adjustment become necessary, it should be made only by an officer or electrician sergeant having had experience with apparatus of this kind.

137. Boat telephone, Model 1909.—A number of boat telephones of this model are still in service, the system consisting of two hand sets, one apparatus box, and a battery. The use of this model is similar to that described above for the 1917 Model.

SECTION XIV

OTHER CASEMATE EQUIPMENT AND STORES

Accessories ..... Paragraph 138

138. Accessories.—*a. Portable ammeter, Weston, Model 45, 0–25 amperes.*—A commercial instrument for general use in mine work.

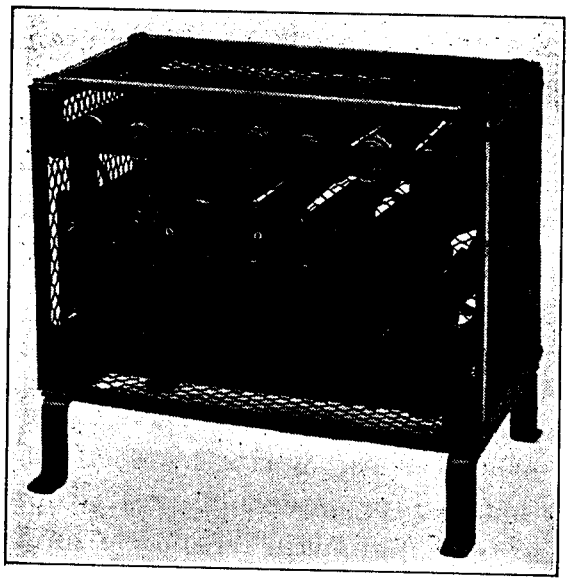

FIGURE 49.—Forty-ampere load rheostat

While it is the standard model, a number of Model 1, 0–25 ampere ammeters are in use in the service.

b. Portable voltmeter, Weston, Model 280, 0–3–15–150 volts.—A commercial instrument for general use in mine work, such as testing mine transformers, assembled mines, voltage of batteries, etc. While this is the standard model for issue, a number of Model 45, 0–3 volts, and a number of Model 1, 0–150 volts, are in use in the service.

c. 40-ampere load rheostat (fig. 49).—Furnished for use in regulating the maximum current in making tests of the storage battery, casement generator, and motor generators, and for use when burning out cable in connection with cable repairs.

d. Attachment plug.—An ordinary 2-piece plug for use in connecting an extension cord to a lamp socket.

e. Casemate wire, black, No. 4.—For use between the casemate generator and the power panel, and between the power panel and the storage battery.

f. Casemate wire, No. 14.—Furnished in black, blue, red, and yellow, for overhead wiring between the power panel, interrupter panel, and operating boards.

g. Clock oil.—A high-grade oil for use on the moving parts of selectors and relays.

h. Cylinder oil.—A high-grade, light oil for use with the 5-kilowatt and 10-kilowatt sets and the Hornsby-Akroyd engine.

i. Double connector.—A small brass tube with a set screw at each end, used for connecting wires temporarily.

j. Dry cells.—A commercial No. 6 dry cell for general use, such as in testing mine transformers, fuzes, instruments, etc.

k. Dynamo oil.—A high-grade light oil for use in the oil holes on the motors and generators.

l. Electric lamps.—These are furnished in four types: An 8-candlepower, 80-volt, red carbon lamp; a 16-candlepower, 45-volt, green carbon lamp; a 32-candlepower, 45-volt, green carbon lamp; and a 25-watt, 110-volt, Mazda lamp. All of these lamps are for use on the signal block, and in addition the Mazda lamp is used on the power panel.

m. Fuze wire, 3, 12, and 25 ampere.—For use in cut-outs and fuze boxes to protect any circuit against excessive current.

n. Lamp cord.—For overhead wiring between the interrupter panel and the operating boards, for extension cord, drop cord, etc.

o. Lamp receptacle.—A porcelain receptacle for fastening direct to a wall or ceiling.

p. Lamp sockets.—Both metal sockets and porcelain sockets are furnished for use with extension and drop cords.

q. Porcelain cleats.—Both 1-wire and 2-wire cleats are supplied for use in the casemate, such as for the overhead wiring between the power panel, the interrupter panel, and the operating boards.

r. Porcelain cut-out.—A double cut-out for inserting in both sides of a line to protect the line against excessive current. Two types have been supplied—a fuze wire cut-out and a fuze plug cut-out.

s. Porcelain knob.—A 2-piece insulating knob for use in stringing double wires along walls, ceilings, etc.

t. Porcelain tube.—This is for insulating wires where they pass through walls or partitions.

u. Rosette.—An ordinary porcelain rosette for drop lights.

v. Shellac.—An orange flake shellac for insulating and protecting small wires, such as the wiring on the back of the control panel. It is prepared for use by dissolving the flakes in alcohol.

w. Snap switch.—A 10-ampere, 125-volt, single-pole, porcelain switch about 2½ inches in diameter, consisting of a base, top, and handle, for general use.

PART FOUR

SUBMARINE MINE MATÉRIEL

(Except casemate, electrical, and fire control)

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SECTION XV

CABLES AND ACCESSORIES

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Cable accessories	156

139. General.—All cable will be kept in the cable tanks and will be directly in charge of the chief loader, under the technical super-

vision of the electrical specialist, noncommissioned staff (see par. 40 *c*). For instructions covering the storage and care of cable, see paragraphs 14 and 15, TR 1160–15.

140. 1-conductor cable.—This is made up of a 7-strand, soft-drawn, annealed copper conductor covered by a five sixty-fourths-inch wall of insulation of 30 per cent rubber compound, which then in turn is served with tape, two layers of soft rove jute bedding, a layer of 134-mil galvanized steel armor wire, and a layer of jute saturated with weatherproof compound. The completed cable is approximately seven-eighths inch in diameter.

141. Reel for 1-conductor cable.—Made of spruce and yellow pine creosoted under heat and pressure, with steel side plates and connecting bolts. The sides are 6 feet in diameter, and the drum, upon which the cable is wound, is 3 feet 9¾ inches long. The reel is built to hold approximately 2 miles of cable weighing about 5 tons. While this is the standard single-conductor cable reel, there are many smaller reels still in the service.

142. Seven-conductor cable.—An armored cable containing seven insulated conductors; it is no longer manufactured for submarine mine use; that which is on hand is to be used as single-conductor shore cable.

143. Nineteen-conductor cable.—An armored cable about 1½ inches in diameter containing 19 insulated conductors, arranged in two concentric layers around a single central conductor. One conductor in each layer is distinguished from the others by some characteristic mark, the marked conductor in the outer layer being No. 1, that in the inner layer No. 13, and the central conductor No. 19. The other conductors are numbered at the shore end of the cable in a clockwise direction, and at the distant end in a counterclockwise direction; 19-conductor cable is no longer manufactured for submarine mine use; that which is on hand is to be used as a single-conductor shore cable.

144. Cable-reel jack.—This consists of a jack proper mounted on a wooden brace and supported by steel braces. The jack proper consists of a forged steel screw, a bell-shaped cast-iron base, and a cast-iron swiveled trunnion. Each jack is furnished with a steel lever 1 inch in diameter and 2 feet long. The two jacks, when in use on shore, are held in the proper relative positions by means of two iron ties provided with turnbuckles at their centers. The ends of these ties are bent over at right angles and fit in the securing bolt holes in the wooden ends, the holes being reinforced with ¼-inch steel plates. When in use on the planter the jacks are

bolted to the deck by means of securing bolts. These jacks replace the old wooden cable-reel frame, a number of which are still in service.

145. Cable-reel frame.—Each end of this frame is the old form of cable-reel jack. The two ends, when in use, are held in the proper relative positions by means of two iron tie rods in the same manner as the cable-reel jacks. Each end consists of a wooden standard with an iron head through which works a screw turned by a small lever, the upper end of the screw carrying a journal in which the end of the reel axle rests. The base and three diagonal braces are of wood; the braces are dovetailed into the base and standard, and the whole is held firmly together by bolts and lag screws. Lag screws are also provided by means of which the ends of the frame may be fastened to the deck of the mine planter.

146. Cable-reel axle.—For use with the cable-reel jacks, and is capable of handling reels weighing up to 10 tons. It is made of high-grade wrought iron, is 78 inches long, and 2½ inches square in section except for a distance of 6 inches from each end, the ends for this distance being turned round to a diameter of 2½ inches. Each axle is equipped with two forged steel collars with two set screws. While the standard axle is 78 inches long, a number of 72-inch axles are in use.

147. Cable-tank thermometer.—This consists of a magnifying spirit tube supported in a galvanized-iron case approximately 14 by 1¼ inches. The case is provided with a suspension ring at the top and with rubber buffers on the bottom and around the periphery near the top and near the bottom. This thermometer is accurate at any part of the scale within 2° F.

148. Cable tags.—*a. Brass.*—Used for marking the conductors of submarine mine cable when they are not to be immersed in water. They are made of soft sheet brass, are 1¼ inches in diameter and 1/16 inch thick, with a 3/16-inch hole near the perimeter.

b. Lead.—Used for marking the conductors of submarine mine cable when they are to be immersed in water. They are the same size as the brass tags.

149. Junction boxes (figs. 50 and 51).—These boxes are used in splicing cables, the small size for 1-conductor cable and the large size for 7-conductor and 19-conductor cables. They consist of two rectangular cast-iron plates united by four bolts at the corners, and hollowed in the center to form a chamber to receive the turks-heads and the joints connecting the conductors. The ends of the plates are curved to admit the cable ends. The Turk's-heads are

clamped to the lower plate by straps and tap bolts, the cavity of the upper plate covering them when bolted in position. Each cable end is thus made fast before the box is closed. Junction boxes should be painted with asphaltum varnish.

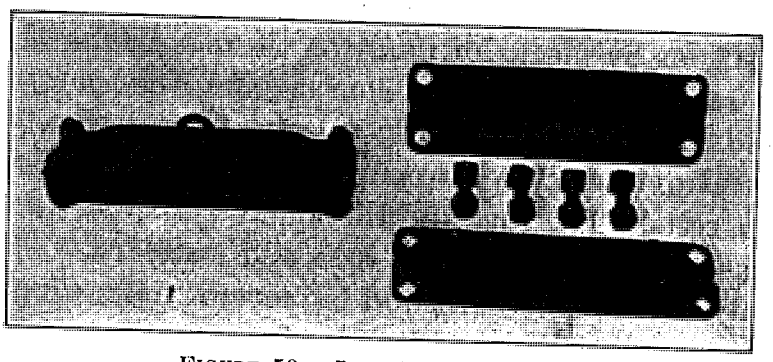

FIGURE 50.—Junction box, small

150. Distribution box, 19-conductor (fig. 52).—A circular, cast steel, disk-shaped box which houses the selector box, receives the end of the shore cable, and from which the mine cables radiate. It is about 27 inches in diameter and 13 inches high, and weighs approximately 300 pounds. It consists of two parts, a bowl-shaped bottom 6 inches deep inside and a slightly curved lid which has an iron ring in its center by which the box is raised and lowered. Eight steel bolts, fastened to the bottom, fit in corresponding holes in the

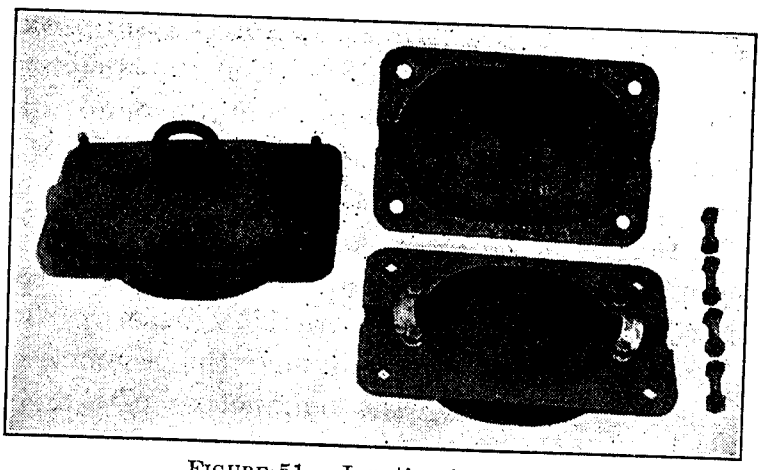

FIGURE 51.—Junction box, large

edges of the lid and are slotted for keys by which the two parts are fastened together, as explained in paragraph 151. The vertical edge of the bottom is cut with 20 slots, each about 2½ inches deep. One of these slots is larger than the others and receives the shore cable, while the 19 smaller slots are for the mine cables. When in use these slots are numbered from 10 to 19 clockwise and from 9 to 1 counterclockwise from the shore cable slot looking down into the

box. This results in the slots being opposite the correspondingly numbered water-tight connectors of the selector box. The lid has corresponding projections or lugs which enter these slots, and which, in position, fit snugly against the cable ends. The cables are held from being pulled out by Turk's-heads worked upon them. To prevent the cable ends from slipping out of the slots while joints are being made between them and the selector box before the lid is put on, the shore cable is secured by a bolted collar on the inside of the distribution box and the mine cables by placing their Turk's-heads under the clawlike radial projections cast upon the inside rim between the slots. Distribution boxes should be painted with asphaltum varnish.

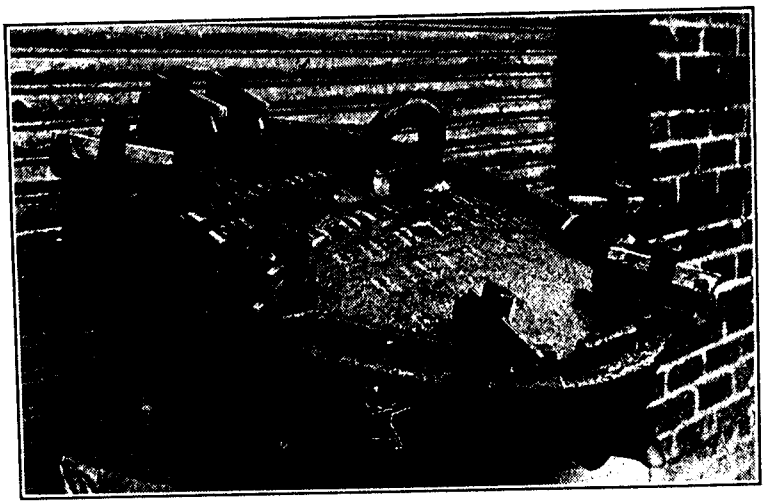

FIGURE 52.—Distribution box, 19-conductor

151. Flat and split keys for distribution box.—These are steel keys used for securing the distribution-box lid to the distribution box. Two keys are used in each stud-bolt slot, one a flat key 5¼ inches long and 7/32 inch thick with a lug at each end, and the other a wedge-shaped split key 5 inches long made of one piece of 3/32-inch steel bent double. The flat key is first inserted into the slot in the stud bolt with the wider end toward the center of the box and the lugs down so they engage over the shoulder on the lid through which the stud bolt projects. The small end of the split key is then inserted, from the outside, into the slot above the flat key and securely driven home with a hammer. Figure 52 illustrates the correct way to apply these keys.

152. Wrench for distribution and junction boxes.—A double-head, open-end wrench, 5/8-inch and 3/4-inch openings, for use on the bolts and nuts of distribution and junction boxes.

153. Cable cutter.—A device designed to cut heavily armored submarine cable up to 1½ inches in diameter. It is a modification of the regular commercial bar-iron shear.

154. Cable-reel sling.—For use in handling reels of submarine mine cable weighing approximately 8 tons. It consists of two 8-inch 16½-pound channels, each fitted with three ⅜-inch steel filler plates securely riveted to the channels. The channels are held together by four ½-inch cover plates on top and two on the bottom riveted to the flanges of the channels. A 1¾-inch round bolt with hexagonal head and nut for attaching a supporting chain passes through the center of the built-up beam. Two forged-steel side hooks, each supported by a 1¼-inch bolt which passes through a $1\frac{5}{16}$-inch hole at either end of the beam, complete the sling. A lateral adjustment of these hooks is provided by three $1\frac{5}{16}$-inch holes at each end of the beam, and a vertical adjustment by two $1\frac{5}{16}$-inch holes, on 3-inch centers, in the top of each hook. (Hooks of future manufacture will have slightly longer hooks with a single hole in the top of each hook, thus doing away with any vertical adjustment.) The lower end of each side hook is bent at right angles to the shank and shaped so as to engage in the square hole through the axis of the reel.

155. Turk's-head collars.—These are for use in making Turk's-heads on the ends of submarine mine cable; they are made of cast iron, with all edges rounded, in two sizes. The smaller size is used with single-conductor cable, has an inside diameter of 1 inch, an outside diameter of 2 inches, and is $\frac{13}{16}$ inch thick. The larger size is used with multiple-conductor cable, has an inside diameter of $1\frac{9}{16}$ inches, an outside diameter of $2\frac{11}{16}$ inches, and is 1⅛ inches thick.

156. Cable accessories.—*a. Large staple.*—For securing the inside end of cable to the outside of the reel, and the outside end to the inside of the reel.

b. Small staple.—For fastening individual conductors to the cross timbers in the cable tank and for general use.

c. Galvanized-iron wire, No. 14 B. W. G.—For use in serving Turk's-heads when they are to remain under water for any length of time and for use in the repair of cable.

SECTION XVI

ANCHORS, MOORING ROPES, BUOYS, AND ACCESSORIES

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157. 500-pound buoy anchor.—This is 22 inches in diameter and 6½ inches high. It is made of cast iron except the mooring-rope bail, which is wrought iron or steel. In shape it is a right cylinder with a 7-inch recess in the top for the bail; in the side there is a maneuvering hole; the bottom is slightly dished to give better holding power in mud. These anchors should be painted with asphaltum varnish.

158. Cast-iron anchors.—These come in three sizes—a 1,000-pound anchor 26½ inches in diameter and 8½ inches high, exclusive of toes; a 2,000-pound anchor about 33¼ inches in diameter and 10½ inches high, and a 3,000-pound anchor 38 inches in diameter and 12 inches high. The mooring-rope bail in the center and the raising-rope bail near the edge are of wrought iron or steel. The bottoms are slightly dished to increase the holding power in mud. For a rock bottom, six projecting toes increase the holding power and corresponding depressions at the top permit of piling when in storage. Each anchor has four through holes from top to bottom so that two or more anchors may be nested and bolted together to form anchors of greater weight. Cast-iron anchors should be painted with asphaltum varnish.

159. Automatic anchor, Model 1916.—*a. Description.*—Figure 53 shows two views of the base and Figure 54 the anchor complete. It is a device by means of which submarine mines may be anchored in various depths of water with any desired depth of sub-

mergence. Two models have been supplied the service, M–1 and M–2. The M–1 anchor weighs approximately 2,300 pounds without the mooring rope or distance weight, while the M–2 weighs approximately 3,000 pounds. These two models are identical except that the base of the M–2 model is heavier.

(1) *The base* consists of an iron casting approximately 3 feet 2 inches in diameter and 1 foot 10 inches high, cored out for the reel and provided with a vertical recess for the pawl, with a band brake which is adjusted by means of a brake adjusting bolt with nut and lock nut, and with a pawl stop and pawl lock. A handhole is provided for use in washing out the anchor with a hose after raising and before taking it inboard, and to permit the water to drain from the anchor before it is brought inboard. The handhole cover is arranged to rotate around one end when the two handhole bolts are loosened. A bail for attaching the raising rope and a hook for use in securing the distance weight are provided at suitable positions on the base.

(2) *The cover* consists of a cylinder of ⅛-inch sheet steel, a top of ¼-inch steel plating, a circular angle bottom which bolts to the anchor base, and an inside cone of ⅛-inch steel, four struts, and an iron roller box containing four brass rollers. The cover is approximately 2 feet 8 inches in diameter and 3 feet high. Some covers have not been provided with this cone, and it is not shown in Figure 54. The rollers in the roller box, which is mounted in the top of the cover are used to reduce the friction of the mooring rope in paying out. The roller box casting is provided with a bail for use in handling the anchor.

(3) *The reel* around which the mooring rope is wound consists of a spool and brake drum of cast iron or cast steel, a phosphor-bronze gear, and a special steel ratchet, all assembled on a steel shaft. The spool and brake drum are cast integral around the square shaft, the ends of the shaft and the bearing surface of the brake drum being turned on the same centers to insure that they are accurately concentric. The ratchet and bronze gear are accurately and tightly fitted to the shaft in the order named, the gear being held in place against the ratchet by a pin driven through the shaft and bearing against a machined groove on the face of the gear. The dimensions of the anchor reel are such as to provide for a capacity of approximately 400 feet of ½ by ¾ inch marline-covered rope, 300 feet of ½ by ⅞ inch rope, 240 feet of ⅝ by 1 inch rope, or 180 feet of ¾ by 1⅛ inch rope.

(4) *The pawl* is made of cast or forged steel. Its function is to engage or disengage the ratchet-wheel teeth so as to permit the reel to rotate or to prevent rotation, as desired. A steel rod is screwed through the pawl, the upper end of the rod being secured to the pawl so as to prevent the rod from unscrewing or becoming loose. To the lower end of this rod is attached a shackle for use in securing the distance line. The inside of the pawl is drilled to provide for mounting a compression spring around the rod; this spring urges the pawl upward to engagement with the teeth of the ratchet. A brass follower is screwed into the bottom of the base casting for securing the spring and as a means of adjusting its compression.

(5) *The pawl stop* (fig. 54).

(*a*) This is a phosphor-bronze rod which normally projects over the top of the pawl and prevents it from engaging the ratchet.

(*b*) Experiments have shown that during the first few feet of descent of the anchor the pawl may, if allowed, oscillate considerably, the tension on the distance line tending, at times, to approach zero, and the pawl consequently tending to become engaged in the teeth of the ratchet and thus increase the possibility of an excessive submergence of the mine. The pawl stop mechanism is designed to prevent the pawl from becoming engaged in the ratchet during this period.

(*c*) The pawl stop mechanism consists essentially of a bronze rod squared at the outer end and rounded and threaded at the inner end. The threaded portion is threaded through a steel plate which is screwed onto the face of a bronze gear which is mounted inside the base on a bronze bushing passing through the side of the anchor base. The inner or rounded portion of this rod extends, when the anchor is ready for planting, over the top of the pawl, thus holding the pawl disengaged from the ratchet, while the outer or squared portion of the rod passes through a squared hole in a removable pawl stop cap which is normally bolted to the anchor base. As the reel rotates, a bronze gear mounted on the reel shaft and engaging in the bronze gear mounted on the bronze bushing rotates the latter, imparting to the pawl stop rod a motion of translation which withdraws the rod from over the pawl and permits the pawl to move upward and engage in the ratchet if the tension on the

distance line is sufficiently reduced. The construction of the pawl stop is such that it can be adjusted so as to prevent the pawl from rising until after any desired number of revolutions of the reel less than about *five*.

(*d*) *Precaution.*—Before winding the mooring rope on the reel at any time, the pawl stop rod should be removed temporarily, as otherwise this rod will be screwed in too far and the threads on the inner end will become burred. This rod is removed by removing the two five-eighths-inch bolts which secure to the anchor base the cap through which the squared end of the pawl stop rod slides. This cap is then used to unscrew and remove the pawl stop rod.

(6) *The pawl lock* (fig. 53) consists essentially of a steel rod which, due to the action of a compression spring, projects under the bottom of the pawl, after the pawl has been moved up into engagement with the ratchet by the action of the pawl spring, in such a manner as to insure that after the pawl has once engaged in the teeth of the ratchet it will be impracticable for the pawl subsequently to be withdrawn from the ratchet by a tension on the distance line.

(7) *The friction brake* (fig. 53) is a steel band brake for use in controlling the speed of rotation of the reel; it is provided with a standard type of brake lining. The surface of the brake drum should be cleaned of rust and should be free from oil when the anchor is tested or used.

b. Adjustments.—(1) *The pawl spring adjustment.*

(*a*) The pawl spring should be adjusted by means of the brass follower provided for that purpose, so that with the pawl in its uppermost position fully engaged in a tooth of the ratchet, the pawl spring will be under an initial compression of 30 to 35 pounds as determined by a spring balance engaged in the shackle at the bottom of the pawl rod. This adjustment value should invariably be used with the M–1 anchor except where the auxiliary weight is used on the bottom of the anchor, in which case the initial adjustment should be from 10 to 15 pounds. For the M–2 anchor, the initial adjustment should be from 10 to 15 pounds.

(*b*) If the initial adjustment can not be reduced to the values prescribed by means of the brass follower, sufficient turns of the pawl spring should be cut off, by means of a cold chisel or otherwise, so that the proper value of this adjustment may be secured.

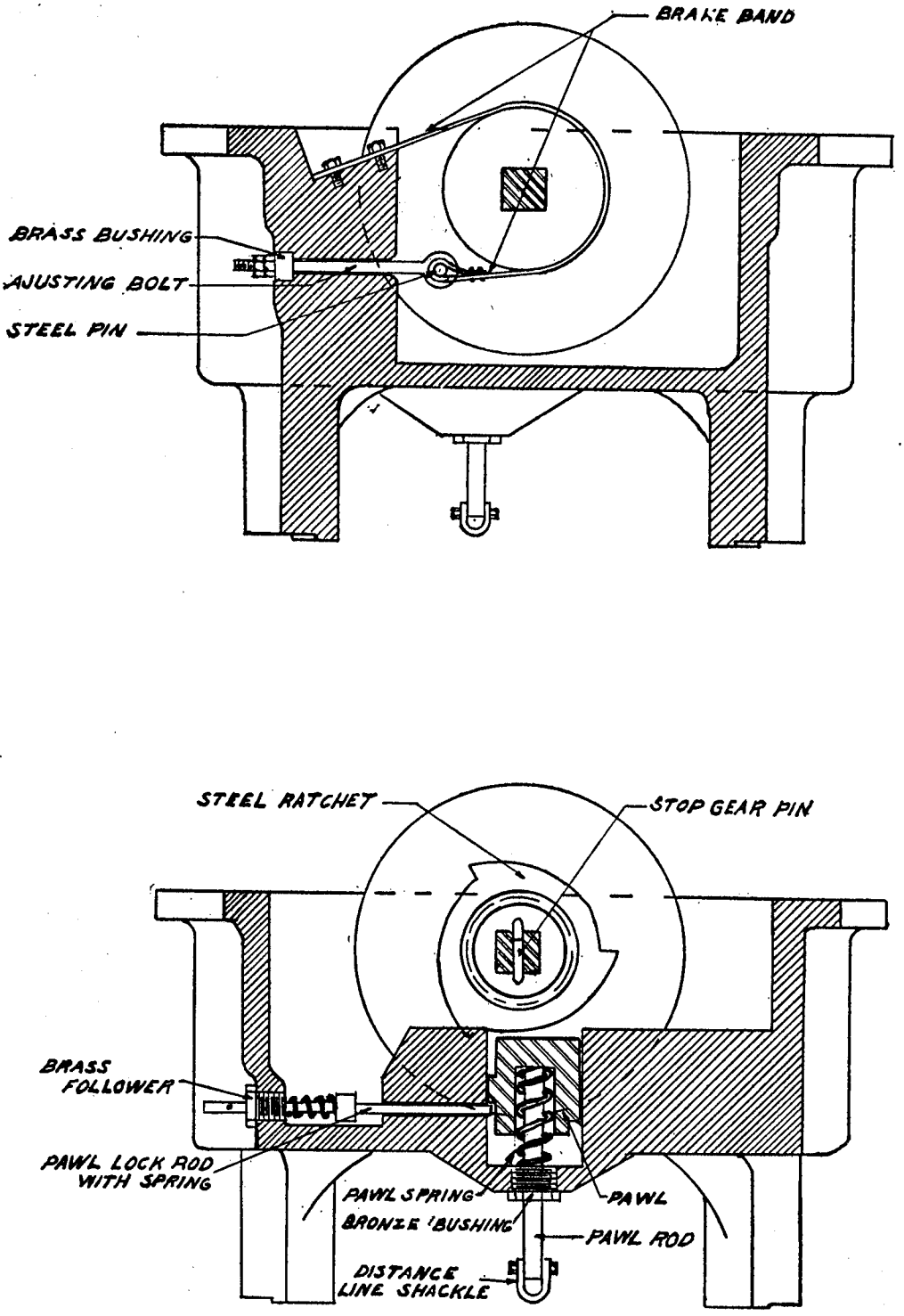

FIGURE 53.—Automatic anchor, Model 1916, base

(*c*) It is essential that the pawl itself should slide freely, without binding, throughout its travel in the pawl recess, and this should be checked frequently by pulling the pawl entirely down several times in the pawl recess and then releasing it.

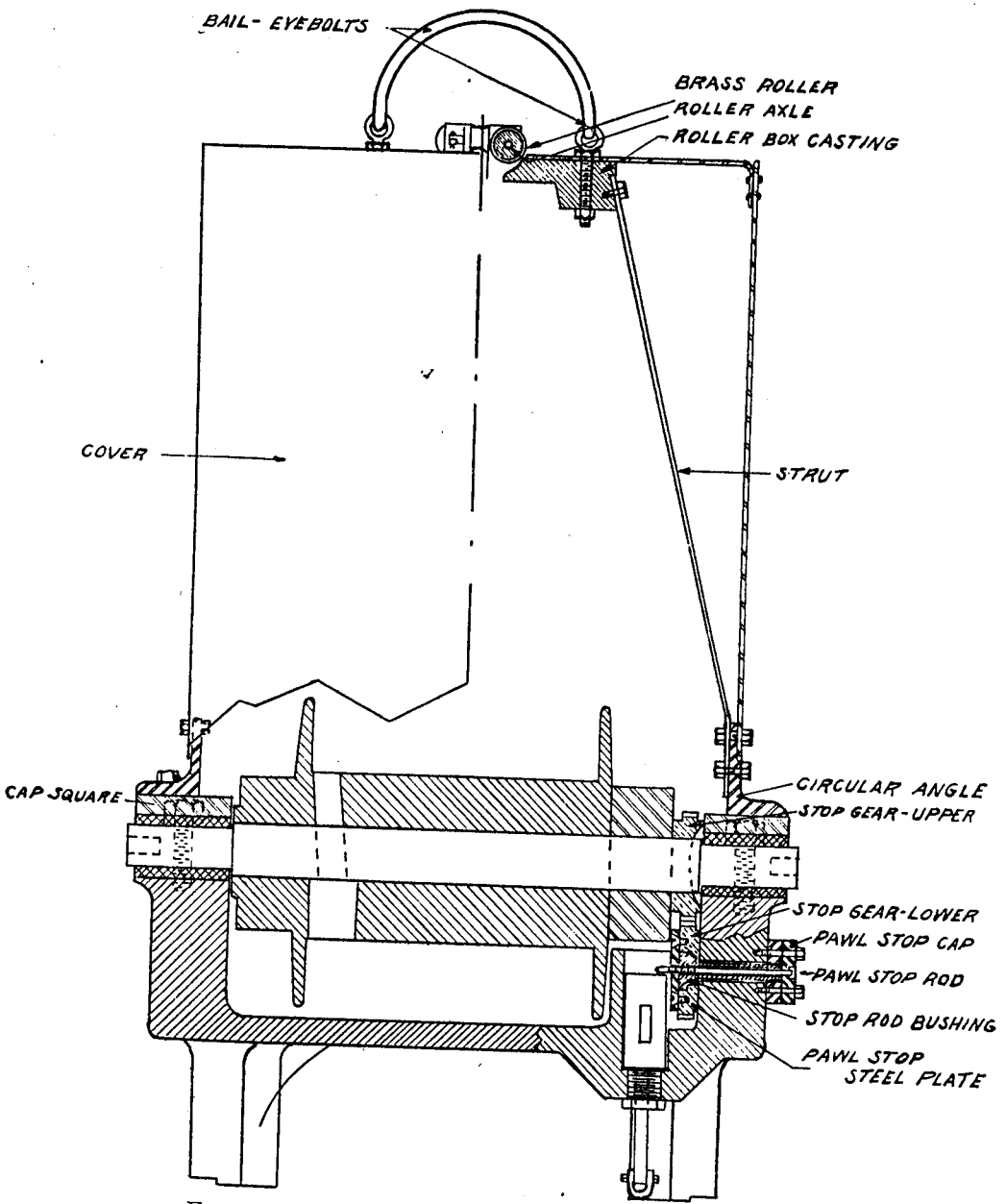

FIGURE 54.—Automatic anchor, Model 1916, complete

(2) *The pawl stop adjustment.*—When the anchor is adjusted for planting, the pawl stop rod should be adjusted as follows:

(*a*) Where the depth at mean low water is 55 feet or greater: With the pawl down, screw the pawl stop rod in, by means of the pawl stop cap, until the outer end of the pawl stop rod is flush with the bottom of the counter-

sunk recess in the pawl stop cap. Secure the cap in place by means of its securing bolts.

(*b*) Where the depth at mean low water is from 35 to 55 feet: With the pawl up, screw the pawl stop rod in by means of the pawl stop cap until it brings up against the side of the pawl, then pull the pawl down and screw the pawl stop rod in one turn more. The rod should now project over the pawl sufficiently to hold the pawl away from the ratchet against the action of the pawl spring. Secure the cap in place by means of its securing bolts. Where the anchor is to be planted at a depth between these limits of 35 and 50 feet mean low water, it is essential that there should be no more rope off the reel before planting than is necessary to reach from the anchor to the mine when suspended from their respective davits.

(*c*) It is not contemplated that the 1916 automatic anchor will ordinarily be used where the depth at mean low water is less than 35 feet.

(3) *The pawl lock spring adjustment.*

(*a*) This spring should be adjusted, by means of the brass follower provided for that purpose, so that it has an initial compression of about 10 to 15 pounds.

(*b*) The holes are provided in the outer end of the pawl lock rod for the insertion of wire nails or similar articles for use in withdrawing the pawl lock rod from any contact with the pawl when desired and holding it in the withdrawn position. Care should be exercised not to attempt to pull the pawl down unless the pawl lock rod is in the withdrawn position, and also not to have the pawl lock rod secured in this position by a nail or otherwise when the anchor is planted.

(4) *The friction brake adjustment.*—The friction adjustments for this anchor for the different size mine cases are as follows:

Mine case	Weight of charge	Approximate friction adjustment
	Pounds	*Pounds*
No. 32	100	100
No. 40	200	250
Nos. 42 and 43	200	350
Larger than No. 43	200	500

c. Auxiliary weight.—The design of the M–1 anchor is such that, where required, additional weight can be secured by bolting to the bottom of the anchor a cast-iron auxiliary weight, with the result that, by means of suitable auxiliary weights, this anchor may be used in any locality in which the depth of the water does not exceed the capacity of the reel. Auxiliary weights are furnished only where required.

d. Distance weight.—(1) This is made of commercial lead and weighs approximately 200 pounds. It is a prolate spheroid in shape, the axes being 15 inches and 7⅞ inches. For attaching the distance line, a ¾-inch steel eyebolt with a shank 5 inches long is cast in the top of the weight, 1 inch of the end of the bolt being bent at right angles to its axis to prevent turning or withdrawal. A hole 1⅜ inches in diameter is cored through the weight at right angles to the longer axis, near the top, to receive a rope strap for use in hanging the weight on the anchor when hoisting the anchor aboard the planter, and to hook the raising fall in when taking up the distance weight.

(2) While the distance weight described above is the standard, there are in the service many old-style distance weights with a 1⅜-inch hole cored through the longer axis, instead of the steel eyebolt, to receive the distance line.

(3) The distance weight is attached to the end of the distance line, its function being to hold the pawl of the automatic anchor out of engagement with the ratchet, against the pawl spring, so that as the anchor descends the mooring rope will unreel, permitting the mine to float on the surface of the water until the distance weight reaches the bottom. When it reaches the bottom, the pull against the pawl spring is released and the pawl is forced up, by the pawl spring, into engagement with the tooth of the ratchet, locking the reel and preventing any further unreeling of the mooring rope. The anchor continues downward and pulls the mine under the surface of the water equal to the length of the distance line less the part of the mine which floats above the surface (about 2 feet) while the distance weight is descending.

(4) To obtain the desired submergence below mean low water, make the length of the distance line equal to the submergence desired, plus 2 feet, plus the height of the tide above mean low water at the time of planting. For example, say the rise of the tide on the day of planting is 8 feet (obtained from Coast and Geodetic Survey Tide Tables), that it is high water at 1 p. m., and that the group will be planted about 10 a. m. A submergence of 10 feet at mean low

water is desired. It takes six hours for the tide to rise. At 10 a. m. the tide will be 4 feet above mean low water. The length of the distance line should, therefore, be 10+2+4=16 feet. If the mines were to be planted at 1 p. m., the length of the distance line should be 10+2+8=20 feet. In every case sufficient additional length must be allowed for fastening the distance line to the distance weight and the pawl rod. As local conditions vary the time of high water from that given in the tables, it is best to take a reading of the tide gage before going out and to adjust the length of the distance lines on the planter just before planting the mines.

(5) A convenient way for attaching one end of the distance line to the pawl rod, and the other end to the distance weight, is by means of two half hitches and a seizing, or a bowline.

e. Serial numbers.—Each anchor is stamped with its serial number on the base, the cap squares, the cover, the axle, and the pawl. To insure best results, the parts of each anchor, as indicated by the serial numbers stamped on these parts, should be assembled together.

f. Attaching mooring rope.—(1) The mooring rope is attached to the anchor by means of the end fitting described in paragraph 165 or the socket described in paragraph 166. After attaching the end fitting, or socket, to the mooring rope, pull the rope back through the reel until the end fitting, or socket, is seated in the hole in the reel so that it does not project above the surface of the reel.

(2) Wrap the mooring rope tightly and closely on the anchor reel by means of the crank, hammering it into place. Care should be taken that the rope is wound on the reel in the proper direction, as indicated by the shape of the hole through the reel.

(3) Pass the end of the mooring rope up through the roller box of the cover, attach a thimble and two clips, and whip the end. Figure 55 shows the correct way to attach clips, and Figure 56 two incorrect ways.

(4) All the mooring rope, except that actually required for securing the anchor to the mine on the davits, should be coiled on the anchor reel, none being coiled outside the anchor.

g. Storage.—Automatic anchors should be stored in a suitable storeroom, with the bases completely assembled except for the mooring rope, and piled separately from the covers. The mooring rope can, when required, readily be wound on the anchor reel, and to assemble the anchor it is then necessary only to put the cover in place and bolt it down.

h. Care.—(1) Each anchor should be inspected at sufficiently frequent intervals to insure that all parts are kept free from rust at

all times. The brake drum, the journals, and all finished parts of the pawl, pawl recess, pawl lock, and pawl stop, should be covered with oil to prevent rusting.

(2) Prior to use, each anchor should be overhauled thoroughly to see that all parts function properly and that no parts bind. The oil should be removed from the brake drum before the anchor is used for planting.

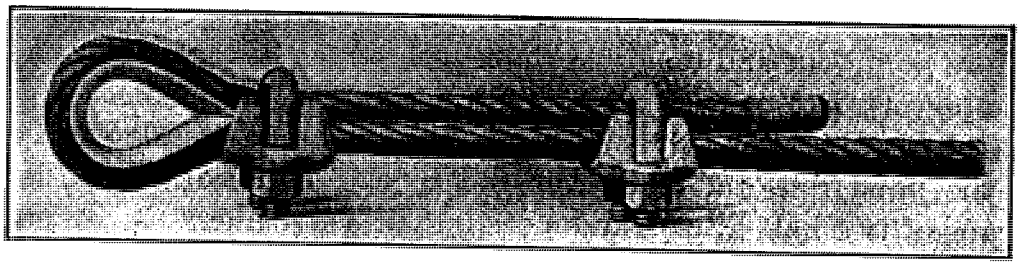

FIGURE 55.—Correct way to attach clips

(3) The interior of the anchor, except the machined parts, should be kept painted with red lead, and the exterior with asphaltum varnish.

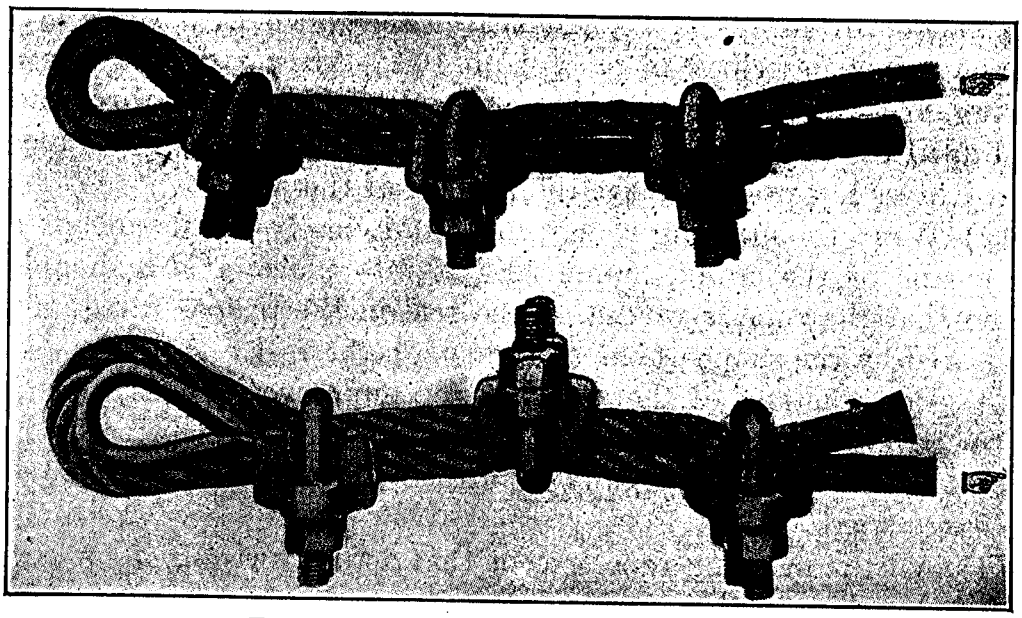

FIGURE 56.—Incorrect ways to attach clips

i. Accessories.—(1) *Crank.*—This is about 1 foot long with a square head which fits into a hole in one end of the reel shaft. It is used to wind the mooring rope on the reel.

(2) *Double head open end wrench.*—For use on the 5/8 and 7/8 inch hexagonal bolts and nuts on various parts of the anchor, 1 1/8 and 1 1/2 inch openings, 13 1/2 inches long.

(3) *Socket wrench.*—About 1 foot long with a $2\frac{7}{32}$-inch hexagonal opening, for use on the 1 3/8-inch cap square bolts.

160. Automatic anchor, Model 1910.—A bell-shaped anchor 28 inches in diameter at the bottom and 28½ inches high over all, weighing approximately 1,300 pounds. It is obsolete as an automatic anchor and should be used only as an ordinary cast-iron anchor. When it has been taken out of the water it should be taken apart and cleaned, otherwise it should be treated as a cast-iron anchor.

161. Mine and anchor shackles.—*a.* These are used to attach the mooring rope to the anchor and to the mine case. Each shackle consists of a shackle proper, a pin, and a split cotter. The shackle proper is made of 1-inch wrought iron bent into the usual curved form with an eye at each end. The pin is made of the same material with an oval cross section 1¼ by ⅝ inch, and has a head on one end and a small hole for the cotter through the other end. The pin passes through the eyes at the end of the shackle proper and is held in place by the cotter. All pins are interchangeable. The anchor shackle and the mine shackle are identical, but the pin of this shackle will not fit the eyes of the old model sister hooks. Therefore when using the old model sister hooks it is necessary to use the old model anchor shackle.

b. While the shackle described above is the standard mine and anchor shackle, there are in the service many old model shackles whose pin is held in place by a cotter passing through both a small hole near the end of the pin and a similar hole through one of the eyes, the mine shackle being similar but smaller than the anchor shackle.

c. Shackles should be kept painted with asphaltum varnish.

162. Sister hooks (fig. 57).—*a.* These are used to connect the bail of the cast-iron anchor to the anchor shackle; they are always used in pairs with the points of the hooks in opposite directions. They are made of wrought iron, with oval-shaped eyes through which the shackle pin passes. The oval shape of both the shackle pin and the eyes, with small clearance, prevents the hooks from separating.

b. When using the old model sister hooks, which have 1¼ by 1 inch eyes, it is necessary to use the old model anchor shackle, as the pin of the new model shackle will not fit the eyes of the old model sister hooks. The eyes of the new model sister hooks are $1\frac{5}{16}$ by ⅝ inch, and are designed to fit the pin of the new model shackle.

c. Sister hooks should be kept painted with asphaltum varnish.

163. Marline-covered steel-wire mooring and raising rope.—*a. Description.*—This rope is used for mooring mines to anchors, both automatic and cast iron, for mooring keg and steel marking buoys to their anchors and to distribution boxes, and for raising all types of anchors. The distribution box is raised by its buoy mooring rope. The rope consists of five outer strands wound around a central fiber core, each of the outer strands consisting of 19 galvanized steel wires twisted together and wound tightly with marline.

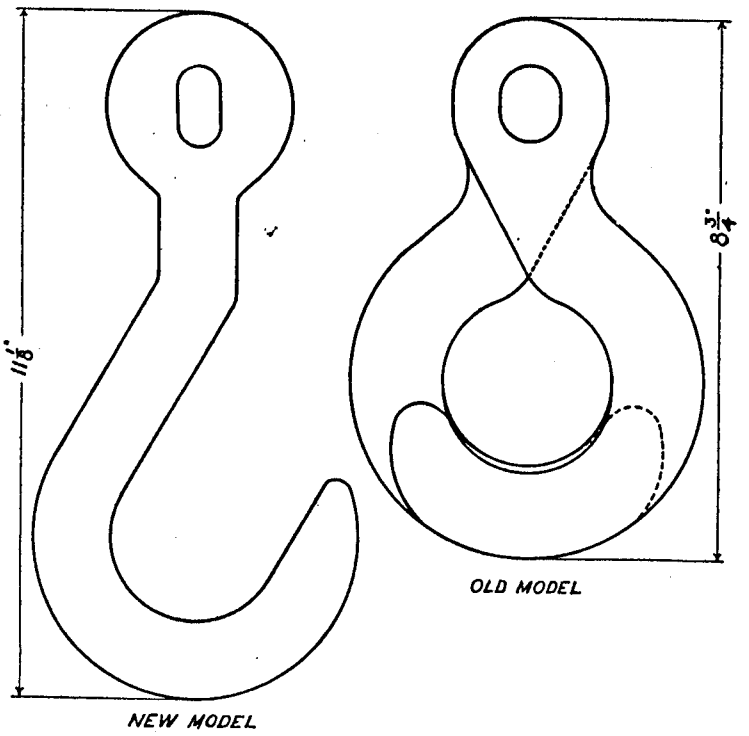

FIGURE 57.—Sister hooks

b. Properties.—The various sizes of this rope, together with their properties, are shown in the following table:

Size of rope	Maximum breaking strength	Maximum safe working load
	Pounds	*Pounds*
½ by ¾ inch	17,600	3,500
½ by ⅞ inch	18,400	4,000
⅝ by 1 inch	28,800	6,300
¾ by 1⅛ inches	40,000	8,900

c. Size of rope to use.—(1) The size of mooring rope to use in any particular case is a matter for local determination, and depends upon the size of the mine, the depth of the water, and the strength of the tides and currents.

(2) Ordinarily the ½ by ¾ inch and ½ by ⅞ inch ropes should be sufficiently strong for all raising ropes, except where, due to silting, a larger size may be necessary.

d. Length of mooring ropes.

Type of anchor	Size of mine case	Length to cut mooring rope
Automatic	All	Depth of water plus 10 feet.
Cast-iron	No. 32	Depth of water less 12 feet.
Do	No. 40 (spherical)	Depth of water less 13 feet.
Do	No. 40 (cylindrical)	Depth of water less 14 feet.
Do	No. 42 (plain)	Depth of water less 14 feet.
Do	No. 42 (corrugated)	Depth of water less 14 feet.
Do	No. 43	Depth of water less 15 feet.
Do	No. 46	Depth of water less 16 feet.
Do	No. 48 (plain)	Depth of water less 16 feet.
Do	No. 48 (corrugated)	Depth of water less 16 feet.
Do	No. 50	Depth of water less 15 feet.

The above lengths allow 3 feet for thimbles and clips, the rope being bent back 1½ feet at each end for this purpose. (Fig. 55.)

e. Length of raising ropes.—For all mine and buoy anchors, and for distribution boxes: Depth of water plus 80 feet. This is also a convenient length when used as anchor rope for the distribution box boat. The 80 feet of raising rope in addition to the depth of water is to allow the rope to reach from the surface of the water over the cathead and through the snatch block to the gypsy head of the winch.

f. Fastening raising ropes.—Attach the raising rope to the anchor or distribution box by means of an anchor knot (fisherman's bend) or bowline, and to the mine cable by two half hitches and a seizing of marline.

g. Depth of water.—In every case the depth of water referred to is the depth at low tide.

h. Determining length.—In determining the length of mooring rope for a 32-inch mine case with a cast-iron anchor, 5 feet is allowed for the length of the mine, anchor, and shackles; 10 feet for submergence; and 3 feet for the thimbles and clips, which results in a length equal to the depth of water at low tide, minus 5 feet, minus 10 feet, plus 3 feet, or the depth of water less 12 feet. For the larger mine cases, an additional allowance has been made for any increased spherical diameter and for the length of the cylindrical part of the case, to the nearest foot.

i. Tagging mooring ropes.—Where the lengths of the mooring ropes vary for any group of mines, each rope should be tagged at each end with the number of the corresponding mine.

j. Care.—(1) Marline-covered rope should be stored where there is a fair circulation of air. The date of receipt should be stenciled on each reel, and if not used at the end of five years it should be run through a bath of tar oil supplied for this purpose. This may be done by setting up an empty reel about 20 feet in front of the full reel and placing a tub or trough of tar oil between them. A trough lower in the center than at the ends will be found more convenient than a tub. As the rope comes off the full reel it is passed through the oil and the surplus oil slicked off with a piece of burlap, thus returning the surplus oil to the bath. The freshly oiled reel will continue to drip for several days, and sand should be put on the floor under the reel to take up the excess oil.

(2) After marline-covered rope has been used in water, it should be thoroughly dried and then reoiled as described above.

k. Tar oil.—This is a distillate from straight pine tar and is free from any substance not a product of the distillate of pine wood. It has a specific gravity of 1.02 to 1.07 at 60° F. and has a clear color.

164. Heart-conductor mooring rope.—*a. Description.*—This rope is for use with the mooring swivel described in paragraph 176 and serves both as a mooring rope and single-conductor cable from the cast-iron anchor to the mine. It consists of a 7-strand rubber insulated copper conductor surrounded by a layer of weatherproof braid, an inner layer of 18 galvanized steel wires, and an outer layer of 6 strands, each strand consisting of 19 galvanized steel wires twisted together and tightly wound with marline impregnated with wax. The rope is approximately 1 inch in diameter and has a maximum breaking strength of about 25,000 pounds and a maximum safe working load of 5,000 pounds.

b. Attachment to mine and anchor.—The upper end is attached to the mooring swivel clamp by means of the end fitting described in paragraph 167, and the lower end is attached to a special junction box by an end fitting. The junction box is attached to a cast-iron anchor by means of a shackle.

165. End fitting for marline-covered mooring rope (fig. 58).—*a. Description.*—Used for attaching ½ by ¾ inch and ½ by ⅞ inch marline-covered mooring rope to the automatic anchor. It consists of an outer steel collar with a slightly cone-shaped interior and flat on two of its outer sides, and a smaller inner wedge ring containing five longitudinal slots. It is designed to fit, when attached to the end of a mooring rope in the hole provided in the anchor reel, in such a manner that the mooring rope can be coiled smoothly and

tightly on the reel. The outer steel collar is identical for the two sizes, the inner wedge ring varying in size.

b. Attaching to mooring rope.—To attach the end fitting to the mooring rope, proceed as follows:

(1) Pass the end of the mooring rope through the small end of the hole through the reel, seize the marline-covered rope with one or two turns of marline about 12 inches from the end, unwrap the marline covering from each of the five strands of the steel rope down to the seizing, and cut off both the marline and the hemp core.

(2) Slip the collar, small opening first, over the bared strands and push it down on the rope out of the way.

(3) Slip the wedge ring, slotted end first, over the bared strands so that it rests against the marline shoulder.

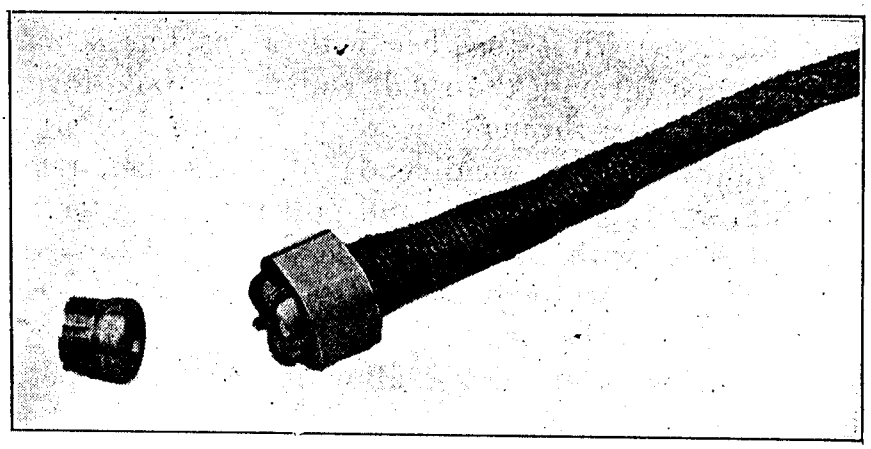

FIGURE 58.—End fitting for marline-covered mooring rope

(4) Holding the wedge ring firmly in place against the marline, bend each bared strand sharply over the upper edge of the wedge ring and down into one of the slots, hammering the strands into place with a light hammer so as to fit the wedge ring closely. Place a few turns of marline around the ends of the strands to hold them in place.

(5) Slip the collar up over the bared strands and wedge the collar and ring together with each strand in its proper slot.

(6) Place the end fitting in a bench vise and force the wedge ring and strands with a hammer into the collar until their upper edges are approximately flush.

(7) Engage the end of a piece of marline about 15 feet long under one of the strands near the end fitting, arrange the strands uniformly along the mooring rope, and wrap the marline regularly and closely around the rope so as to cover the bared strands completely; then secure the free end of the marline with two half hitches.

166. Socket for marline-covered mooring rope.—*a. Description.*—Used for attaching the 5/8 by 1 inch and 3/4 by 1 1/8 inch marline-covered mooring rope to the automatic anchor. It is made of cast iron, is about 2 3/4 inches in diameter and 2 1/2 inches long, with a cone-shaped hole through its center 1 1/4 inches in diameter at one end and 2 inches in diameter at the other.

b. Attaching to mooring rope.—To attach the socket to the mooring rope, proceed as follows:

(1) Seize the marline-covered rope with marline about 3 inches from the end, and carefully remove the marline covering from each strand above the seizing. Untwist and open up the strands of bare wire and clean the wires thoroughly in kerosene to remove all oil and grease. Then carefully clean the wires in a mixture of half water and half hydrochloric acid and allow to dry.

(2) Bind the loose wires together with a marline seizing, pass the end of the rope through the small end of the hole through the reel, and draw the rope through the reel to a vise. Insert the end of the rope in the bottom (small end) of the socket, remove the marline seizing, separate the wires, and pull the rope back until the ends are about flush with the top of the socket. Wrap additional marline, or burlap if necessary, below the socket, securing the rope in a vertical position in the vise.

(3) Having melted some socket alloy in a melting pot over a Khotal lamp, pour it into the socket slowly and carefully, keeping as far away from the socket as practicable while pouring. Be sure there is no oil or water on the wires or the socket.

(4) When the alloy has cooled, pull the rope back through the reel until the socket is seated in the hole in the reel so that it does not project above the surface of the reel.

(5) Do not pour the alloy directly into the hole in the reel, as it will then be difficult, if not impracticable, to remove the mooring rope from the reel to replace it.

167. End fitting for heart-conductor mooring rope.—Used for attaching heart-conductor mooring rope to the special junction box described in paragraph 168. It is similar to the end fitting for marline-covered mooring rope described in paragraph 165 *a*, except that the wedge ring contains six longitudinal slots instead of five. It is attached to the heart-conductor mooring rope in the same manner, except that after removing the marline covering from the six strands for about 12 inches from the end, the inner 18 galvanized steel wires are cut off at the same point. When the end fitting is in place, the insulated conductor projects through the center of the wedge ring.

168. Special junction box (fig. 59).—This is used for attaching a cast-iron anchor to the heart-conductor mooring rope and for making electrical connection between the heart-conductor mooring rope and the single-conductor cable. It consists of a cast-steel box 13½ inches long and 5 inches wide with a cover which is fastened to the box by four bolts. The lower end of the box is designed to receive the Turk's-head of a single-conductor cable, and the upper end to receive the end fitting of a heart-conductor mooring rope. The two conductors are joined by a water-tight joint which is placed inside the box. At the lower end of the box an eye is cast integral with the box for attaching to a cast-iron anchor by means of a shackle.

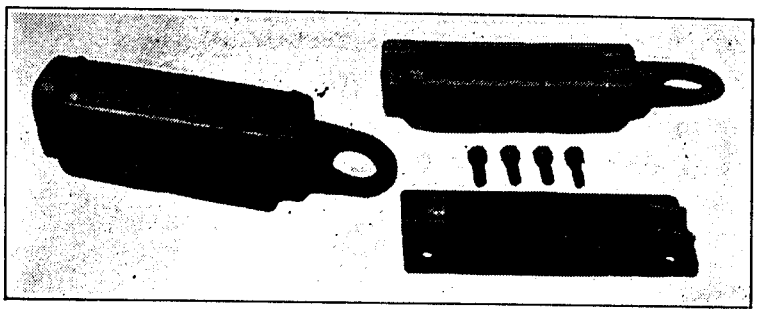

FIGURE 59.—Special junction box

169. Marline-covered steel-wire distance weight rope.—This is used for attaching the distance weight to the automatic anchor, its length determining the amount of submergence of the mine (par. 159 *d* (4)). It is similar in construction to the mooring and raising rope (par. 163 *a*), is ¼ by ⅝ inch in size, has a minimum breaking strength of 3,600 pounds, and a maximum safe working load of 890 pounds. The care of this rope is described in paragraph 163 *j*.

170. Mooring-rope accessories.—*a. Thimble.*—Used in connection with mooring-rope clips for attaching marline-covered steel-wire mooring rope to cast-iron anchors and to mines, to prevent wearing of the rope. They are made of cold-rolled steel, galvanized, and are furnished in four sizes, for use with ¾-inch, ⅞-inch, 1-inch, and 1⅛-inch ropes. For correct method of attaching thimble to rope see Figure 55.

b. Clip.—Used in connection with the mooring rope thimble for fastening mooring rope as shown in Figure 55. It consists of a forged steel base having diagonal grooves which fit the strands of the rope and a U bolt with two nuts. The base should be in contact with the long end and the U bolt in contact with the short end of

the loop in the rope. The correct way to attach clips is shown in Figure 55. Two incorrect ways, which should be avoided, are shown in Figure 56.

171. Mine buoy.—*a. Description.*—Used to mark the position of the mine when planted. It consists of a rectangular block of spruce 6 by 6 by 24 inches, with a transverse hole 1 inch in diameter bored through the center of the block approximately 8 inches from one end.

b. Mine buoy rope.—The mine buoy is attached to the maneuvering ring of the mine by 60 feet of ½-inch cotton rope (measuring line), the rope being doubled by fastening one end to the buoy by means of a bowline, the other end being passed through the maneuvering ring and tied to the buoy by means of a bowline, or two half hitches, within the original bowline. This results in the buoy floating approximately 28 feet from the mine, which is sufficient length for submergence of the mine and change of tide, and for taking the buoy into the yawl in order to draw the line taut to take submergence and plot the mine.

c. Marking the buoy rope.—The mine buoy rope is marked every 5 feet, in order to obtain the submergence of the mine, by several turns of friction tape around the rope, one such mark being placed on the rope 5 feet from the maneuvering ring, two marks (about an inch apart) at 10 feet, three marks at 15 feet, and so on. It is necessary to mark only one rope of the double rope, but both ropes should be marked at the 5-foot distance, then by seeing that the two 5-foot marks are opposite each other when fastening the rope to the buoy and mine, the 5-foot mark will be 5 feet from the mine. A convenient way to mark the rope is to fasten both ends of the 60-foot length to a mine buoy in the usual way, draw the rope taut, mark both ropes 5 feet from the bend, then mark only one of the ropes every 5 feet thereafter.

d. Care.—Mine buoys should be kept painted with red lead.

172. Keg marking buoy.—*a.* This is used to mark the position of the distribution box during the planting of mines, and subsequently until such time as the mine-group commander desires to remove it, and to mark the line of mines when planting. It consists of an oaken keg of one-half barrel capacity and is fastened to its mooring rope by either a rope bridle or a chain bridle. The chain bridle is fastened to the keg by means of a hole drilled through each end hoop and the projecting edge of the keg. The bunghole is kept tightly plugged to make the keg water-tight.

b. The chain bridle consists of two short pieces of chain fastened together by an iron ring for attaching the mooring rope. An eyebolt, with a nut and washer, is fastened to the free end of each chain. The eyebolts are inserted into the holes in the end hoops and the washers and nuts applied.

c. Keg buoys should be kept painted with red lead.

173. Steel marking buoy.—*a.* This is used for the same purpose as the keg buoy (par. 172 *a*). It is similar to a spherical mine case, is 28 inches in diameter, has a 3-inch opening into which a metal plug is screwed to make it water-tight, and has four stud bolts for attaching a mine cap, to the bail of which the maneuvering ring is fastened.

b. Steel buoys should be kept painted with red lead; they should be examined frequently for signs of rust, and scraped and painted when necessary. When in storage, the handholes should be fitted with greased wooden plugs supplied for this purpose. These plugs are made of white pine, are 2 inches thick and tapered, with a large diameter of $3\frac{7}{16}$ inches and a small diameter of $2\frac{9}{16}$ inches.

SECTION XVII

MINE CASES, COMPOUND PLUGS, AND ACCESSORIES

	Paragraph
Mine cases	174
Mine cap	175
Mooring swivel (fig. 61)	176
Compound plugs with fuze cans	177
Accessories for compound plugs	178

174. Mine cases.—*a. General description.*—(1) Three types of mine cases are in service: Spherical, plain sphero-cylindrical, and corrugated sphero-cylindrical. They are made of open-hearth steel of great toughness and elasticity, and are galvanized. The mine cap is identical for all mine cases.

(2) Every mine case is tested before acceptance by internal hydrostatic pressure to detect any imperfections. Those of early manufacture were subjected to a pressure of 100 to 120 pounds per square inch, while those of later manufacture, made under present specifications, were tested to 400 pounds per square inch.

(3) The top hemisphere of every mine case is provided with an external maneuvering ring; the bottom hemisphere has a $5\frac{1}{2}$-inch hole, threaded to receive a compound plug, at the pole. The edge of this hole is reinforced by a steel ring welded to the inside, and near it are four bosses, also welded, carrying stud bolts which pro-

ject outside the case to secure the cap. The stud bolts are keyed into the bosses by means of steel pins to prevent the bolts from turning. A broken stud bolt may be removed by drilling out the key pin and then unscrewing the bolt. Extra stud bolts are supplied for replacements.

b. Spherical mine case.—This consists of two hemispheres, ribbed and welded together at the equator, thus avoiding all rivets. The No. 32 case is 32 inches in diameter and made of ¼-inch steel, while the No. 40 case is 40 inches in diameter and made of $\frac{5}{16}$-inch steel.

c. Plain sphero-cylindrical mine case.—(1) This type of mine case is made by inserting a steel cylinder ½-inch thick between two hemispheres, the cylinder and hemispheres being ribbed and welded. All such cases are 32 inches in diameter and their hemispherical parts ¼-inch thick except the No. 50 case, which is 40 inches in diameter and $\frac{5}{16}$-inch thick. Some of the larger-size cases are stiffened by extra welded ribs.

(2) All sphero-cylindrical cases are designated by the diameter in inches of a sphere having approximately the same buoyancy. For example, a No. 40 cylindrical case is made by inserting a cylinder 32 inches in diameter and 20⅜ inches in length between the two hemispheres of a No. 32 case, which is sufficient to make the displacement approximately equal to that of a spherical case 40 inches in diameter.

d. Corrugated sphero-cylindrical mine case.—This is similar in every way to the plain sphero-cylindrical case except that the cylinder is made of corrugated steel of less thickness, which materially diminishes the weight of the case for the same buoyancy. All corrugated cases are 32 inches in diameter and are made of ¼-inch steel throughout.

e. Size, weight, and buoyancy of mine cases.—(1) The following table shows the dimensions, weights, and buoyancy of each mine case complete except the moorings. The actual free buoyancy when planted will be as shown in the last column reduced by the weight of the moorings and cable.

(2) From this table any mine case can be identified readily by measuring the diameter of the spherical portion and the length of the cylindrical portion.

Size, weight, and buoyancy of mine cases

Mine case			Weight in air					
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Size, number	Length of spherical portion	Length of cylindrical portion	Computed weight empty	Cap and compound plug complete	TNT charge	Assembled and loaded mine	Displacement sea water	Buoyant effort difference between columns 7 and 8
	Inches	*Inches*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	
32 (spherical)	32	0	241	71	100	412	635	223
40 (spherical)	40	0	491	71	200	762	1,241	479
40 (cylindrical)	32	20⅜	550	71	200	821	1,242	421
42 (cylindrical)	32	26⅞	643	71	200	914	1,435	521
42 (cylindrical corrugated)	32	26⅞	496	71	200	767	1,480	713
43 (cylindrical)	32	30⅜	693	71	200	964	1,540	576
46 (cylindrical)	32	42	859	71	200	1,130	1,886	756
48 (cylindrical)	32	50⅝	982	71	200	1,253	2,143	890
48 (cylindrical corrugated)	32	50⅝	711	71	200	982	2,239	1,257
50 (cylindrical)	40	25½	946	71	200	1,217	2,428	1,211

f. Storage and care.—(1) Mine cases should rest on racks or skids and, where space permits, should not touch each other. In handling them care should be taken not to injure the bails or stud bolts. They should be arranged so that the holes are in sight, and the holes should be fitted with greased wooden plugs supplied for this purpose. These plugs are made of white pine, are 2 inches thick, and tapered, with a large diameter of 5⅞ inches and a small diameter of 5 inches.

(2) The galvanized cases will not need painting ordinarily until they have been in the water. When taken from the water they should be thoroughly dried and any rust removed with wire brushes and steel scrapers. Then a heavy coat of red lead should be applied, and when this is dry a coat of gray paint.

(3) The red lead is supplied in dry powder form. About 7 gallons of red lead paint can be made by mixing 100 pounds of dry red lead, 5 gallons of raw linseed oil, 1 quart of turpentine, and 1 quart of liquid drier. This mixture should be applied within two or three weeks after mixing. One gallon of paint should be sufficient to give ten No. 32 cases one coat.

(4) Seven gallons of gray paint can be made by mixing 100 pounds of white lead, 2½ gallons of raw linseed oil, 2½ gallons of turpentine, 1 gallon of liquid drier, and about 1 pound of lampblack to tone down the mixture.

(5) Mines properly painted, as explained above, if kept in a dry storehouse and not put in the water, should not require repainting for several years. However, mine cases in storage must be inspected frequently, both inside and outside, for any signs of rusting. For examining the interior of cases an electric lamp lashed to the end of a stick will be found useful.

(6) When handling cases and changing their positions on the racks an abrasion will sometimes be made in the surface of the paint, which if neglected may serve as a starting point for corrosion, which will extend rapidly under the surface of the paint. Should loose paint or rust be seen, the case should be repainted. A small wooden mallet may be used to tap the case at all points to loosen scales of rust or paint, then the surface should be thoroughly wire brushed or scraped and the case repainted as stated above.

(7) The stud bolt threads, the handhole threads, and the flat surface around the handhole should be kept coated with light slushing oil.

g. Cleaning the interiors of mine cases.—At one post where an inspection of mine cases showed large spots of rust on the interiors, the following method of cleaning them was found most convenient:

(1) A plug proper was bored and tapped and a 1½-inch shaft, 1 foot long, inserted.

(2) Two old style cable reel jacks were bolted down the proper distance apart, and to one of these jacks a board was bolted having a U-shaped groove at the top reinforced with iron. The maneuvering ring of the mine case rested in this groove and supported one end of the mine case during cleaning. While this board was bolted to an old style cable reel jack, for which the new style jack is not suited, the board may be fastened to any suitable fixed timber, or a frame built for the purpose. The plug proper, prepared as described above, was screwed into the other end of the case with the shaft resting on the cable reel jack.

(3) About 150 pounds of large gravel were put into the case, the plug screwed in, an iron washer put on the shaft, and the case placed on the two supports described above. The case was revolved, by means of an electric motor and a belt, for from 10 to 20 minutes, depending upon the condition of the interior. During this time the plug end of the case was raised and lowered by means of the cable reel jack supporting it, so as to allow the gravel to work in both ends as well as in the middle of the case. After revolving the required length of time, the plug was removed and the case emptied by picking it up by the maneuvering ring.

(4) Before putting a case, cleaned as described, back in storage, its interior should be given a coat of red lead by means of a long-handled brush.

h. Accessories.—(1) *Double end wrenches,* **S** *and straight, for mine case nuts.*—The **S** wrench is 11½ inches long; the large end fits the stud bolt nuts on the mine case, while the center and small end fits the follower on the compound plug. The straight wrench is 10½ inches long; the large end fits the stud bolt nuts, while the small end fits the nut of the cable clamp bolt on the mine cap.

(2) *Flat key.*—This is a split key used to prevent the stud bolt nut from working loose. It is 4¾ inches long and is made of one piece of 3/32-inch steel bent double. One type of this key has a lug at one end to prevent the key from entirely passing through the slot in the stud bolt, while another type has a circular shaped end for the same purpose. The other end of the key is beveled to a point. After the key has been inserted into the slot in the stud bolt and driven home with a hammer, the two sides of the key are spread apart to hold the key in place.

(3) *Tap for mine case threads.*—A tap for cleaning out burred or crossed handhole threads of mine cases is carried on hand at the Submarine Mine Depot. It may be obtained, upon request, for temporary use. When received it should be used as soon as practicable and then returned to the Submarine Mine Depot. The socket wrench for the plug proper fits this tap.

(4) *Mine loading skid* (fig. 60).—Used in the loading room for supporting mine cases in an upright position when they are being loaded and prepared for planting and when they are being disassembled. The case is placed upon the skid with its maneuvering ring down, and an iron bar (lever of socket wrench for plug proper), run through the holes in the sides of the skid and the maneuvering ring. This prevents the mine case from falling over and from turning when the compound plug is screwed into place or unscrewed. Loading skid blocks (fig. 60), placed on the skid against the mine case, assist in holding it upright.

(5) *Mine case truck.*—An ordinary 2-wheel warehouse hand truck for moving mine cases and other heavy mine matériel.

175. Mine cap.—*a.* This is used to secure the Turk's-head of the mine cable, to protect the connection between the cable and the loading wire of the compound plug, and for attaching the mooring rope to the mine.

b. The mine cap consists of a hemisphere of ¼-inch steel flanged and slotted at its base to fit over the stud bolts. The cap is held in

place by special steel washers and nuts, the washers being of such shape as to bear on the flange of the cap and upon the surface of the case. The nuts are prevented from working loose by steel-split keys driven through the slotted ends of the stud bolts. A hole about 1½ inches in diameter at the pole of the cap is connected by means of a slot with a hole about 3 inches in diameter punched through the cap between two legs of the bail; this permits the entrance or removal of the Turk's-head by simply removing the apron which covers the hole.

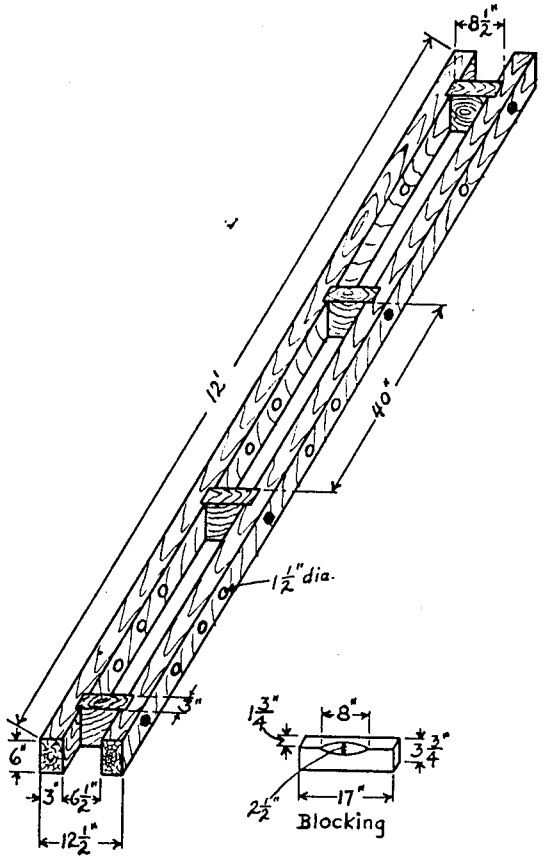

FIGURE 60.—Mine-loading skid

c. A forged steel clamp, shaped to receive a single-conductor cable, is welded to the edge of the hole in the pole of the cap, and a steel binder, with apron (often spoken of as the cable clamp), is bolted to the clamp for binding the cable in place and for covering the 3-inch hole.

d. A tripod bail, consisting of three legs and one eye, to which the mooring rope is attached, is riveted to the cap.

e. While the mine cap described above is the new model mine cap, there are many old model caps in service. The only difference between the two caps is that on the new cap the forged steel clamp is between two of the tripod legs and the apron is directly below the

center of the steel binder of which it is a part, whereas on the old model cap one of the tripod legs is directly in front of the center of the forged steel clamp, which necessitates a cable clamp with the apron offset to the right of the steel binder of which it is a part.

f. Special socket wrench for nut of cable clamp bolt.—This is a T socket wrench 4 inches long for use on the hexagon nuts of the cable clamp bolt on the mine cap.

176. Mooring swivel (fig. 61).—*a. Purpose.*—This device has been designed to obviate a difficulty frequently encountered, particularly in deep water and strong current, of the destruction of mooring rope and cable by the rotation of the mine case. By utilizing a special heart conductor marline-covered mooring rope, in place of single-conductor cable and the regular mooring rope, this device provides a means whereby the mine may rotate freely on its vertical axis under the action of strong currents without twisting the mooring rope, and at the same time permits the uninterrupted maintenance of electrical connection to the mine.

b. Description.—(1) The mooring swivel replaces the mine cap. The flange of the bell of the swivel body is of the same dimensions as the flange of the standard mine cap and is fastened to the mine by washers, nuts, and keys in exactly the same way. Figure 61 shows a mooring swivel attached to a mine case.

(2) The swivel body consists of a steel bell and shell, the shell being welded to the bell. The upper part of the shell is drilled and tapped axially to receive the standard water-tight connector, consisting of rubber packing, brass gland, and steel follower. The loading wire is led from the plug proper through the bell and water-tight connector to a bronze contact screw which is screwed into the brass upper contact plate. This contact plate is fastened to a bakelite upper insulating ring by means of four screws, the insulating ring in turn being attached to the steel shell by four screws.

(3) The lower part of the interior of the shell is machined to receive a rotating steel swivel head. A recess is machined in the top of the swivel head to receive the bakelite lower insulating ring which is held in place by four screws. The brass lower contact plate is attached to the lower insulating ring by four screws, one of which serves as a spring-clamp screw to support in its axial position a phosphor bronze contact spring. This spring serves to maintain, during the rotation of the swivel, the electrical connection to the mine by pressure on the upper contact plate. This connection between the lower contact plate and the swivel head is maintained by soldering the end of the short piece of loading wire, which passes

through the center of the swivel head to the contact plate. The other end of this loading wire passes through a water-tight connector in the lower end of the swivel head shaft, and a water-tight connection is made between this loading wire and the conductor of the special mooring rope in the space provided for the purpose in the center of the clamp.

(4) The swivel head consists of the swivel-head proper and swivel-head shaft, integrally machined from a steel forging. The swivel-head shaft fits in the bearing ring bushing. Annular grooves in the bearing surface provide an oil seal for the electrical contacts and retain oil for the proper lubrication of the bearing.

(5) The thrust bearing of this device consists of an angular contact ball bearing placed between the lower circular face of the swivel-head proper and the interior surface of the steel bearing ring and sealing chamber. The inner element of the bearing carries the swivel head and rotates with it, while the outer element rests on the bearing ring.

(6) The bearing ring and sealing chamber are assembled to the swivel body by 6 bolts and nuts equally spaced around the exterior of the swivel body, a water-tight joint being obtained by the use of a soft-lead gasket between the swivel body and the bearing ring.

(7) The exclusion of water from the electrical contacts and connections within the swivel body, and the insulation of these electrical connections are accomplished by an oil seal consisting of a special heavy oil provided for the purpose. The interior of the sealing cylinder is fitted with an oil-retaining ring of hard wool felt. This oil-retaining ring has been boiled in a waterproof compound to prevent sea water from soaking into the felt, and is a tight fit inside the sealing chamber and only a close fit, without friction, around the shaft of the swivel head. In assembling this device, care must be taken to see that all the spaces above the oil-retaining ring inside the device and surrounding the swivel head are packed with the special heavy oil, excluding all bubbles and pockets of air.

(8) As the mine with the mooring swivel attached is lowered into the water, the hydraulic pressure of the surrounding sea water will force up the oil-retaining ring to the point where the pressure of the oil inside will uniformly equal the pressure of the water surrounding the mine. The maintenance of the seal is doubly assured, first by the circular grooves in the swivel-head shaft bearing ring bushing already described, and second by the reservoir of oil maintained within the sealing cylinder between the bearing ring and the oil-retaining ring and around the shaft of the swivel head. In addition

to its insulating function this oil seal provides lubrication for the necessary bearing surfaces and prevents corrosion of the metal surfaces within the device.

(9) The attachment of the swivel head to the heart conductor mooring rope is accomplished by a steel clamp in two parts bolted together through their flanges by four bolts and nuts. The two halves of the clamp are exactly similar. The upper part of the clamp incloses and supports the lower end of the swivel head shaft; the central portion provides a space for the handmade vulcanized water-tight joint; and the lower part provides room for the end

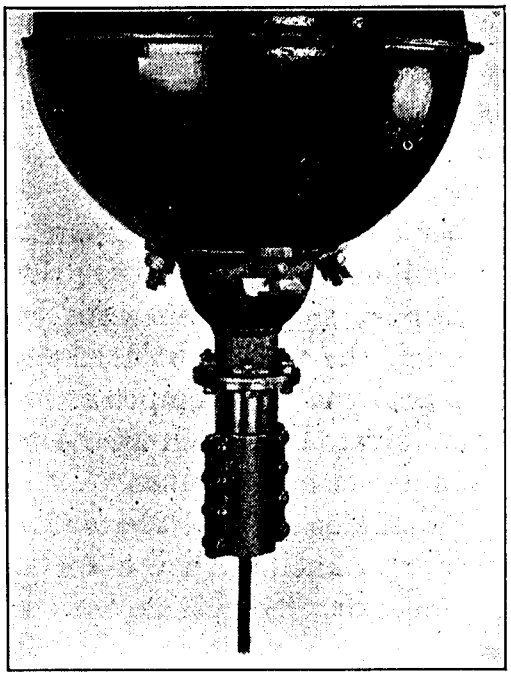

FIGURE 61.—Mooring swivel

(Clamp illustrated is an earlier model than clamp described in text)

clamp at the upper end of the single-conductor mooring rope. The lower end of the swivel-head shaft is square so as to prevent it from rotating in the clamp, and it is provided with a double shoulder so as to hold it securely in place.

c. Assembly.—(1) First see that all parts are free from rust. Place the swivel body on the loading room table with the bell down. Tighten the upper insulating ring, the upper contact plate, and the contact screw. Fill the interior of the shell with the special heavy oil provided for the purpose to a depth of one-eighth inch above the shoulder in the shell of the swivel body, care being taken to exclude all bubbles and pockets of air. The heavy oil may be put in cold or melted and poured in.

(2) Examine the swivel head to see that the contact spring is properly adjusted to center its contact when compressed one-half, that the lower contact plate and lower insulating ring are tight, and that a sufficient length of the swivel head conductor projects from the lower end of the swivel head to make a water-tight joint.

(3) Coat the surfaces of the swivel head smoothly with the special heavy oil, then press the swivel head lightly, shaft end up, into the swivel body, and allow it to rest, with the pressure of its own weight, on the imprisoned seal of heavy oil and the compressed contact spring.

(4) Pack the ball bearing solidly with the special heavy oil, which can be accomplished most readily by placing the bearing in an empty friction-tape can and pouring melted oil into the bearing until it overflows. When the oil has solidified, wipe off the excess and slip the bearing over the swivel head shaft with the side of the bearing on which the ball retaining lock ring is located down or next to the swivel head.

(5) Lay a lead washer on the flange of the swivel body. Slip the cast-steel bearing ring and sealing cylinder over the swivel head shaft, carefully entering the upper shoulder into the swivel body. Place the six body bolts through the proper holes, screwing them in, and tighten gradually so as uniformly to compress the lead washer, then screw the nuts onto the bolts. Inasmuch as the bolts screw into the flange of the body, the nuts act as lock nuts.

(6) Fill the sealing cylinder around the swivel-head shaft to a depth of about three-fourths inch with the special heavy oil, carefully excluding all air pockets. Slip a hard wool felt oil-retaining ring over the end of the shaft with the extractor rings up, and press the felt ring into the sealing cylinder in firm contact with the heavy oil.

(7) Thread the free end of the swivel-head shaft conductor through a rubber packing, brass gland, and steel follower, such as are used in the plug proper, and screw the follower into its recess in the end of the swivel-head shaft with moderate pressure.

(8) After the mine case is loaded and the compound plug assembled to it, thread the end of the loading wire through a steel follower, brass gland, and rubber packing. Remove one-half inch of insulation from the end of the loading wire with the insulation cut to a square shoulder. Thread a small brass washer over the stranded conductor, separate the strands and clean them. With the washer in contact with the insulation, bend each strand down across the washer, spacing them equally, and cut off the ends extending beyond the washer (fig. 72). With the rubber packing in contact

with the washer and the follower, enter the assembly into its recess in the upper part of the shell inside the bell, then screw the follower home with moderate pressure so as to make a water-tight joint and at the same time bring the bent ends of the conductor into contact with the head of the contact screw.

(9) Coil the loading wire into the bell of the swivel body and fasten the assembled swivel connection in place on the mine case exactly as a mine cap is fastened to a mine case.

(10) Place the two halves of the clamp over the lower end of the swivel-head shaft and bolt the clamp in place temporarily so as to protect the end of the shaft until the heart conductor mooring rope is attached aboard the mine planter (*b* (9) above.)

177. Compound plugs with fuze cans.—*a. General description.*—(1) The plug proper is made of cast iron and the latest model fuze can (1910) of cast brass. The transformer collar and connecting collar are of cast brass, while the connecting bolts are of steel. The principal parts are screwed together and held in place by set screws. Cross sections of the old model and model 1910 compound plugs and fuze cans, with the names of the various parts, are shown in Figures 62, 63, and 64.

(2) The connection of the compound plug with the mine case makes an earth plate, of which the electrical resistance in salt water is about 1 ohm.

b. Compound plug, old model (fig. 62).—This plug differs from the models 1908 and 1910 plugs in that only the old model brass fuze can may be used with it. The plug proper is secured to the lower tube as shown in the figure. The present policy is to use these plugs and fuze cans in submarine mine target practice.

c. Compound plug, model 1908.—(1) The plug proper differs from the old model and model 1910 in that there are connecting bolts screwed into the plug proper to support the weight of the mine transformer. The rubber fuze can screws into a fuze-can cap, the cap being screwed into the plug proper in a manner similar to the old model. By using this same fuze-can cap, the brass fuze can, model 1910, may also be used with this plug proper.

(2) The rubber fuze can was made for use with guncotton, but is perfectly satisfactory for use with trotol. Guncotton, of course, is no longer used in submarine mine work. It is the present policy to use up the model 1908 plugs and rubber fuze cans in mine practice with trotol after the supply of old-model plugs and fuze cans has been exhausted.

d. Compound plug, model 1910.—This is shown in Figures 63 and 64. The connecting bolts screw into the fuze-can cap, the cap being screwed into the plug proper. The rubber fuze can is interchangeable with the brass fuze can for use with this plug. The 1910 plug should not be used for mine practice unless there are no older model plugs on hand.

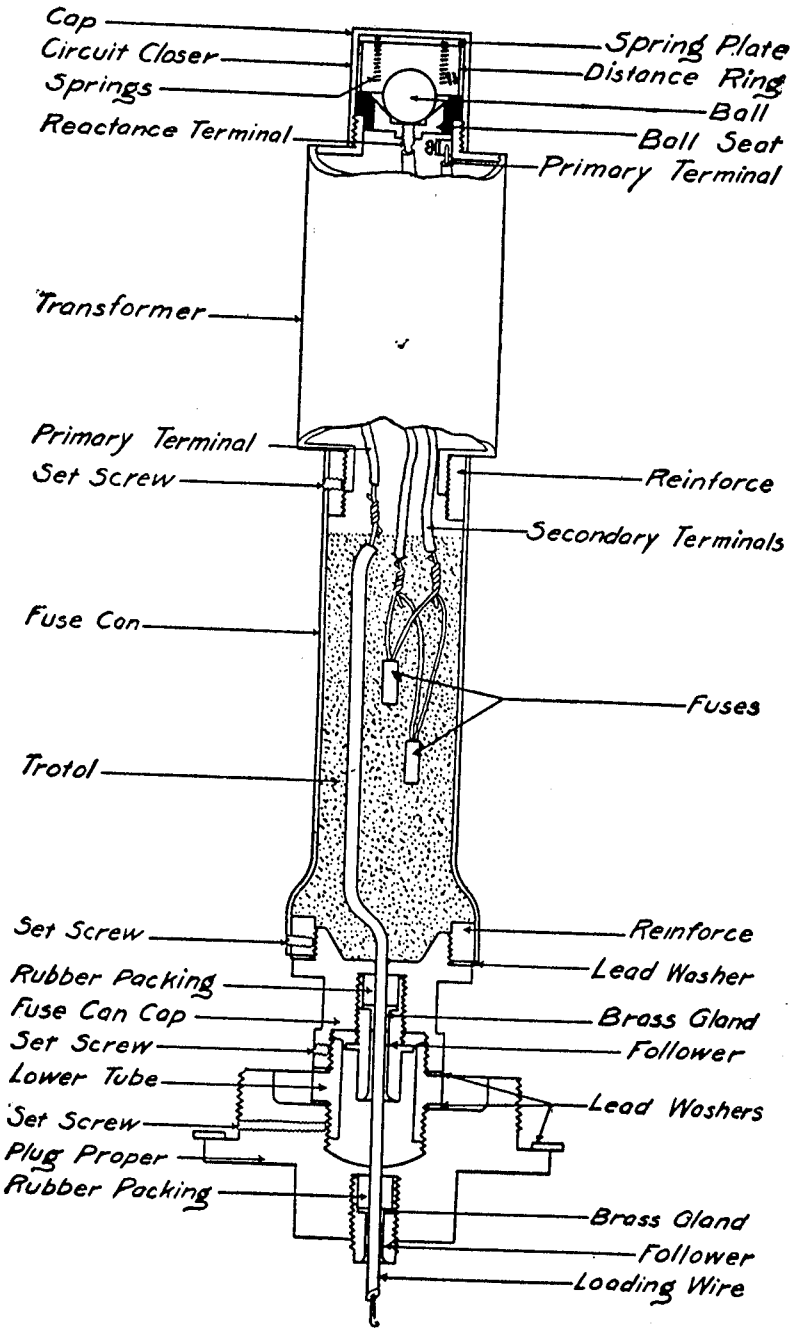

FIGURE 62.—Compound plug, old model

e. Assembling a compound plug with old model fuze can.—(1) Cut a piece of loading wire 3 feet long and bare the ends. Join one end to the lower black wire of the transformer by a telegraph joint

(fig. 62) and tape it. Draw this wire and the two red secondary wires through the fuze can, cover the threads of the transformer with rubberoid, and screw the can on the transformer.

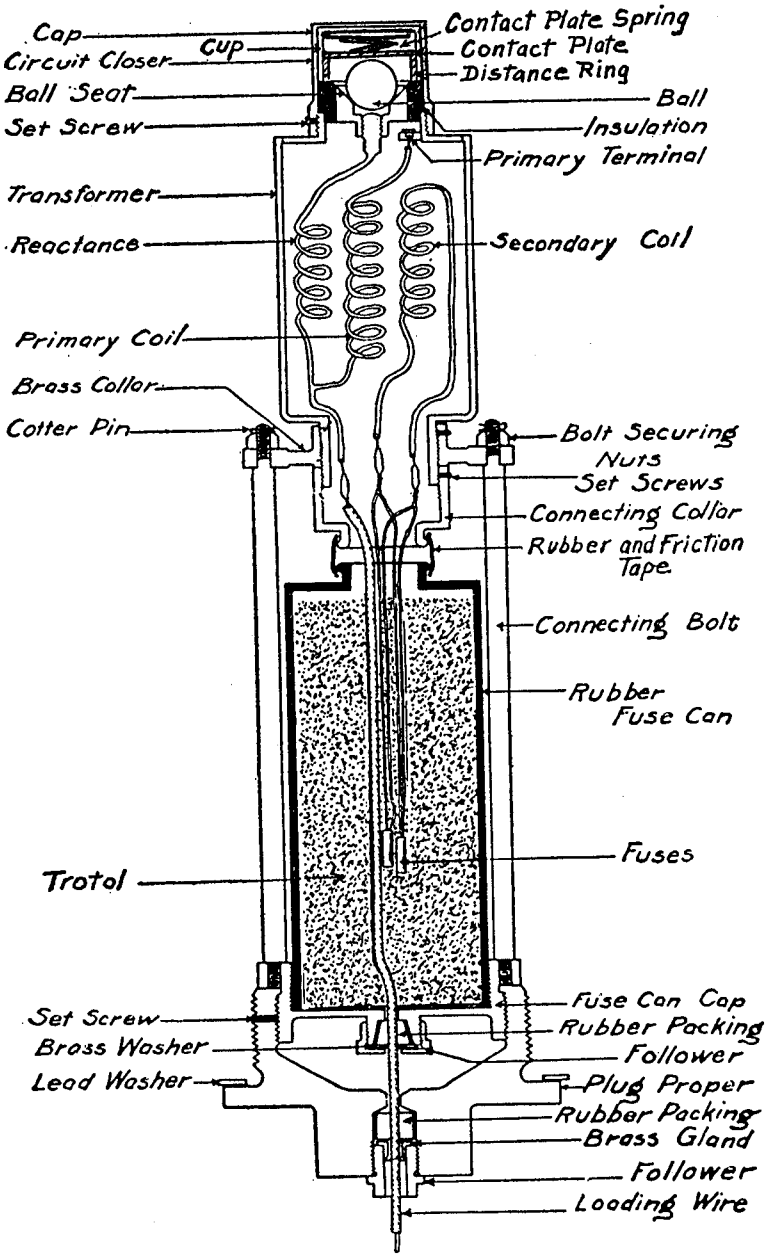

FIGURE 63.—Compound plug, model 1910, with rubber fuze can

(2) Join two tested service fuzes with their leads in pairs, and connect the two terminals thus formed to the two red terminals of the transformer (fig. 62) and tape the joints.

(3) Hold the fuze can vertically, with the transformer down, place the fuzes in the can and pour trotol in around the fuzes and up to the screw threads.

(4) Draw the loading wire through a lead washer (2¾ inches inside diameter) and the fuze-can cap. Cover the threads of the cap with rubberoid and screw it into the fuze can.

(5) Thread a rubber packing, brass gland, and brass follower with rubberoid on its threads, over the loading wire and screw the follower into the cap with moderate pressure.

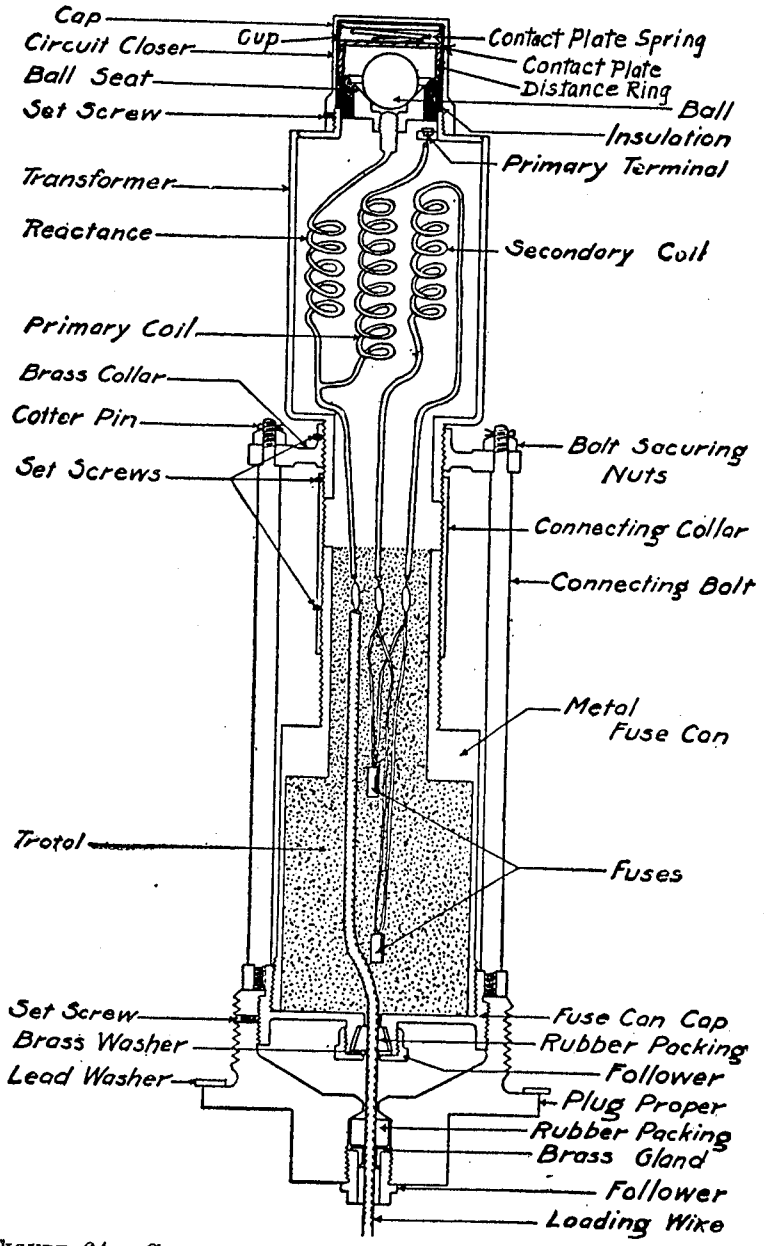

FIGURE 64.—Compound plug, model 1910, with brass fuze can

(6) Put rubberoid on the threads of the lower tube and screw it into the fuze can cap with a lead washer (1¾ inches inside diameter) between it and the cap.

(7) Draw the loading wire through a lead washer (1¾ inches inside diameter) and the plug proper and screw the plug hard against the lower tube.

(8) Thread another rubber packing, brass gland, and steel follower with rubberoid on its threads, over the loading wire and screw the follower into the plug proper with moderate pressure.

f. Assembling a compound plug with rubber fuze can.—(1) Cut two tested service fuzes with 9-inch leads, bare the ends for 1 inch and connect in multiple.

(2) Cut a 3-foot length of loading wire and bare the ends for a telegraph joint. Thread this wire through the fuze can and fuze-can cap. Cover the threads of the cap with rubberoid and screw it on the fuze can.

(3) Thread a rubber packing, brass gland, and brass follower on the loading wire and screw the follower into the fuze-can cap with moderate pressure.

(4) Hold the plug proper upright in a vise. Cover the threads of the fuze can with rubberoid, screw the assembled can into the plug proper and secure it with the set screw. Handle the loading wire carefully when passing it through the plug proper and when screwing the fuze can in place.

(5) Put the fuzes in the can and fill the can to the top with trotol.

(6) Cut the three transformer leads about 6 inches long and bare the ends for 1 inch.

(7) Cover the threads of the brass collar with rubberoid and screw it on the transformer. Slip the connecting collar over the fuze leads and loading wire and rest it on the fuze can.

(8) Support the transformer by turning it upside down and hanging it on the ends of two connecting bolts passing through the holes in the collar.

(9) Join the secondary (red) leads and the fuzes, and the primary (black) lead and the loading wire, by telegraph joints. Smooth these joints with a file and wind with rubber tape.

(10) Take the transformer off the connecting bolts and hold it right side up above the fuze can until the lead wires are extended; then lower it, coiling the leads in the base of the transformer. Put rubberoid on the threads of the transformer and screw on the connecting collar and secure it with the set screw.

(11) Place the brass collar on the connecting bolts and secure it with the nuts and cotter pins.

(12) Put a thin coating of rubber cement on the lips of the fuze can and the connecting collar. Lay a piece of rubber tape, about 18 inches long, around the opening without stretching. The same length of protective tape is then laid over the rubber tape with considerable force.

(13) Assemble on the loading wire the rubber packing, brass gland, and steel follower with rubberoid on its threads, and screw the follower into place in the base of the plug proper.

(14) Great care must be taken not to injure the insulation of the loading wire in tightening up the follower in the stuffing box of the fuze can or of the plug proper.

g. Assembling a compound plug with Model 1910 brass fuze can.—(1) Cut two tested service fuzes with 12-inch leads, bare the ends for 1 inch, and connect in multiple.

(2) Cut a 3-foot length of loading wire and bare the ends for a telegraph joint. Thread this wire through the fuze can and fuze-can cap. Cover the threads of the can with rubberoid and screw the can into the cap.

(3) Cover the threads of the connecting collar with rubberoid and screw it down against the shoulder of the can.

(4) Thread a rubber packing, brass gland, and brass follower with rubberoid on its threads over the loading wire, and screw the follower into the fuze-can cap with moderate pressure.

(5) Place the plug proper upright in a vise. Coat the threads of the fuze-can cap with rubberoid, and screw the assembled can into the plug proper with the spanner wrench. Handle the loading wire carefully when passing it through the hole in the plug proper and when screwing the fuze can in place.

(6) Put the fuzes in the can, and fill the can to the top with trotol.

(7) Cut the transformer leads to 4 inches, and bare the ends for 1 inch.

(8) Cover the threads of the brass collar with ruberoid, and screw it on the transformer.

(9) Lower the transformer on the connecting bolts, and join the secondary (red) leads with the fuzes and the primary (black) with the loading wire by telegraph joints. Coil the leads and joints in the base of the transformer.

(10) Screw the connecting collar up against the brass collar on the transformer, first covering the threads with rubberoid.

(11) Place the nuts and cotter pins on the connecting bolts.

(12) Assemble the rubber packing, brass gland, and steel follower with rubberoid on its threads, on the loading wire and screw the follower into place in the base of the plug proper.

h. Testing assembled compound plugs.—With a voltmeter and a sufficient number of dry cells to give a full-scale reading on the lower scale of the voltmeter connected in series, carry one lead to the loading wire and the other lead to the plug proper. There should be a

poor circuit with the plug vertical and a good circuit when the plug is tipped over beyond 45°. A convenient hook-up for conducting this test is described in paragraph 97.

i. Disassembling compound plug with old-model fuze can.—The following method of disassembling loaded old-model compound plugs eliminates the danger of accidental explosion:

(1) After removing the plug from the mine, clamp it in the assembling device, transformer end down.

(2) Remove the steel follower and cut the loading wire flush with the plug proper.

(3) Remove the plug proper.

(4) Remove lower tube, lead washer, and fuze-can cap.

(5) Reach into the fuze can and carefully pull up the fuzes until they can be cut at the joint between the fuze leads and secondary wires of the transformer. Destroy the fuzes at once by throwing them into deep water or exploding in a testing box.

(6) Remove the fuze can and transformer from the assembling device and pour the priming charge into the box provided.

(7) The mine transformer can now be unscrewed with no danger of accident.

j. Care of compound plugs.—All parts of compound plugs should be kept free of rust and the steel screw threads coated with light slushing oil.

178. Accessories for compound plugs.—*a. Taps for follower hole in plug proper.*—These were supplied for preparing old model plugs proper for submine practice by drilling two additional follower holes, one on each side of the central hole. A complete set consists of three 7/8-inch taps, one each taper, plug, and bottoming. These taps are also for use in chasing the threads of follower holes in all plugs proper whenever such threads become burred.

b. Wrenches.—(1) *Double head open end wrench for $\frac{5}{16}$ and $\frac{7}{16}$ inch hexagon nut.*—About 7 inches long, and fits the connecting bolt nuts and the followers.

(2) *Special socket wrench for plug proper* (fig. 65).—This consists of a cast-iron head which fits the hexagonal end of the plug proper, and a machine steel lever about $1\frac{3}{16}$ inches in diameter and 33 inches long which fits into the four openings in the cast-iron head.

(3) *Spanner wrench for brass fuze can for Model 1910 compound plug* (fig. 65).—A Y-shaped spanner about 8 inches long with two lugs which fit in holes in the shoulder of the fuze can.

(4) *Spanner wrench for brass fuze-can cap for Model 1910 compound plug* (fig. 65).—A semicircular wrench about 15 inches long. It engages in one of the slots in the circumference of the fuze-can cap.

(5) *Special wrench for connecting collar for Model 1910 compound plug* (fig. 65).—A flat semihexagonal wrench about 9 inches long, which fits around the connecting collar.

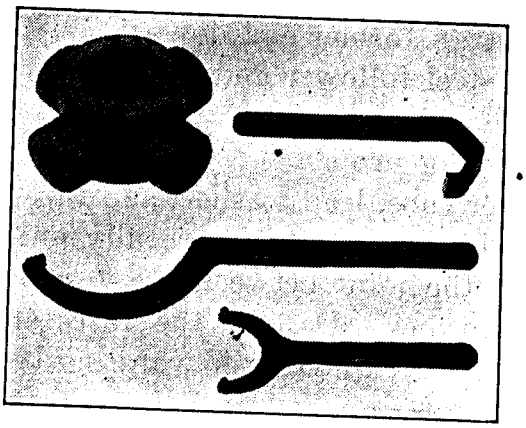

FIGURE 65.—Special wrenches for compound plugs

c. Assembling device (fig. 66).—(1) *Clamp.*—This consists of a base plate 9 by 13 inches with holes for fastening to a work bench, and a top plate provided with a slot which fits the hexagonal head of the plug proper.

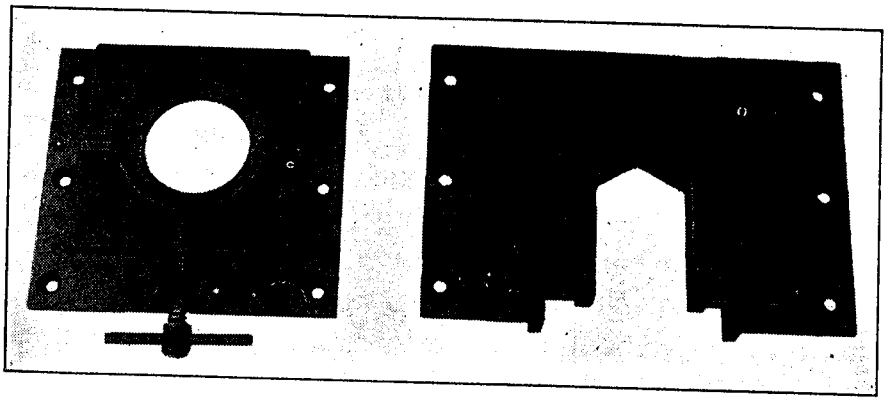

FIGURE 66.—Assembling device for compound plug

(2) *Support.*—Consists of a base plate 9 inches square with holes for fastening to a work bench, a fixed top plate with a semicircular opening, a movable top plate with a semicircular opening, and a socket screw which works against the movable top plate. The two top plates fit around the mine transformer case which is clamped in position by turning the socket screw.

SECTION XVIII

EXPLOSIVES

Paragraph
TNT 179

179. TNT.—*a. Description.*—(1) This explosive, sometimes referred to as trotol, is trinitrotoluene and is used as the explosive charge for all submarine mines. It is a fine crystalline yellow powder manufactured by nitrating toluene, is relatively insensitive to friction or ordinary shock, insoluble in water, very stable in storage, and very powerful when detonated. Its melting point is about 81° C., and its specific gravity in powdered form is about 1.55. It has no dangerous chemical action on metals.

(2) TNT is supplied in wooden boxes doubly lined with wax paper. Boxes contain either 50 or 100 pounds of explosive.

b. Storage and care.—(1) TNT will be stored in a perfectly dry place, preferably in a magazine, where the temperature does not go above 100° F. If it is not practicable to store it in a magazine it will be stored in the dryest place available where it is protected from all fire risks.

(2) The boxes will be stored in tiers with the marked end out, the bottom tier resting in skids.

(3) TNT is relatively safe to handle, but the same care should be observed in storing and handling as with other high explosives.

(4) If from any cause the boxes of explosive are wet and there is reasonable assurance that the interior has become wet, a box will be selected and opened. If the interior is wet, a full report on the circumstances will be made to the Chief of Coast Artillery, through military channels. The boxes will be opened and the contents dried in open air, out of the direct rays of the sun. Boxes containing TNT should always be opened out of doors, never in a magazine, and non-sparking tools should always be used.

(5) TNT may be stored with wet guncotton (15 per cent water based on dry weight of the explosive), explosive D, and dynamite. For information concerning storage of quantities of explosive and safe distances for such storage, see Section XV, TR 1370–A.

c. Inspection.—Inspection at forts will be limited to seeing that the rules for storage and care are strictly observed. Technical inspections will be made when required by the Ordnance Department.

SECTION XIX

PLANTING EQUIPMENT

	Paragraph
Measuring reel and frame (fig. 67)	180
Snatch blocks	181
Triplex block, 2-ton	182
Come-along (fig. 68)	183
Mine and anchor davits	184
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Eyebolt	188
Cable bracket	189
Sprocket wheels and chain	190
Grapnel (fig. 71)	191

180. Measuring reel and frame (fig. 67).—*a.* This is a device for handling the measuring line used in marking out the mine field.

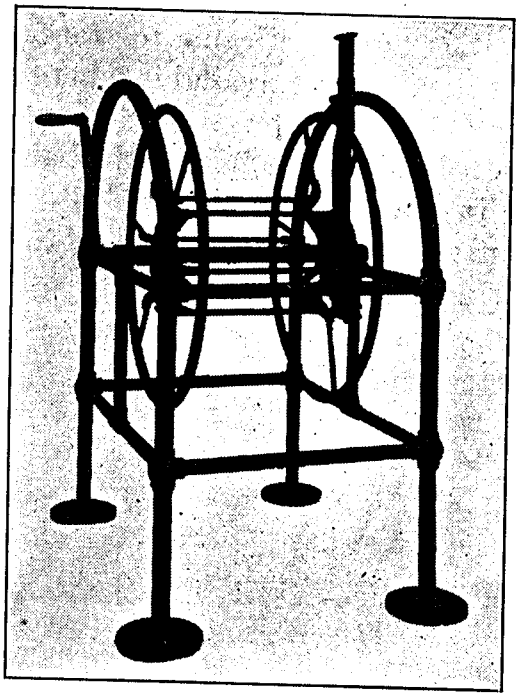

FIGURE 67.—Measuring reel and frame

It consists of a reel, axle, frame, brake, footplates, and crank handle. The approximate overall dimensions of the device are 26 inches wide exclusive of crank, 31 inches long, and 43 inches high to the top of the brake lever. The reel, axle, and frame are made of steel tubing and rods.

b. The brake operates by friction applied by hand levers, and consists of a steel drum 4½ inches in diameter secured to one end of the axle and acted upon by two vertical levers shaped to fit the drum

and hinged to the vertical brace on the end piece of the frame. A link is provided with which the two levers may be locked together to hold the reel in any desired position.

c. While the above is the standard measuring reel and frame, there are a number of old style wooden ones in service. This wooden measuring reel and frame is about 5½ feet long, 36 inches high, and 24 inches wide, and consists of a wooden reel with two heads 24 inches in diameter and 2½ inches thick and a drum 31 inches long and 8 inches in diameter, mounted on a wooden frame with iron rod braces and an iron crank handle.

181. Snatch blocks.—*a. 12-inch block.*—For use in changing the direction of pull on the fall of rope, such as when lifting mine cases from the water to the deck of the planter, the block being attached to the mine davit; or for changing the direction of pull on single-conductor cable when taking it over the cathead, the block being attached near the deck on the opposite side from the cathead. It is a black japanned commercial block with a 6¼-inch sheave, self-lubricating metalline bushing, a hollow steel shell, wrought-iron straps, extra heavy swivel hook, and safety locking link.

b. Special 24-inch block.—For use when paying out, or taking in, the shore cable over the bow of the mine planter. It is a special galvanized block with a 10-inch cast-iron sheave, a bronze bushing, forged-steel shell, heavy swivel eye, and a locking link and pin. The end of the steel sheave pin contains an oil hole for lubricating the bushing.

182. Triplex block, 2-ton.—*a.* These are fastened to the mine and anchor davits for lifting mines and anchors aboard the mine planter, and for lifting mines and anchors from the deck and supporting them over the water ready for planting. They are commercial spur-gear chain blocks designed for handling weights up to 2 tons. These blocks have been furnished with 20 feet of load chain and 20 feet of hand chain for use with the 9½-foot anchor and mine davits and for the 10-foot anchor davits; with 24 feet of load chain and 28 feet of hand chain for the 13½-foot mine davits; and with 25 feet of load chain and 30 feet of hand chain for the 15-foot mine davits.

b. Lubrication is an important factor, and the blocks should be kept well lubricated by occasionally placing a few drops of lubricating oil in the 4 oil holes.

c. For continuous easy lifting, one man accustomed to the work can lift 1 ton of 2,000 pounds, 3 feet in one minute. One man can handle 2,600 pounds without exerting a pull of more than 80 pounds.

A 120-pound pull on the hand chain is required to life 2 tons (4,000 pounds). To lift a load 1 foot, the operator pulls 42 feet of hand chain.

183. Come-along (fig. 68).—A device, about 15 inches long, for gripping single-conductor cable when it is desired to exert a strong pull in order to haul tangled cable aboard, or loosen cable from some obstruction on the ocean bottom, when sufficient cable is not aboard to obtain the necessary purchase. It is made of forged steel and is a toggle arrangement which grips the cable between two scored jaws when a pull is exerted on the handle. The jaws are separated by pushing in on the handle. A 1½-inch eye in the end of the handle provides for attaching a rope to pass over the cathead.

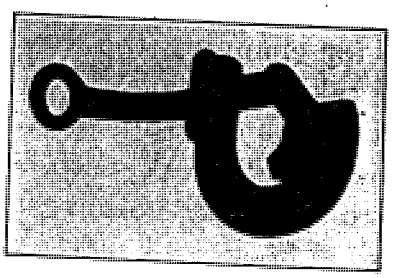

FIGURE 68.—Come-along

184. Mine and anchor davits.—*a.* These are for use in hoisting mine cases and anchors aboard the planter and for supporting mines and anchors over the water prior to planting. They are furnished in various sizes, the longer davits being designed for handling the long cylindrical mine cases. The length, or height, of a davit is the vertical distance of the highest part of the davit proper above the deck, and is not the length measured along the line of metal.

b. A davit is made of wrought steel or forged steel. It is tapered at the bottom to fit in the deck-plate socket, and the upper portion is tapered and finished with an eye to which the triplex block is fastened. The davit is secured to the planter by means of a deck plate and a rail plate. The deck plate is fastened to the deck by means of lag screws, bolts, or rivets. A hardened tool steel disk, upon which the end of the davit rests, is provided for placing in the bottom of the deck-plate socket. The rail plate, through which the davit passes, is fastened to the rail of the planter by bolts. A steel collar, fastened to the davit close under the rail plate by set screws, prevents any upward movement of the davit.

c. There are two types of rail plates, those without davit turners and those with davit turners. Where a davit turner is not provided, the davit is maneuvered by ropes attached to a swivel plate at the

upper end of the davit, and is locked in the inboard or outboard position by means of a locking pin which passes through a hole in the locking plate and a corresponding hole in the rail plate. The locking plate is fastened to the davit just above the rail plate by means of set screws.

d. A davit turner consists of a bronze gear wheel keyed to the davit, a steel worm which engages the bronze gear wheel, and a crank handle. The worm is supported by two lugs cast integral with the rail plate and provided with cap squares. The worm and bronze gear wheel should be kept well lubricated when in operation.

185. Trip hook (fig. 69).—*a.* A device designed to enable any load up to 6,000 pounds to be released readily from it by pulling up a brass collar against a spring, which permits the end of the

FIGURE 69.—Trip hook

hook to drop down and release its load. One of these hooks is attached to the end of the load chain of each triplex block suspended from a mine or anchor davit. The hook engages the mine, or anchor, which is suspended over the water from the davit, thus permitting the mine, or anchor, to be dropped into the water at any desired moment while planting.

b. The complete hook is about 20 inches long and consists of a forged steel hook with a removable swivel head. The tip of the hook is pivoted about the hook proper with an arm extending up between the two sides of the hook proper so that the end of the arm is covered by a brass collar around the hook. A locking pin, which is attached to this collar, is inserted through a hole in the collar and hook to lock the tip of the hook in its normal position. A phosphor bronze spring above the collar holds the collar in its lower position

over the hook tip arm. By removing the locking pin and pulling up on the collar by means of a lanyard attached to a ring on the collar and passing through an eye above the collar, so as to give an upward pull on the collar, the arm of the hook tip is released from under the collar and the hook tip is free to drop and release its load. The spring and collar may be replaced by removing the nut from the shank of the bolt and then removing the swivel head.

c. While the above description covers the standard 3-ton trip hook, there are a number of 2-ton hooks in service.

186. Cathead (fig. 70).—A device used when taking up single-conductor cable and raising rope, the cable and rope passing over a sheave in the end of the cathead. It consists of two channels about

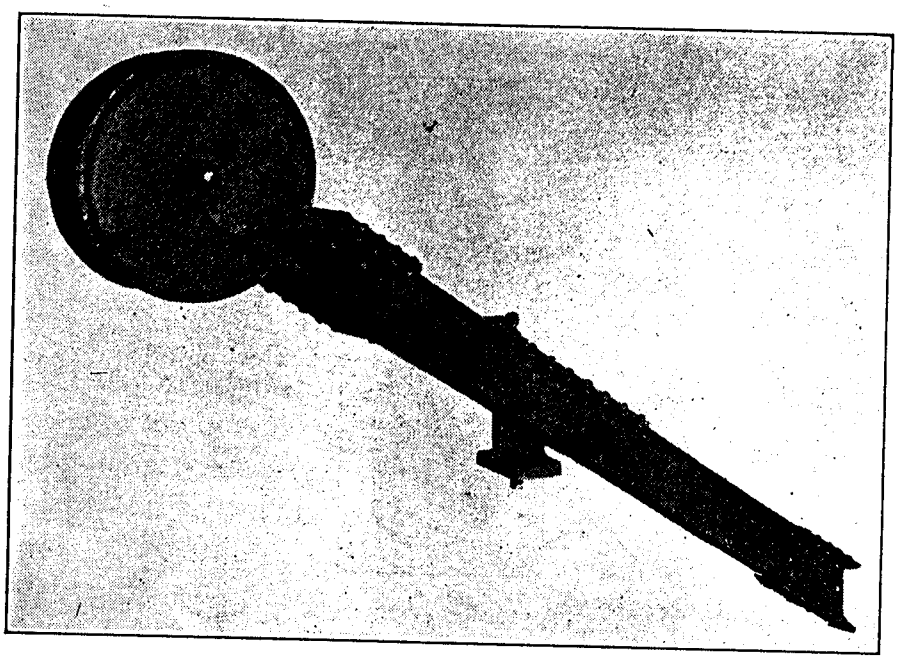

FIGURE 70.—Cathead

8 feet long, bent to the proper shape and riveted together by means of steel plates, the upper end being about 9 inches square; a cast steel head socket riveted and bolted securely in place at the upper end; a cast steel rail shoe, riveted between the channels, which fits in a socket on the boat rail to prevent lateral movement; and a cast-steel sheave, 18 inches outside diameter and 10 inches inside diameter, mounted in a cast-steel sheave shell 23 inches in diameter, with a 3-inch shank which fits into the head socket and is held in place by a nut and washer on the end of the shank. The head socket and sheave are furnished with bronze bushings. The lower end of the cathead is shaped so as to fit into a cast-steel deck socket, about 1 foot square, which is bolted to the deck. A ring for handling the cathead is riveted in place on the upper side.

187. Deck plate for cable-reel jack.—This is a device which is set into the deck of the planter and is used to fasten the cable-reel jack to the deck; two are required for each jack. It consists of a ½-inch steel securing plate 8 inches square, a cast-steel deck casting 3½ inches square and 3¼ inches high, four ½ by 4½ inch steel bolts for securing the plate and casting to the steel deck under the wooden deck of the planter, and a ⅞ by 8 inch bolt with washer and nut for securing the jack to the deck plate. Where an under steel deck is not available, a hole should be drilled in each corner of the securing plate and the plate fastened to the bottom of the wooden deck by large wood screws.

188. Eyebolt.—This is set into the deck of the planter, in prolongation of the cathead, for attaching a snatch block through which to pass the raising rope on its way from the cathead to the gypsy head of the winch. It consists of a 6-inch square cast-steel deck socket, an eyebolt with a 2½-inch threaded end which screws into the deck socket, and a 2½-inch threaded plug for filling the hole of the deck socket flush with the deck when the eyebolt is not being used. The socket is fastened to the deck by four ¾ by 5½ inch bolts with countersunk heads.

189. Cable bracket.—For supporting the single-conductor cable overhead along the sides of the planter prior to planting. It consists of a 1½-inch steel rod bracket about 4 feet long, the outer end being offset 2 inches, 1 foot from the end and the end turned up at right angles for 2 inches, a steel socket with two bolt holes for fastening it to the deck house so as to support the end of the bracket, a steel plate with a hole for supporting the bracket about 15 inches from the turned-up end, and a ½-inch steel stud to be tapped into the bracket just behind the plate to prevent the end of the bracket from pulling out of the socket. A slot is provided in the plate at the upper part of the hole so that the bracket may be removed by turning it until the stud can be pulled through the slot in the plate.

190. Sprocket wheels and chain.—For transmitting the power of a winch to the cable reel when taking up shore cable. It consists of two 7-tooth cast steel sprocket wheels (outside diameter 13½ inches), and a sprocket chain for connecting the two. One sprocket wheel fits the cable reel axle and the other fits the winch axle, to which they are keyed. The chain, which is about 20 feet long, may be shortened by the easy removal of links.

191. Grapnel (fig. 71).—A special heavy 2-prong device for grappling for heavy cable on the ocean bottom. It is made of 2-inch square steel, is about 2 feet high, and is W in shape with the two prongs offset in opposite directions and an eye in the center for attaching a rope.

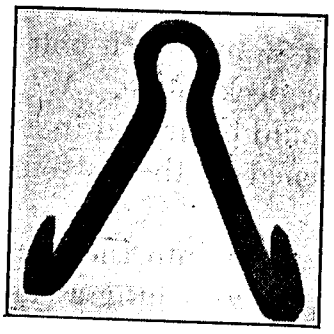

FIGURE 71.—Grapnel

PART FIVE

SHORE DUTIES

	Paragraphs
SECTION XX. Preparation of anchors, mooring ropes, raising ropes, and accessories for planting	192–199
XXI. Loading-room duties	200–209
XXII. Preparing cables	210–211
XXIII. Preparing mines for submine target practice	212–213
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SECTION XX

PREPARATION OF ANCHORS, MOORING ROPES, RAISING ROPES, AND ACCESSORIES FOR PLANTING

	Paragraph
Automatic anchors, Model 1916	192
Mooring ropes	193
Raising ropes	194
Shackles	195
Sister hooks	196
Mine buoys	197
Marking buoys	198
Selector box	199

192. Automatic anchors, Model 1916.—Each anchor should be thoroughly overhauled to see that all parts function properly and that no parts bind. Thoroughly clean the brake drum, the journals, and all finished parts of the pawl, pawl recess, pawl lock, and pawl stop, then cover them with a light coat of oil except the brake drum, which should be free from oil when the anchor is

planted. Attach the mooring rope as described in paragraph 159 *f*, place the cover on the base and bolt it down, and carefully check all the adjustments described in paragraph 159 *b*. (See par. 225 *c*.)

193. Mooring ropes.—After determining the size of rope to use (par. 163 *c* (1)), the various lengths should be cut as shown in paragraph 163 *d*. If the ropes are to be used with cast-iron anchors a thimble and clips should be attached to each end of each rope and the ends of the ropes whipped with marline; if the ropes are to be used with Model 1916 automatic anchors, one end of each rope should be fastened to an anchor reel by means of an end fitting or socket as described in paragraph 165 *b* or 166 *b*, and the rope coiled on the reel, the free end passed up through the roller box of the cover, and a thimble and clips attached as shown in Figure 55.

194. Raising ropes.—After determining the size of rope to use (par. 163 *c* (2)), cut each raising rope equal to the depth of water plus 80 feet (par. 163 *e*) and whip the ends with marline.

195. Shackles.—Attach a shackle to each thimble on each mooring rope, making sure that the pins and cotters readily fit into place. Where cast-iron anchors are to be used, see that there is enough clearance around the bail of each anchor for attaching the shackle, otherwise sister hooks will have to be used. Attaching the shackles to the ropes at this time insures their being at hand when needed.

196. Sister hooks.—Where these are to be used they should be attached to the shackle pin in the usual manner when the shackle is attached to the mooring rope as described in paragraph 195. Attaching the hooks at this time not only insures that they will fit the shackle pins, but also prevents their being misplaced. When old style sister hooks are used, old style shackles must also be used (par. 162 *b*).

197. Mine buoys.—Paint the tactical number of the mine on each buoy; this will be of use in case some of the buoys disappear after planting. Cut the required number of 60-foot lengths of ½-inch cotton rope (measuring line), pass one end through the hole in the buoy and make secure by means of a bowline, fasten the other end within the bowline, draw the double rope taut, and mark the rope every 5 feet as described in paragraph 171 *c*.

198. Marking buoys.—Where the keg buoy is used, see that the bunghole is securely plugged, attach a chain bridle to each keg as described in paragraph 172 *b*, and place the required number of kegs in the loading-room tank to soak and test for leaks. Where the steel buoy is used, clean the threads of the buoy, cover the buoy and plug threads with rubberoid, screw the plug into place so as to make

a water-tight connection, and place the buoys in the loading-room tank to test for leaks.

199. Selector box.—*a.* The selector box is prepared and tested in the casemate. For a description of the selector box and the mounting of the selector in the selector box, see paragraph 99. Short pieces of loading wire are connected to the selector box in the casemate (see *b* below), and the shore and mine cable conductors connected to these short pieces by water-tight joints made on the distribution box boat.

b. Cut 20 pieces of good loading wire about 12 inches long and prepare and connect each piece to the selector box cover as follows:

(1) Dip a sharp knife blade in water and make a shallow cut around the insulation about half an inch from the end. Cut deeply into the insulation from this cut to the end of the conductor and

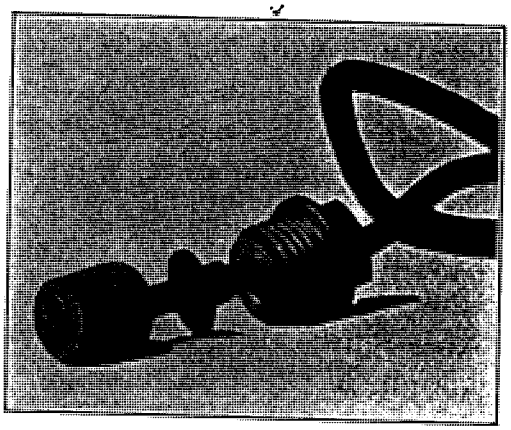

FIGURE 72.—Assembly of water-tight connector

remove the insulation, which should leave the conductor protruding one-half inch from the squared end of the insulation.

(2) Thread a small brass washer over the end of the conductor, separate and clean the strands, and with the washer in contact with the squared end of the rubber insulation, bend each strand down across the washer, spacing them equally, and cut off the ends extending beyond the washer (fig. 72).

(3) Thread a new rubber packing, a brass gland, and a brass follower from the selector box, over the other end of the wire in the order shown in Figure 72. Push the rubber packing, gland, and follower forward as far as they will go (rubber packing in contact with the washer).

(4) With the follower and packing held between the forefinger and the thumb, and with the loading wire gripped in the other fingers of the same hand, enter the assembly into a connector recess of the selector box cover and push forward until it can be felt that the

bent ends of the conductor are in contact with the head of the contact screw in the bakelite bushing. Hold the conductor firmly in this position and start the follower in. If the conductor and the packing are properly seated, two full turns can be given the follower with the fingers; then complete the screwing home of the follower by using the open-end wrench supplied for the purpose.

c. Test the selector box for operation connected to a test bank of 19 mine transformers in the casemate (fig. 29).

SECTION XXI

LOADING-ROOM DUTIES

	Paragraph
Making a telegraph joint	200
Insulating a joint	201
Making a water-tight joint	202
Mounting selector box in distribution box	203
Testing fuzes	204
Preparing a compound plug for service	205
Testing assembled compound plug	206
Loading a mine	207
Testing loaded and assembled mine case	208
Unloading mines	209

200. Making a telegraph joint.—Remove the insulation from the ends for 1½ inches and brighten the wires. Place the ends to be joined across each other about one-half inch from the insulation, so as to make an angle of about 45° with each other. Grasp the wires firmly at the junction and wind each free end tightly around the other wire for at least four turns, with the winding in opposite directions. Trim the ends of the wires so they will be smooth and present no sharp points.

201. Insulating a joint.—Cut a piece of rubber tape about 2 inches long with diagonal ends, the cuts being made so that both acute angles, or both points, are on the same edge of the tape, resulting in a short edge and a long edge. Stretch the tape and remove the paper or cloth covering. Starting at a point about three-fourths inch back on the insulation, with the long edge of the tape toward the joint, wind the tape around the joint under tension so that each turn covers the previous one about one-third its width. Continue the wrapping until the same amount of insulation is covered at each end, then work the wrapping back over the joint and secure the end by pressing it firmly a short time or by placing a drop of rubber cement under it.

202. Making a water-tight joint.—*a.* Join the wires by means of a telegraph joint (par. 200). Scrape the insulation clean for about 2 inches on each side of the joint, and cover the scraped insula-

tion with rubber cement and allow it to set, which takes about one minute. Cut two pieces of rubber tape about 4 inches long with diagonal ends, the cuts being made so that the two points are on the same edge of the tape. Stretch the pieces of tape and remove the paper or cloth covering. Beginning about 1½ inches along the insulation, wrap the tape, with the long edge toward the joint, firmly and tightly (under tension) until about one-fourth inch of the insulation on the other side is covered, then wind the tape back and forth over the joint so as to taper toward the ends. With the other piece of tape, begin at the other end and wrap as before. The finished insulation should be thick at the middle and taper toward the ends, and should be firm and tight. Cover the insulation with tin foil to distribute uniformly the vulcanizing heat along the joint and prevent burning the insulation, wrap the tin foil with friction tape, and vulcanize the joint for from 30 seconds to 1 minute, depending upon the intensity of the heat applied. After vulcanizing, remove the friction tape and tin foil, inspect the joint, and wrap with new friction tape, using two pieces, starting at opposite ends and overlapping.

b. It is only by the application of the proper amount of cement and careful wrapping and heating that the rubber tape will adhere properly to the insulation at both ends of the joint. When applying the rubber tape it should at all times be kept stretched hard, and the hands kept free from oil or grease.

c. A set of rules for the *time of heating* for a water-tight joint may be stated as follows:

(1) Be sure the flame is not hot enough to set fire to and burn the friction-tape covering.

(2) See that the flame is not so broad as to make it impossible properly to heat the ends of joint without burning the rubber insulation on the wire.

(3) Keep the joint turning in the flame to heat all sides uniformly and be sure to give the ends plenty of heat.

(4) Apply the heat until the joint becomes so warm that it may be held between the fingers but not gripped in the hand. This will eliminate the time factor of heating, as the different kinds and sizes of flames will impart the heat at different rates.

(5) If a piece of waste soaked in alcohol, gasoline, or kerosene is used for a torch, use only a very small piece of waste. This may be gripped in a pair of pliers or fastened to the end of a piece of wire or iron rod.

(6) The best way to heat a joint is to use the small alcohol lamp supplied for this purpose.

203. Mounting selector box in distribution box.—After the selector box has been assembled and tested in the casemate, mount it in the distribution box as described in paragraph 99 *d*.

204. Testing fuzes.—Fuzes are tested by means of a hook-up similar to that described in paragraph 97. The testing wires or leads are carried to the fuze testing receptacle outside the building and the fuze leads joined thereto, care being taken to see that all switches are open while this is being done (par. 97 *g*). A full deflection should be obtained when the circuit is closed through the fuzes.

205. Preparing a compound plug for service.—*a*. First test the mine transformer and secure the upper end of the black wire to the binding post in the neck of the transformer, as described in paragraph 96 *b*. Screw the ball seat home, coat the transformer threads with rubberoid, hold the assembled circuit closer (pars. 96 *e* and 96 *f*) upside down, and screw the transformer into it. For a description of the assembling of the various types of compound plugs from this point on, see paragraph 177 *e*, *f*, and *g*.

b. After the plug tests satisfactorily, set up all set screws.

c. When compound plugs are prepared for drill or for instruction purposes, omit the rubberoid from the screw threads, and take care that the transformer leads are not needlessly shortened.

206. Testing assembled compound plug.—See paragraph 177 *h*.

207. Loading a mine.—*a*. Spread a piece of canvas or a paulin on the floor of the loading room and place a loading skid on the canvas. Bring the mine case from the storeroom to the loading room and place it on the loading skid with the loading hole up. Remove the plug, inspect the interior of the mine case for any foreign substance, and thoroughly clean the screw threads. Put an iron bar through the holes in the sides of the skid and through the maneuvering ring of the mine case to prevent the case from falling over and from turning while the compound plug is being screwed home. Bring a box of trotol from the explosive house and insert a loading funnel into the loading hole. The charge for a 32-inch mine case is 100 pounds of trotol, and for the larger sizes 200 pounds. Pour the trotol into the mine case through the funnel, spreading it out, if necessary, so that there will be ample room for inserting the compound plug. Only one box of trotol for each mine being loaded should be brought into the loading room at one time.

b. After the proper amount of trotol has been placed in the mine case, thoroughly clean the screw threads and then coat them with rubberoid to make a water-tight connection. Coat the threads of the

compound plug with rubberoid, lay a lead washer (5⅝ inches inside diameter) over the loading hole, and screw the compound plug into the mine case with the socket wrench, taking care to see that the lead washer is properly centered between the plug and the mine case as the plug is tightened so as to give the same amount of bearing surface all the way around. Badly deformed lead washers should not be used, as they are likely to have too slight bearing surfaces at some points. To insure setting the compound plug tight, tap the end of the socket wrench lever a few times with a large mallet.

c. Bolt the mine cap to the mine case and put the mine into the testing tank for test, where it should remain for from 2 to 12 hours, depending upon the time available. The mine should show practically the same resistance as the compound plug. Upon completion of this test, take the mine from the tank, push the loading wire inside the cap to avoid injury in handling, and load it on a hand car for transportation to the planting wharf.

d. When through loading mines, the canvas on the floor should be taken up and thoroughly cleaned, the floor of the loading room scrubbed, and all refuse destroyed.

e. The precautions to be observed in handling trotol are given in paragraph 179.

208. Testing loaded and assembled mine case.—After the mine has been in the testing tank for from 2 to 12 hours, carry one of the testing leads (par. 97 *a*) to the loading wire and the other lead to the mine case. There should be a poor circuit with the mine vertical and a good circuit when the mine is tipped beyond 45°.

209. Unloading mines.—*a.* Trotol may be unloaded from mines without danger, but the usual precautions in handling high explosives must, of course, be observed (par. 179).

b. Remove the mine cap and the compound plug, place a piece of canvas or a paulin on the floor, and by means of a triplex block raise the mine case by its maneuvering ring and pour the trotol out into the original boxes; then close the boxes.

c. Carefully examine the trotol when it is removed from the mine case, and if there is indication that any of it has undergone a change while in the mine case, a report should be made to the Chief of Coast Artillery.

SECTION XXII

PREPARING CABLES

Paragraph
Figure 8's 210
Making a Turk's-head 211

210. Figure 8's.—*a.* Take a reel of tested single-conductor cable from the cable tank and place it on cable reel jacks. Cut about 20 feet from the end so as to eliminate that part which was above water during storage. Unreel the cable and cut it to the following lengths:

Mine numbers	Length to cut
1 and 19	1,425 feet plus twice the depth of water.
2 and 18	1,225 feet plus twice the depth of water.
3 and 17	1,025 feet plus twice the depth of water.
4 and 16	825 feet plus twice the depth of water.
5 and 15	725 feet plus twice the depth of water.
6 and 14	625 feet plus twice the depth of water.
7 and 13	525 feet plus twice the depth of water.
8 and 12	475 feet plus twice the depth of water.
9 and 11	425 feet plus twice the depth of water.
10	375 feet plus twice the depth of water.

Carefully tag each end of each length with the number of the mine for which it is cut, and work a Turk's-head on each end of each length as described in paragraph 211.

b. Coil each length in a figure 8 by the use of an improvised rack, in order to secure uniformity in the size of the coils. This rack is made of a 4 by 6 inch timber 12 feet long crossed at right angles by two 4 by 6 inch timbers 6 feet long placed 5 feet apart with each crosspiece 3½ feet from the nearer end of the 12-foot timber. A hole is bored through each of the timbers about 2 feet from each crossing (a total of 8 holes), and a 3-foot length of pipe inserted in each hole. These pipes make the form on which the coils are made. The diameter of the holes depends upon the diameter of pipe to be used; 1½-inch pipe is better than 1-inch pipe, as the larger size will not bend so easily. The holes should be large enough to permit inserting and removing the pipes easily, as the easiest way to remove the figure 8 from the rack is to remove the pipes.

c. A cable must be coiled for planting so that both ends are free, one end to be passed to the distribution box boat and the other to be carried forward on the planter and attached to the mine. This is accomplished by starting the figure 8 about 135 feet from the mine

cap end, which is the approximate length required to run forward to attach to a mine when using a mine planter. Coil the cable on the form, spreading out the laps at the center to reduce the height at that point, until the entire length is coiled. Lash the outer loops and the center of the figure 8, leaving ends of the lashings long enough to lash the 135 feet of cable remaining uncoiled. Coil the 135 feet of cable for the mine end on top of the coil and lash it with the ends of the lashings.

d. Test the figure 8's for continuity of circuit and grounds by the use of a bridge-megger, before placing them aboard the planter. For instructions covering the testing of cables, see TR 1160–15.

e. After the cable has been coiled and tested, it should be handled most carefully so as not to spoil the coil. Never let the ends outside the Turk's-head hang loose, but have somebody carry them. Much trouble is caused by letting the Turk's-head bob around and strike objects, which often breaks the conductor and injures the insulation.

f. Figure 8's are raised and lowered into the cable tank by means of a cable yoke, which is made locally. It consists of an 11-foot length of 4 by 6 inch scantling with three hooks on the lower side (one near each end and one in the center) and a ring on the upper side at the center for hoisting. The three lower hooks, which are secured to the scantling by bolts and rings, hook into the lashings on the cable. Washers should be placed under the bolt heads. A traveling crane with a triplex block is used to raise and lower the yoke and figure 8.

211. Making a Turk's-head.—Trim the ends of the cable square and place a wrapping of four or five turns of marline about 15 inches from the end. Slip a Turk's-head collar, flat side first, on the cable until it rests against the marline wrapping. Bend back regularly the armor wires over the collar, and unwind and trim the jute covering to the collar. Cut all the armor wires with pliers so as to remove all but 4 inches and 6 inches from alternate strands. Bend the armor wires separately to fit the collar closely, making two right angles with the pliers, and arrange the ends smoothly along the cable. Take a piece of marline 15 feet long for single-conductor cable, and 24 feet long for multiple, engage one end under one of the wires near the collar, wrap it regularly and closely around the cable, and secure the free end with two half hitches.

SECTION XXIII

PREPARING MINES FOR SUBMINE TARGET PRACTICE

Paragraph
Modification of matériel 212
Preparation of mine and compound plug 213

212. Modification of matériel.—The compound plug with old model fuze can be used for submine practice, and in order to prepare

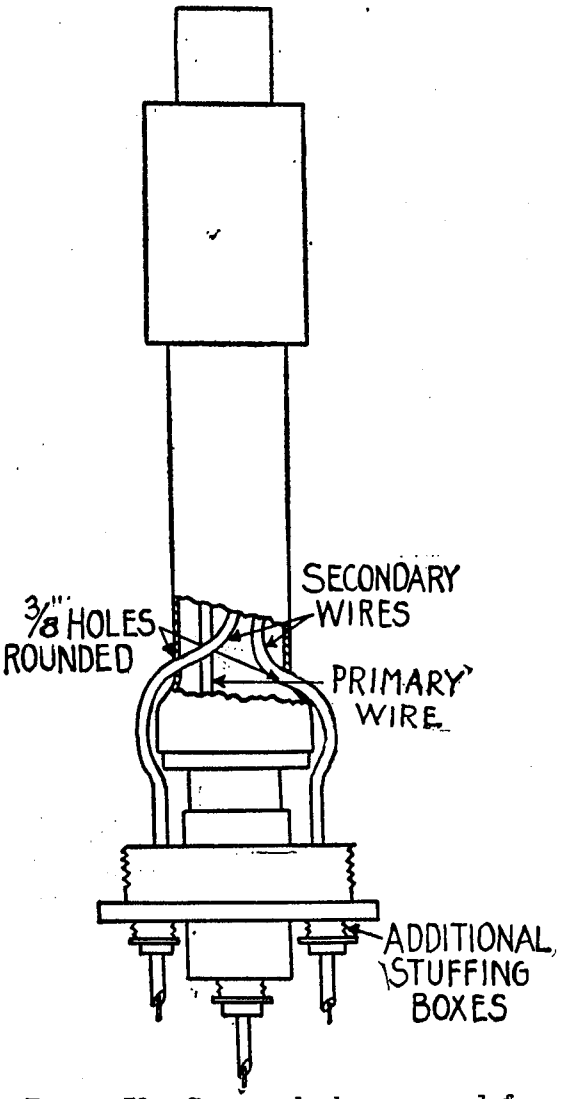

FIGURE 73.—Compound plug prepared for submine

the plug for this purpose the following modifications are necessary:

a. Old model fuze can.—Drill two 3/8-inch holes on opposite sides of the fuze can just above the reinforce (fig. 73), and smooth the inside and outside edges of the holes so that they will not cut the secondary wires.

b. Plug proper.—Prepare two additional stuffing boxes in the plug proper as shown in Figure 74. These will be 180° apart and as near the flat faces of the socket wrench nut as the size of the follower will permit.

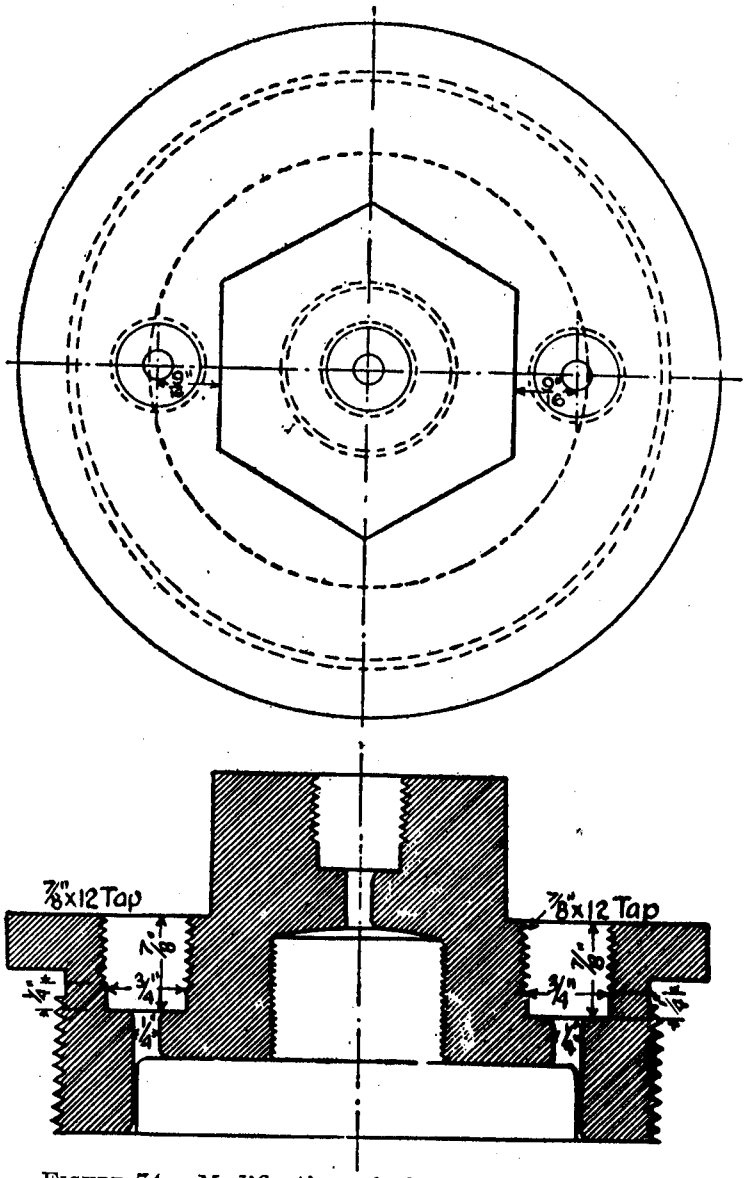

FIGURE 74.—Modification of plug proper for submine

213. Preparation of mine and compound plug.—*a.* Test the transformer and assemble the transformer and circuit closer as described in paragraph 205.

b. (1) Cut a piece of loading wire about 17 feet long, bare one end and join it, by means of a telegraph joint, to the primary terminal of the transformer, and tape the joint. Cut another piece of loading wire about 15 feet long, bare both ends and connect one end to one of the secondary wires of the transformer by a telegraph joint, and

tape the joint. Cut a piece of loading wire about 3 feet long, bare one end and join it to the other secondary wire of the transformer by a telegraph joint, and tape the joint.

(2) Draw the primary wire and the two secondary wires (one long and one short) through the fuze can and screw the fuze can on the transformer. Lead each secondary wire through one of the 3/8-inch holes in the fuze can and wrap the secondary wires around the fuze can for convenience in handling. Draw the primary wire through the fuze-can cap and the plug proper, secure it therein in the usual way by means of rubber packings, brass glands, and followers, and completely assemble the compound plug. Unwrap the secondary wires from the fuze can and lead each secondary wire through one of the holes prepared in the plug proper.

(3) Insert the assembled plug in the mine case, coil the wires on top of the plug, and screw it home in the usual way with rubberoid on the threads, taking care not to injure the primary and secondary wires. When using the socket wrench to tighten the plug, pass the primary wire through the center of the wrench, coil both the primary and secondary wires, and have one man hold the coils while another man tightens the plug. Thread a rubber packing, brass gland, and follower on each secondary wire, cover the threads of the follower with rubberoid, and force the packing and gland into their seat in the plug proper by means of the follower. Coil the three wires to prevent injury, and fasten the mine cap to the mine case in the usual way.

(4) After the mine has been loaded on the planter, remove the apron clamp from the mine cap, insert the cable Turk's-head, and make a water-tight joint between the single-conductor cable and the primary loading wire by cutting into the insulation of the primary wire near the mine so as to make a T joint. Great care should be taken in making this T joint to insure that it is water-tight. Then lead the long and short secondary wires and the primary wire out through the mine cap, and fasten the apron clamp to the mine in an inverted position. Fasten the short secondary wire to the long secondary wire by a few turns of friction tape a few inches from the end of the short wire (fig. 75).

(5) Cut a piece of loading wire about 2 feet long, bare one end, and connect two fuzes in parallel between the terminals of the long secondary wire (15-foot length) and the 2-foot wire (fig. 75), and tape the joints. Carefully clean an empty quart bottle and fill it about three-fourths full of TNT. Insert the fuzes and joints in the bottle and wrap the wires near the neck of the bottle with rubber

tape in such a way that the wrapping will serve as a cork for the bottle. Force this cork tightly into the neck of the bottle so as to make the bottle water-tight, and secure the cork to the bottle with friction tape in such a way that any strain on the leads will not loosen or extract the cork. A convenient way to make the cork water-tight is to pour warm ozite into the neck of the bottle above the rubber tape cork and allow it to harden. (Ozite is a black sub-

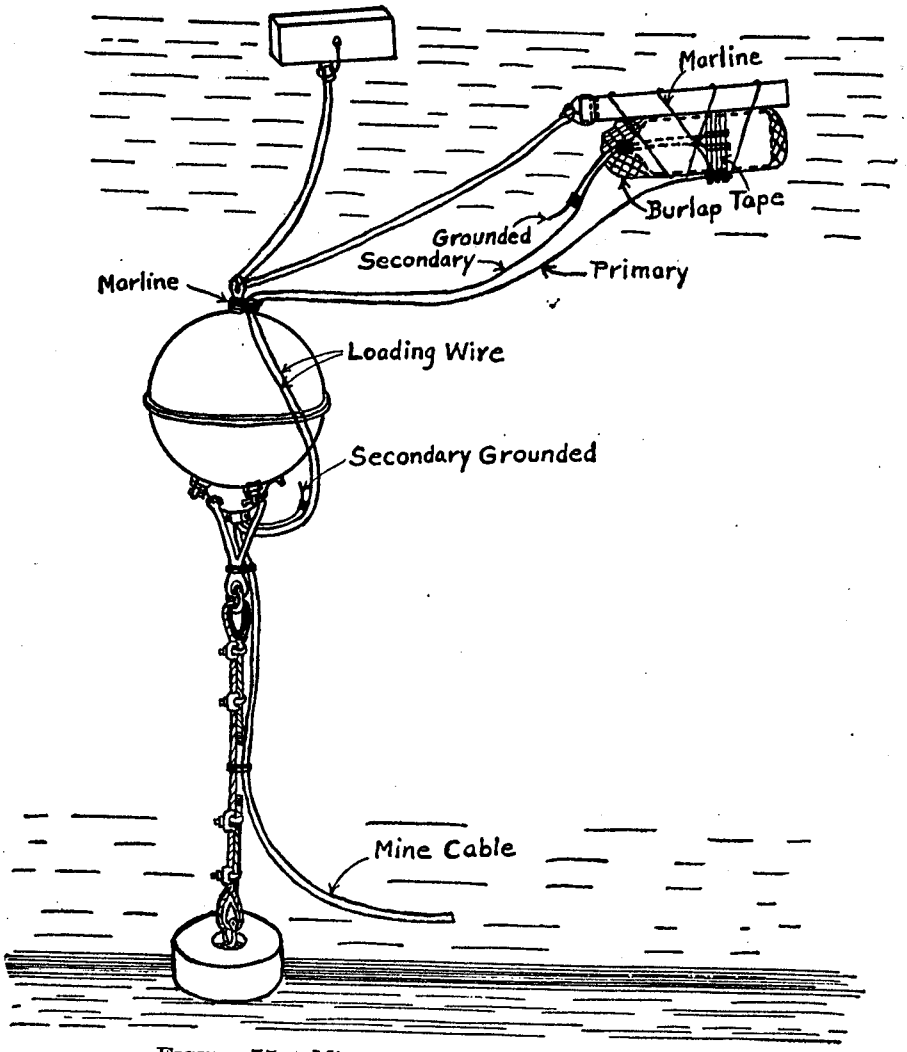

FIGURE 75.—Mine prepared for submine practice

stance used by electricians for making pot heads.) Fasten the 2-foot length of wire to the long secondary wire by a few turns of friction tape a few inches from the end of the short piece (fig. 75). The two short wires (one from the compound plug and the other from the bottle) serve as a long secondary wire, the two exposed ends of these short wires being grounded in the water. Make a water-tight thumb joint on the end of the primary wire, take two turns around the bottle with the end of the primary wire, and tape the wire to the

bottle with turns of friction tape. When the bottle explodes, the primary wire is grounded.

(6) Wrap the bottle of explosive with burlap to prevent breaking, and attach the wrapped bottle to an improvised buoy of sufficient size to keep the bottle and attached wires afloat. A piece of 2 by 6 inch planking about 2 feet long should make a satisfactory buoy, or float, with holes bored through for attaching the burlap-covered bottle by means of marline. The burlap may also be tacked to the float near both ends of the bottle by small nails. Attach this improvised buoy to the mine bail with a double length of marline or a piece of buoy line, a hole having been bored through one end of the buoy for this purpose. The length of the marline or buoy line should be such that there will be no pull on the primary and secondary wires leading to the bottle (fig. 75). To a hole in the other end of the float, attach a piece of marline for lowering the bottle to the water when planting the mine.

(7) Carry the primary wire and long secondary wire up to the maneuvering ring and lash them there (fig. 75).

(8) Place the bottle of explosive in a safe place near the mine, and attach the regular mine buoy to the mine in the usual way. When handling the mines, both before and while planting, take care not to injure the exposed wires.

SECTION XXIV

LOADING THE MINE-PLANTING FLOTILLA

	Paragraph
Responsibility for loading mine planter	214
List of equipment, tools, and supplies	215
Tool boxes	216
Arrangement of matériel on planter	217
Loading figure 8's	218

214. Responsibility for loading mine planter.—The mine planter commander is responsible for the proper loading of the mine planter, the work being done by the planting section, assisted by the loading and property section.

215. List of equipment, tools, and supplies.—The following table gives a suggested list of equipment, tools, and supplies to be taken aboard the various boats for mine planting. This is to serve merely as a check list, and will vary somewhat, depending upon local conditions.

On the planter	On distribution box boat	In each yawl
Alcohol.	Alcohol.	Anchor line.
Alcohol lamps.	Alcohol lamps.	Boat anchor.
Anchors.	Axe.	Boat hook.
Anchor shackles.	Boat anchors.	Can or bucket for bailing water.
Axe.	Boat hook.	Drinking water.
Cables.	Boat telephone.	Hatchet.
Cable cutter.	Buoys for junction boxes.	Heaving lines.
Cable tags.	Buoy ropes.	Knives (1 to each man).
Cotter pins.	Cable tags.	Life buoy.
Crank handle for automatic anchor.	Distribution box.	Life preserver (1 for each man).
Dry cells.	Drinking water.	Marline.
Friction tape.	G. I. wire, No. 14.	Megaphone.
G. I. wire, No. 14	Hacksaw and blades.	Notebook and pencil.
Grappling hooks.	Hammers.	Oars and locks.
Hammers.	Heaving lines.	Running lights.
Heaving lines.	Junction boxes.	Sounding line.
Kerosene.	Kerosene.	Supply of lashings.
Knives (one to each man of the planting section).	Knives (1 to each man).	
Letter and number dies.	Life buoys.	
Marking buoys.	Life preservers (1 for each man).	
Marking buoy ropes.	Marking buoy for distribution box.	
Marline.	Marking buoy ropes.	
Marlinespikes.	Marline.	
Matches.	Marlinespikes.	
Megaphone.	Matches.	
Mines.	Megaphone.	
Mine buoys.	Monkey wrenches.	
Mine shackles.	Notebook and pencil.	
Monkey wrenches.	Pliers.	
Mooring ropes.	Raising ropes.	
Pliers.	Red signal flag.	
Raising ropes.	Rubber cement.	
Rubber cement.	Rubber tape.	
Rubber tape.	Sounding line.	
Sister hooks.	Supply of lashings.	
Socket wrenches for automatic anchor.	Tinfoil.	
Socket wrenches for cable clamp bolt.	Turk's-head collars.	
Spring balance.	Waste.	
Tinfoil.		
Turk's-head collars.		
Voltmeter.		
Waste.		
Wire rope clips.		

216. Tool boxes.—As many as possible of the small articles listed in paragraph 215 should be carried in two tool boxes for use on the planter (one box for the starboard detail and the other for the port detail), and one tool box for use on the distribution box boat.

217. Arrangement of matériel on planter.—The mine planter will be loaded with the matériel for mine planting in the most suitable manner possible, depending upon the design of the mine planter and local conditions of employment. Figure 76 shows one arrangement which has proved to be suitable for the 165-foot type of mine planter, while Figure 77 shows an arrangement which has proved

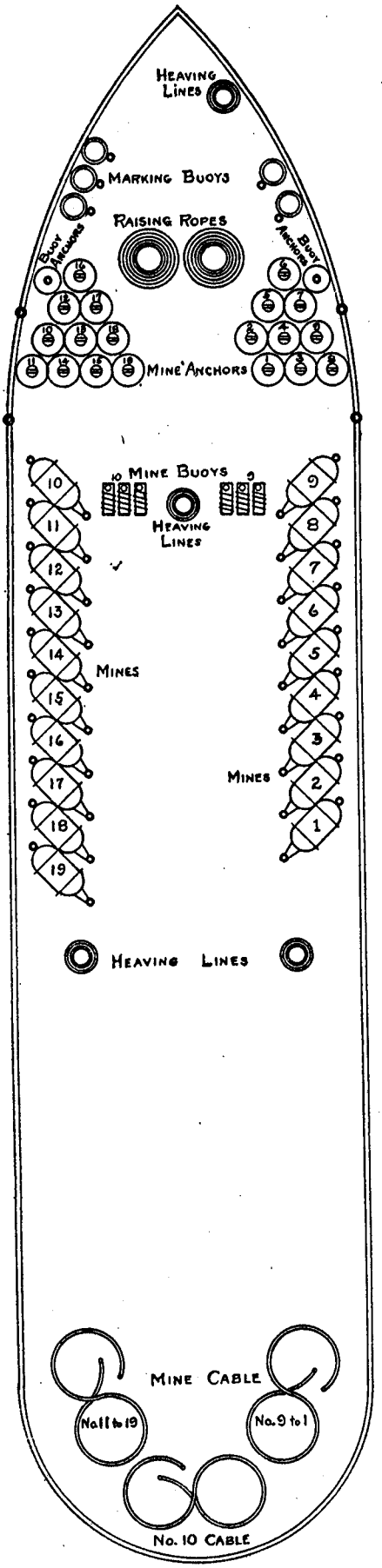

FIGURE 76.—Arrangement of matériel on deck of 165-foot mine planter

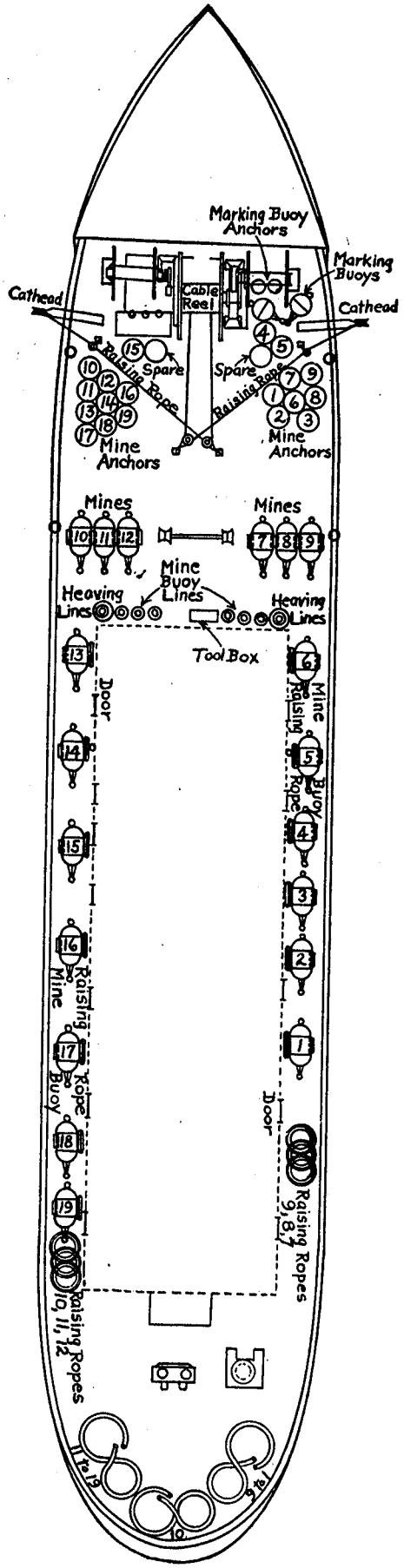

FIGURE 77.—Arrangement of matériel on deck of 172-foot mine planter

satisfactory for the 172-foot type of planter. The mine planter commander will supervise the loading of the mine planter, and he is authorized to vary either of these arrangements. Mines, anchors, and cables, Nos. 1 to 9, will be loaded on the starboard side of the vessel, and Nos. 10 to 19 on the port side, except that No. 10 cable is placed in the center aft. If cast-iron anchors are used, the mooring ropes will be coiled near the anchors.

218. Loading figure 8's.—*a.* Carry the single-conductor cables, coiled and lashed in figure 8's, to the after deck, or lower them to the after deck by means of the cable yoke and a derrick if available. Place coils Nos. 1 to 9 in one pile on the starboard side with No. 1 on the bottom (loaded first) and No. 9 on top (loaded last),

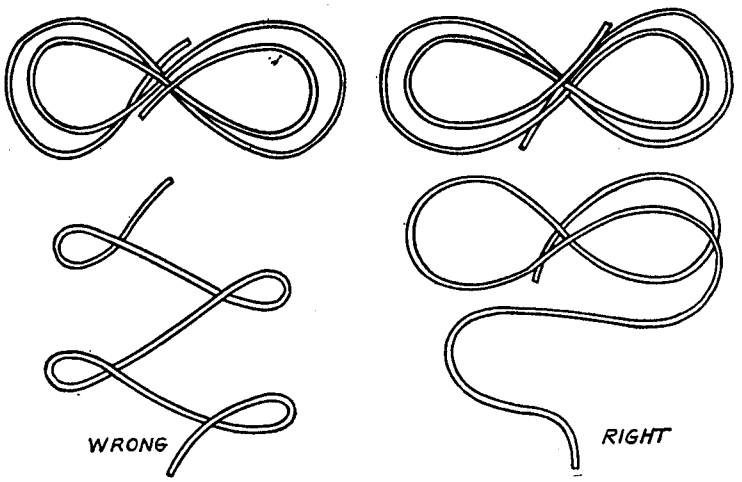

FIGURE 78.—Paying out mine cables

Nos. 11 to 19 in one pile on the port side with No. 19 on the bottom (loaded first) and No. 11 on top (loaded last), and No. 10 coil in the rear center of the after deck so laid that in paying out to the distribution box boat the cable will not drag across the figure 8 (fig. 78).

b. As each coil is placed in position on the planter, check both ends to see that they are properly tagged, then carry its mine cap end forward on the cable brackets close to the mine and lash each cable to each bracket with marline. To do this, use a piece of marline for each bracket long enough to lash each cable, in succession, to the bracket by means of a square knot. This permits each cable to be removed from the brackets by cutting the lashings of that particular cable without loosening the adjacent cable.

PART SIX

DUTIES ON THE WATER

		Paragraphs
SECTION XXV.	Locating distribution box and laying shore cable	219–221
XXVI.	Preparation for and conduct of planting	222–229
XXVII.	Maintenance of mine field	230
XXVIII.	Taking up mines and shore cable	231–233
XXIX.	Instructions for masters of mine planters	234
XXX.	Operations of distribution-box boat and mine yawls	235–236
XXXI.	Handling small boats	237–245

SECTION XXV

LOCATING DISTRIBUTION BOX AND LAYING SHORE CABLE

	Paragraph
Determining location for distribution box	219
Marking location for distribution box	220
Laying shore cable	221

219. Determining location for distribution box.—The locations for the lines and groups of mines are determined from an examination of the harbor chart and of the approved mine project. Mark the locations for the distribution boxes (about 350 feet in rear of the center of each group) on the plotting board and record the azimuths of each location from the horizontal base end stations, or the azimuth and range from the vertical base station.

220. Marking location for distribution box.—For each distribution box to be planted, place a 1,000-pound cast-iron anchor with a marking buoy attached by means of an anchor rope (80 feet plus depth of water) on board the distribution-box boat and direct the boat, in turn, to each of the positions selected for a distribution box, and throw overboard the anchor and buoy. A 1,000-pound anchor is used for this purpose inasmuch as it also serves later as an anchor for the distribution-box boat. Attach the anchor rope to the buoy and to the anchor by an anchor knot or bowline. For methods of directing the distribution-box boat to previously selected positions, see paragraph 252.

221. Laying shore cable.—*a.* Place the reels of cable on the cable jacks on the planter so that the cable will pay out under the reel. If more than two reels are required, the extra ones are carried on deck and shifted to the jacks as the other reels become empty. To brake the reels, use two planks 2 by 8 inches by 12 feet long as levers, holding them against the edges of the reels. The men holding the planks will stand aft of the reel, which is a safe position in case an accident should pull the reel away.

b. The mine planter proceeds to the point along the shore line most convenient to the terminal hut. Unwind one reel of cable to provide enough slack to place the end through the snatch block at the bow, and fasten a hemp rope to the end of the cable. Before submerging a cable end be sure that each good conductor is protected by means of a thumb joint.

c. There are a number of ways to take the end of the cable ashore. If single-conductor shore cable is used, coil enough in a figure 8 in a yawl boat to reach the shore, run the yawl in as close as possible, pass ashore the rope attached to the cable, and the shore detail pulls the cable ashore. If multiple cable is used, it may be taken ashore in a similar manner by making a raft of two yawl boats. Or, in either case, fasten the end of a rope long enough to reach the shore to the end of the cable, take the other end of the rope ashore in a yawl, and have enough men ashore to haul the cable in. The amount of cable which can be handled in this manner depends upon the character of the bottom. But after starting to pull the cable it must be kept going or it will sink in the mud or catch behind small rocks.

d. Another method of taking cable ashore is to use the distribution box boat in connection with a mine yawl. The distribution box boat approaches the planter in a convenient position to run directly toward the selected point on the beach, and the hemp rope attached to the shore end of the cable is passed to the distribution box boat. The distribution box boat draws some slack coils from the reel and passes the end of the hemp line to a yawl. Both the distribution box boat and the yawl then proceed as rapidly as possible toward the beach and run in as far as possible. The yawl passes the end of the rope to the shore detail, which hauls the cable ashore and signals the planter when the cable has been secured.

e. Before connecting the shore end of the cable to the section between the terminal hut and the casemate make an air test of the casemate-hut piece of cable (par. 126 *a*).

f. After the end of the cable has been secured ashore the planter proceeds toward the position for the distribution box, paying out the cable through the cable-laying snatch block. To prevent kinks as far as possible, keep the cable tight by use of the planks as brakes under the edges of the cable reel.

g. Where the tide is strong, always lay cable against the tide, as this assures that the vessel will be under control at all times.

h. When there is but one layer of cable remaining on the reel, warn the master of the planter so that he may check the speed of the vessel, and when there are from but four to six turns left on the reel the

planter should be stopped in position. Secure a rope stopper to the cable outward from the snatch block (a convenient method is by two half hitches and a seizing), unwind the remaining turns by hand, pull the end of the cable through the snatch block, attach one end of a heaving line to the end of the cable by means of a rolling hitch, remove the rope stopper, pass the other end of the heaving line to the distribution-box boat and throw the cable end overboard to be pulled aboard the distribution-box boat, where it is made fast to a cleat. *Every time a cable is pulled aboard the distribution-box boat and made fast to a cleat* have some members of the crew stand by ready to cut away the cable if it is pulled too tight.

i. The distribution-box boat now gets into communication with the casemate and makes a test (par. 126) of the section of cable laid before joining it to the end of the next reel in order to determine the condition of the cable up to this point. A similar test should be made of each section after it is laid and joined to the preceding section, with the junction under water. Unless each section is tested as it is laid it will be difficult to locate faults subsequently.

j. On the planter the end of the next reel of cable is passed through the cable-laying snatch block, one end of a heaving line is fastened to the end of the cable and the other end passed to the distribution-box boat, where the cable is pulled aboard and made fast to a cleat. The crew of the distribution-box boat works a Turk's-head on the end of each cable, fits the two ends into a junction box, makes a water-tight joint, and attaches a keg buoy to mark the position of the junction box. The junction box is lowered overboard, the buoy cast into the water, and the distribution-box boat proceeds toward the planter to get ready for the next junction.

k. After passing the two cable ends to the distribution-box boat, the planter moves on in the direction of the mine field, laying the first hundred yards of cable fairly slack, so as not to pull it away from the distribution-box boat. The planter continues laying the cable until it reaches the distribution-box position. If only a small amount of cable remains on the last reel, it need not be cut, otherwise cut the cable after allowing the necessary amount of slack.

l. If the mines are to be planted immediately, the cable end is passed to the distribution-box boat, which, after making the last junction-box joint, proceeds to the distribution-box marking buoy and awaits the arrival of the planter. The distribution-box boat tests the cable through to the casemate and then connects the cable to the distribution box and gets ready for planting. If the mines are not to be planted at once, the cable is tested through to the distribution-

box boat from the casemate, the conductor end sealed (end of each good conductor when multiple cable is used) by a thumb joint, and the cable end moored to the anchor of the marking buoy as described in *m* below.

m. When it becomes necessary to buoy an end of shore cable because of interruption in the laying of the cable to the distribution box, or delay in connecting the table to the distribution box due to delay in planting the mines, fasten the end of the cable, by means of a piece of strong hemp rope, fairly close to the buoyed cast-iron anchor, in order to prevent damage to the cable due to abrasion on the ocean floor caused by the tides and currents. To do this, rig a cast-iron anchor on the anchor davit (or on the boom traveler of the distribution-box boat) with one end of the anchor rope (80 feet plus depth of water) attached to it by an anchor knot or bowline. Fasten one end of a comparatively short piece of strong hemp rope to the end of the cable by a rolling hitch and the other end to the anchor by an anchor knot or bowline. Swing the anchor out. Carry a marking buoy aft, pass the anchor rope along the rail outside, and fasten it to the buoy by an anchor knot. Drop the anchor and cable and cast clear the marking buoy.

SECTION XXVI

PREPARATION FOR AND CONDUCT OF PLANTING

	Paragraph
Marking out the mine field	222
Taking soundings on the line of mines	223
Numbering mines	224
Preparing mines for planting	225
Precautions in planting with automatic anchors	226
Planting the group of mines	227
Duties of planter details when planting mines	228
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222. Marking out the mine field.—*a.* When using automatic anchors it is not necessary to mark out the mine field, but when using cast-iron anchors it is usually done in order that the lengths of mooring rope will give the submergences of mines for which cut. *For mine service practice*, if desired, the No. 10 marking buoy and one other buoy on each flank, may be retained as the control buoys prescribed by TR 435–55, or if preferred, all but No. 10 will be removed, and the two flank control buoys planted as desired by the battery commander.

b. The following equipment should be taken aboard the planter for laying out the mine field:

1 measuring line (No. 16 cotton line) with reel and frame.
5 cast-iron anchors (500 or 1,000 pounds, depending upon the depth of water and swiftness of current).
5 marking buoys.
5 raising ropes (depth of water plus 80 feet).

Mark the measuring line at 280, 300, 350, 580, and 600 feet from the free end, which may be done by painting at least 3 feet of the line some distinctive color at the designated points. A good system is to paint the 280 and 580 foot marks black and the 300, 350, and 600 foot marks red, the black being warning marks and the red marks the ones at which marking buoys are dropped. Three men should be assigned to the measuring reel and frame, one to operate the brake and the other two the crank handle for winding in the line.

c. Secure the measuring line frame to the forward deck of the planter, care being taken to see that the line will run over on the reel when paying out. Carry the end of the measuring line forward, pass it through the bow chock and back to the heaving line man amidships. In the meantime a yawl (or distribution box boat) makes fast to the distribution box buoy. As the planter passes the yawl the heaving line man casts the coiled end of the measuring line to the yawl where the end is made fast to a cleat, with a half turn, as quickly as possible. The planter proceeds in the direction of the location for No. 10 mine, the chief planter stands near the anchor davit and calls off the marks as they go by, and the mine planter commander gives the command to trip the anchor at the proper time so as to plant a buoyed anchor about 350 feet in front of the distribution box. At a previously arranged signal from the planter, such as one short blast from the whistle, the end of the measuring line is cast free from the yawl and the line is hauled in hand over hand and reeled upon the drum.

d. A yawl makes fast to the buoyed anchor at No. 10 position, the end of the measuring line is passed from the planter to the yawl, and the planter moves along the line to be occupied by the mines, unreeling the line as it goes. The chief planter calls off the marks and the mine planter commander gives the necessary commands for dropping a buoyed anchor at the 300 and 600 foot mark. The planter then returns and does the same for the other side of the line of mines.

e. These five buoys mark the line to be occupied by the mines and indicate the positions of mines Nos. 4, 7, 10, 13, and 16, and divide the

distances into 300-foot lengths so as to enable the planting of mines approximately 100 feet apart.

f. As each marking buoy is dropped into position a yawl boat should take up all slack of the raising rope and coil and secure same under the buoy, leaving just enough slack to float the buoy at high tide.

g. Where there is any danger of the planter running down the distribution box boat or a yawl when passing such boat, on account of the direction or strength of the current or tide, the planter should approach the boat against the tide (the tide running from the direction of the small boat to the planter). This will prevent the planter from being swept down afoul the small boat, with the consequent dangers thereto.

223. Taking soundings on the line of mines.—*a.* When automatic anchors are used, such information as may be required about the depth of water may usually be obtained from harbor charts. When cast-iron anchors are used, this may not be sufficiently accurate, in which case soundings must be taken at the points where the mines are to be planted. These soundings are made from the yawls, a measuring line, marked every 100 feet, being stretched between the marking buoys by the yawls and soundings taken, by means of sounding lines (No. 10 cotton line), at every 100-foot point. The soundings should be recorded in a notebook, together with the number of each corresponding mine and the state of the tide. Another method of taking soundings is to hold one end of the measuring line at the buoy and circle across the line of mines with a yawl, taking the sounding at the point of crossing.

b. Marking sounding lines.—(1) A suggested method of marking sounding lines for use by the mine yawls is to paint the marks with black and red paint as follows:

At 10 feet from the lead, one black band about 1 inch wide.

At 20 feet from the lead, two black bands about one-half inch wide.

At 30 feet from the lead, three black bands about one-half inch wide.

At 40 feet from the lead, four black bands about one-half inch wide.

At 50 feet from the lead, five black bands about one-half inch wide.

At 60 feet from the lead, one red band about one-half inch wide.

At 70 feet from the lead, two red bands about one-half inch wide.

At 80 feet from the lead, three red bands about one-half inch wide.

At 90 feet from the lead, four red bands about one-half inch wide.

At 100 feet from the lead, five red bands about one-half inch wide.

(2) Mark every 2 feet between the above marks with one black band about one-half inch wide, and estimate to the nearest foot when taking soundings.

(3) For lines longer than 100 feet, repeat the above marking, making the 110-foot mark the same as the 10-foot mark, the 120 the same as the 20-foot mark, etc.

(4) When using black paint and red lead for marking sounding lines, see that they are thinned so they will soak well into the lines.

c. In taking soundings, cast the sounding lead well forward into the current, allow it to descend unimpeded, and take a reading at the instant the line is vertical. When using cast-iron anchors exact results are always needed, and it is therefore of the greatest importance to have men in every mine battery who have been trained to take soundings accurately. Time is well spent in training a few leadsmen who can be relied upon.

224. Numbering mines.—Mines are numbered facing outward, the groups of mines being numbered from left to right and from front to rear. The mines of a group of mines are numbered from left to right. To indicate a mine, first give the group of mines number and then the mine number, thus: Group 3, mine 11.

225. Preparing mines for planting.—*a.* At the command ***PREPARE FOR PLANTING MINES,*** the port and starboard details proceed to arrange the anchors, mines, and cables of their respective sides for planting. When the cable ends are secured to the mines the noncommissioned officers report ***Port (Starboard) Side Ready*** to the chief planter, who reports ***Sir, Ready for Mine Planting*** to the planting officer, who then directs the master of the mine planter to proceed to the mine field.

b. Connecting cable end to mine.—Cut the loading wire of the mine to a convenient length, if necessary, and connect it to the conductor of its cable by a water-tight joint. Clamp the Turk's-head in place, taking care that no part of the loading wire is caught under the clamp. For target practice and drill, lash the cable with marline to the bail of the mine cap just above the ring, but when preparing mines for planting during war, this lashing should be made with No. 14 G. I. wire.

c. Attaching mooring rope.—When cast-iron anchors are used, select the mooring rope cut for the particular mine being prepared, shackle one end to the mine and the other end to the anchor, and lash it to the cable at about every 5 feet with marline. When automatic anchors are used unreel enough mooring rope to permit shackling the end to the mine, and then make the pawl-stop adjustment prescribed in paragraph 159 *b* (2). Do *not* lash the cable to the mooring rope when using automatic anchors.

d. Attaching raising rope.—Attach one end of a raising rope (80 feet plus depth of water) to the anchor by an anchor knot (fisherman's bend) or bowline, and the other end to the mine cable by two half hitches and a seizing of marline.

e. Attaching mine buoy.—Attach a mine buoy (numbered to correspond to the mine) as described in paragraph 171 *b*.

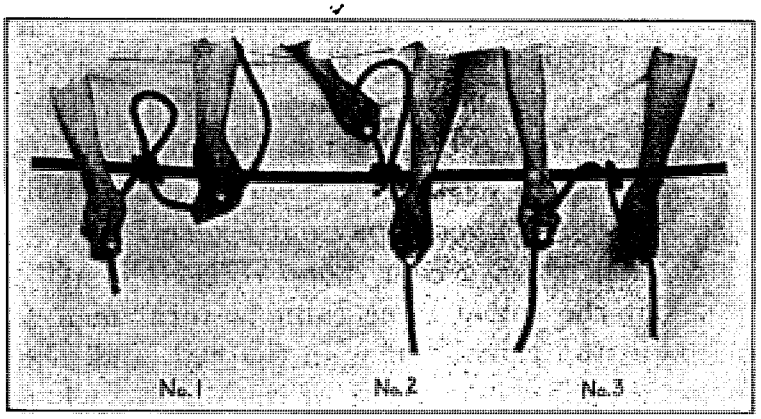

FIGURE 79.—Attaching heaving line to, and releasing heaving line from, cable

f. Mousing triplex block hooks.—Put a mousing around the upper hook of each triplex block to prevent the block from jumping off the davit when the mine or anchor is tripped.

g. Swinging anchor and mine outboard.—Pick up the anchor with the triplex block on the forward davit and swing it outboard clear of the rail. Pick up the mine by its maneuvering ring or by a rope strap through the ring with the triplex block on the aft davit and swing it outboard clear of the rail. A rope strap usually will be found convenient when picking up the mine, especially in rough water. Lower the mine and anchor as close to the water as conditions will permit.

h. Attaching heaving lines to mine cable.—Remove the top turns of the figure 8 and pass the end forward to a position near the forward end of the deck house. Bend a heaving line on the free end of the mine cable with a loose clove hitch and pass the short end of the line back through the hitch parallel to itself so as to form a loop as shown in No. 1, Figure 79. Have a man stand by holding

the loose hitch ready to pull the short end back through the hitch and draw the hitch tight (No. 2, fig. 79) in case the line is secured by the distribution box boat after the heave, and ready to remove the line from the cable by jerking the short end with the right hand so as to pull the loop through the hitch and grasping the line under the cable with the left hand (No. 3, fig. 79) in order to retrieve the line in case it fails to reach the distribution box boat. Similarly bend a second heaving line on the cable a few feet back from the first line, and have a man stand by holding the loose hitch ready to tighten it in case the first heave fails, and ready to remove the line from the cable if the first line is secured by the distribution box boat. A little practice should enable any man quickly to perform these operations without difficulty. Four men are required on the heaving lines, two for heaving and two for manipulating the hitches.

i. Holding cable end along rail.—The end of the cable to be passed to the distribution box boat should be held along the rail as the heaving line is being passed to the distribution box boat, and held slightly taut to prevent a bight from the side from getting into the propeller after the end has been passed to the distribution box boat and before the cable begins to pay out astern.

j. Holding cable and raising rope along rail.—The aft detail cuts the rope lashings of the coiled mine cable, several men of the side detail hold the cable and raising rope on the rail, and a man stands by ready to throw the mine buoy clear of the planter when the mine is tripped. Figures 80 and 81 show a mine and anchor slung from the davits ready for planting, and Figure 82 shows the relative positions of the various parts in the water.

k. After No. 10 mine is planted, the aft deck detail moves the figure 8 for the next mine to a position amidships aft, in proper position for paying out (see par. 218 *a*), and similarly places the figure 8 for each subsequent mine before planting.

l. The usual knots and splices are described in Section V, TR 185–5.

226. Precautions in planting with automatic anchors.—*a.* Keep the davits far enough apart to prevent the anchor and mine from striking each other, lower the mine as close to the water as possible before tripping it, and let go the mine first and immediately thereafter the anchor. If the mine case is high above the water when tripped it will dive under 4 or 5 feet and then come to the surface, and in doing so will jerk out this much mooring rope, and if the anchor is in a position where the pawl is just about to engage in the ratchet the submergence will be this much too little.

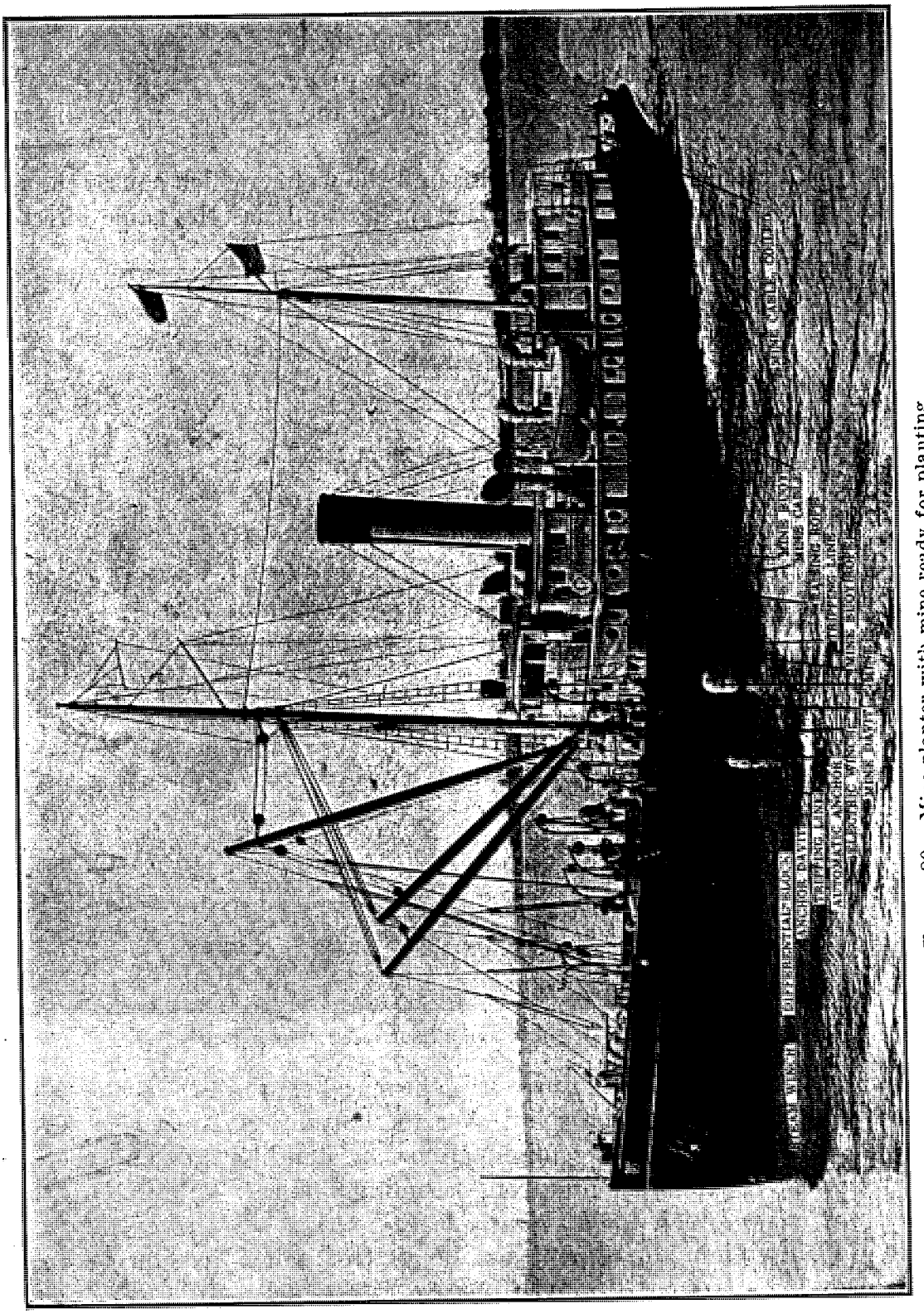

FIGURE 80.—Mine planter with mine ready for planting

b. Causes of too little submergence:

(1) Friction adjustment too small (too little tension on brake drum).

(2) Mine case tripped from too high up.

(3) Not enough tension on the pawl spring.

(4) Pawl spring too weak to pull up the pawl when the distance weight reaches the bottom.

(5) Planter going too fast through the water, which causes the distance weight to drag behind the anchor and has the same effect as

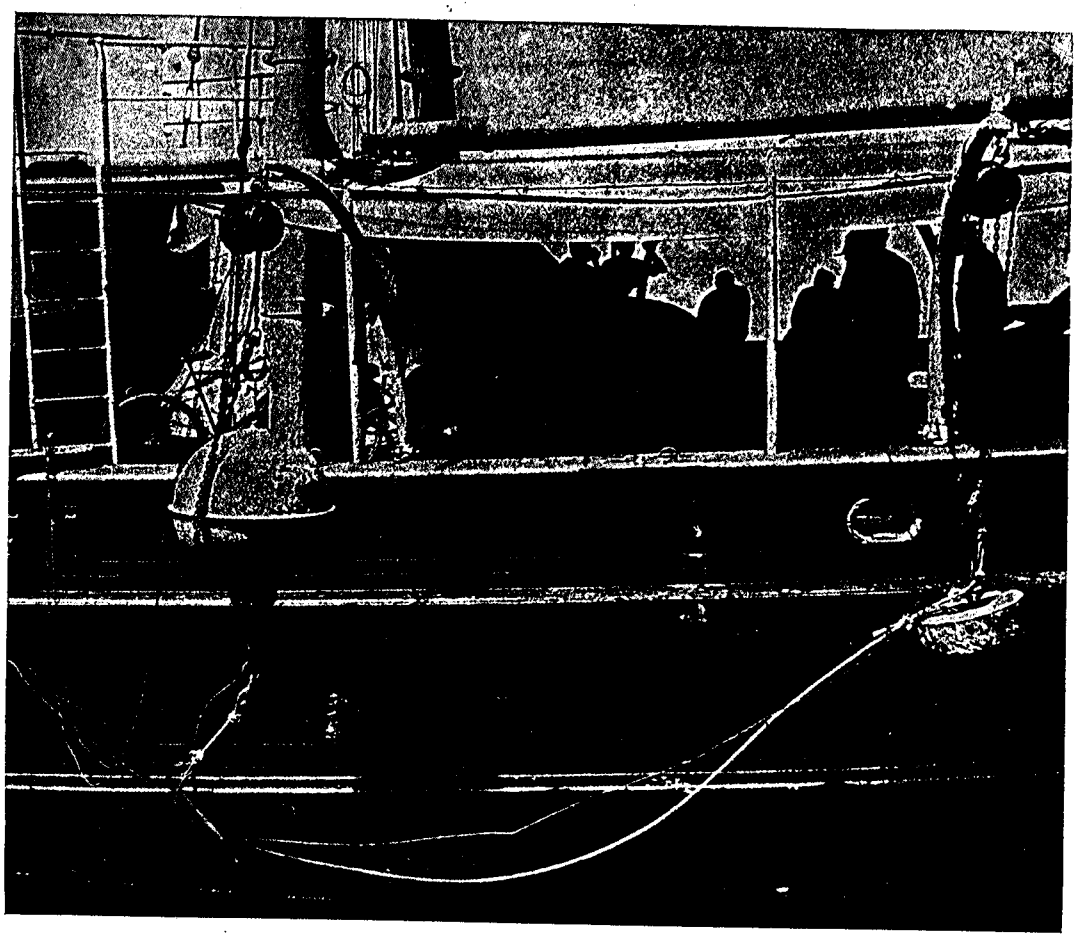

FIGURE 81.—Mine and anchor ready for planting

shortening the distance line. It is the speed through the water which affects this and not the speed over the bottom. With a very strong tide running the planter might almost be standing still and the current keep the distance line from becoming vertical.

c. Causes of too much submergence:

(1) Friction adjustment too large (too much tension on brake drum).

(2) Too much tension on the pawl spring, so that the distance weight in descending does not pull the pawl clear of the ratchet.

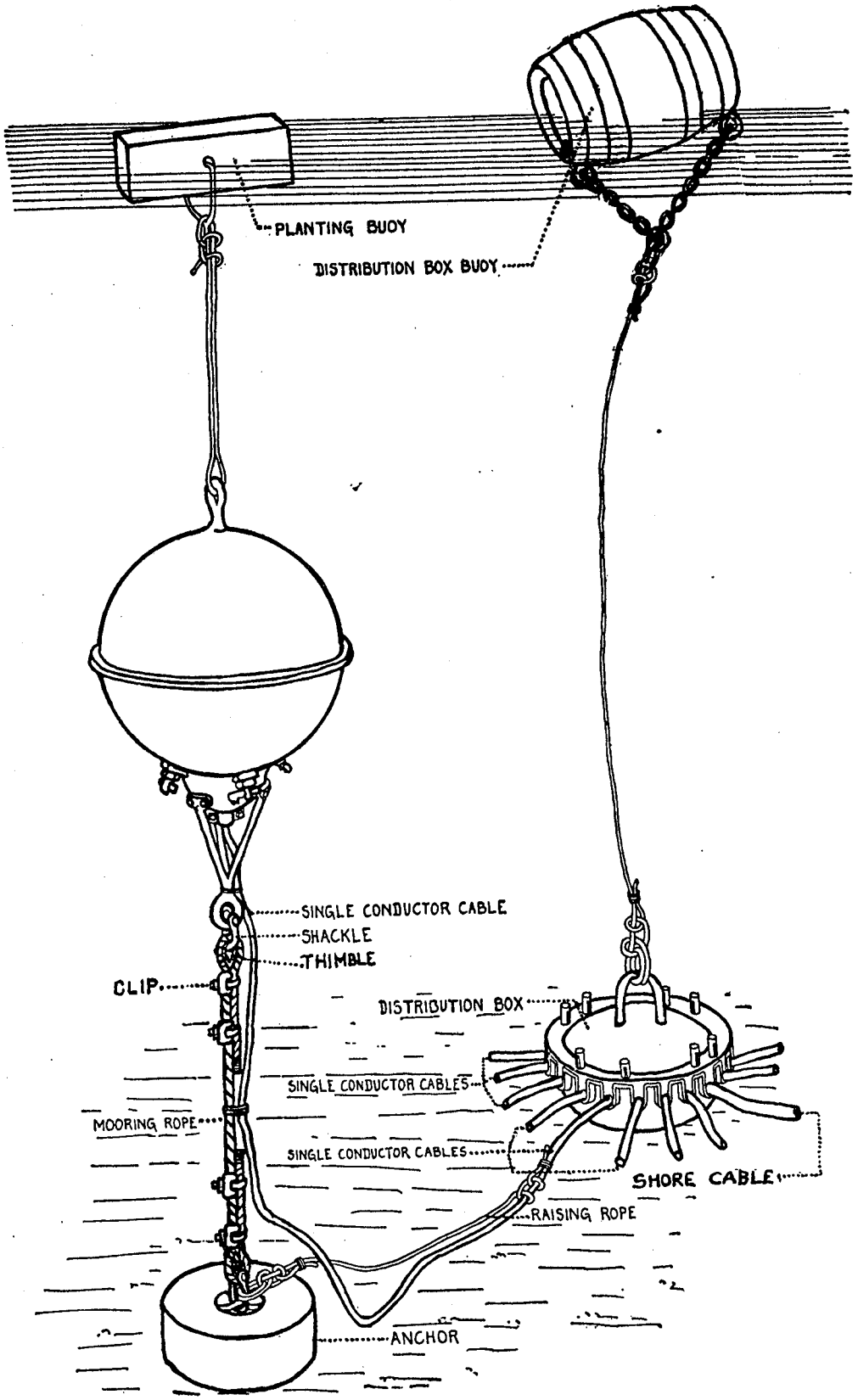

FIGURE 82.—Planted mine and distribution box

(3) Mooring rope jams in unwinding, which will not happen if the rope is wound tightly and evenly on the reel.

(4) Rust on the axles of the reel, causing it to stick.

(5) Distance line fouled on the raising rope before planting.

227. Planting the group of mines.—*a.* Mines should be planted either during periods of slack tide or when the tide is running in across the line of mines to the distribution box (planting against the tide). Under certain circumstances it is positively dangerous to attempt to plant mines either with the tide running out from the distribution box across the line of mines (planting with the tide), or with the tide running athwart the line of mines.

b. Upon arrival at or near the mine field No. 10 mine and anchor should be on the port mine and anchor davits ready for planting, at which time the chief planter reports ***Sir, No. 10 ready.***

c. (1) The mine planter passes close to the distribution box boat with the latter to port, and, as it passes slowly by, No. 5 throws a heaving line to the distribution box boat. The distribution box boat detail immediately hauls in the mine cable, bends on another heaving line to prevent the cable end from becoming lost in case the first line breaks, and lashes the cable to the boat. If the water be rough it may be necessary to pass the cable end to the distribution box boat by a yawl.

(2) The planter moves forward to the position to be occupied by No. 10 mine, the cable paying out from the stern. Good cable preperly coiled should pay out properly without difficulty, but if the cable is springy or improperly coiled the utmost efforts of the after deck detail will be necessary to prevent kinking and bunching. If automatic anchors are used, the distance weight is lowered at the command ***LOWER WEIGHT,*** given after the cable is secured in the distribution box boat. As the planter approaches the position for No. 10 mine the command ***STAND BY*** is given, at which time the locking pins are withdrawn from the trip hooks. As the anchor davit comes abreast of the position for No. 10 mine, the planting officer commands: ***LET GO;*** the trip hook of the mine is released first and that of the anchor immediately thereafter. The mine buoy, cable, and raising rope are then thrown overboard. The second mate, posted on the upper deck aft, signals to the planting officer when but 3 coils of cable remain to pay out.

(3) The planter turns so that the stern will be thrown away from the planted mine, and when the stern is clear of the mine buoy, *all clear* is signaled from the stern by the second mate.

(4) The planter then executes a sweeping circle to starboard, passes to the rear, and comes up with the distribution-box boat to starboard. As it moves by, the free end of No. 9 mine cable is passed to the distribution-box boat as before. The planter moves ahead to a point 100 feet to the left of No. 10 mine, and as it crosses the line plants No. 9 mine, swings off to port, circles, and comes up from the rear with the distribution-box boat to port to plant No. 11 mine, and so on alternately until all the mines of the group of mines are planted.

(5) As soon as a mine is dropped the detail for that side of the planter prepares another for planting. There is ample time to do this while the vessel is turning and planting the other mine.

d. (1) *No mine will be tested from the casemate until after the entire group of mines has been planted and the mine field is clear of all boats.* (See par. 235 *f* (2).) After the last mine of the group of mines has been planted, the mine planter approaches the distribution-box boat in order to receive the milliammeter readings for the mines, which are telephoned to the distribution-box boat from the casemate and reported to the planter by megaphone.

(2) The submergence of each mine is reported to the planter by the yawl, by megaphone, as the planter passes near the yawl to plant the next mine.

(3) If a mine be planted out of line, if the submergence is unsatisfactory, or if an unsatisfactory test is reported from the casemate, the mine must be taken up and replanted.

e. One blast of the planter's whistle should mean that the distribution box boat is to let go of any rope or cable it may be working on at the time. This is important in case it is discovered suddenly that the mine is not ready for planting after the cable has been passed to the distribution box boat, or in case the cable bunched up in going over so that the mine can not be dropped in its proper place. One blast of the distribution box boat's whistle should mean that the distribution box boat has lost the cable end and for the planter not to let go of the mine.

f. Figure 83 shows a method of tripping anchors to obtain a straight line of mines after the first two mines have been planted. The planting officer, from his position on the bridge, gives the command ***LET GO*** as his line of sight passes across the bows of the mine yawls. This method is applicable so long as at least two yawls are made fast to planted mines.

228. Duties of planter details when planting mines.—*a. Chief planter.*—In general charge of deck. Reports to planting officer when each mine is ready for planting.

b. Starboard detail (fig. 84).—Port detail similar in every respect.

(1) *Noncommissioned officer in charge.*—Reports to chief planter when each mine on his side is ready for planting.

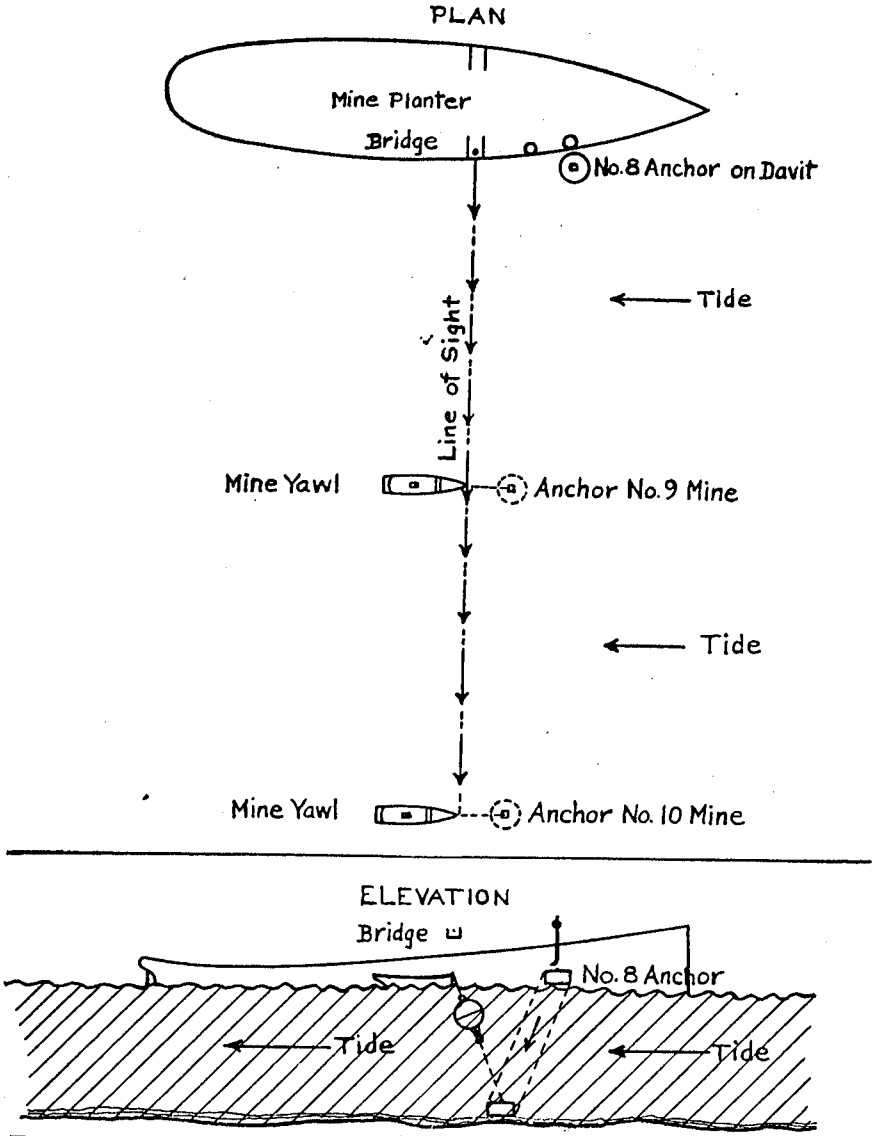

FIGURE 83.—Proper method of tripping anchor to obtain straight line of mines

(2) *Anchor davit men, Nos. 1 and 2.*—Prepare and handle anchors, and perform all duties at anchor davit. No. 1 handles tripping lanyard; No. 2 lowers anchor and removes locking pin from trip hook.

(3) *Mine davit men, Nos. 3 and 4.*—Prepare and handle mines, make water-tight joints between loading wires and cables, and per-

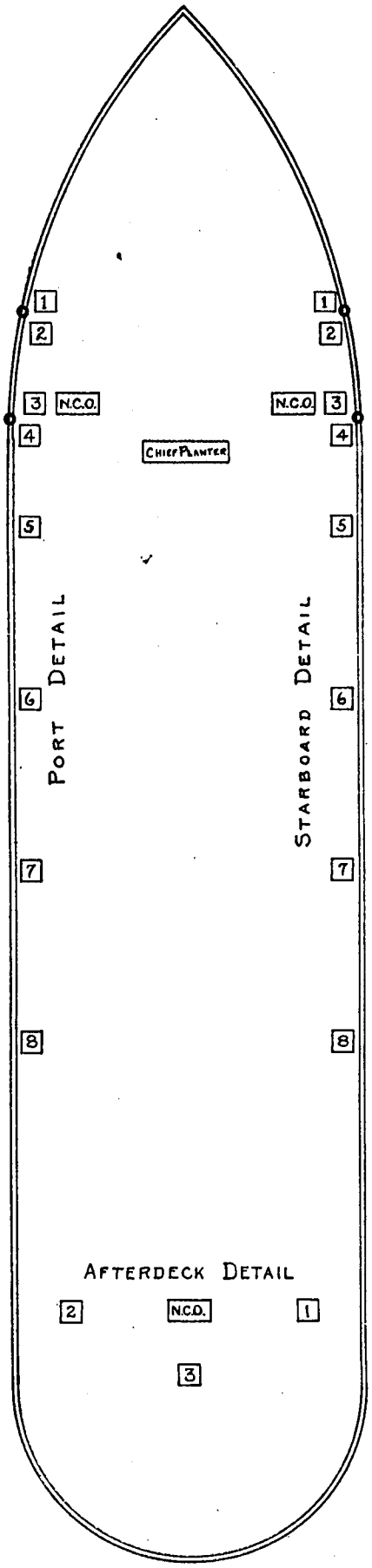

FIGURE 84.—Posts of mine-planting details

form all duties at mine davit. No. 3 handles tripping lanyard; No. 4 lowers mine, removes locking pin from trip hook, and when automatic anchor is used handles distance weight.

(4) *Heaving lineman, No. 5.*—Throws heaving line to distribution box boat and handles mine buoy. Is backed up by No. 5 from port side, who handles second heaving line, and similarly backs up No. 5 on port side. Assists Nos. 6, 7, and 8 in cutting marline lashings holding cable to cable brackets, lifting cable from brackets to rail, and attaching raising rope to cable.

(5) *Cable men, Nos. 6, 7, and 8.*—Pass end of mine cable to distribution box boat by holding it along the rail and keeping a slight strain on the cable until it begins paying out astern. Handle cable and raising rope, holding them along the rail and casting them clear of the side. Assist No. 5 in cutting marline lashings, holding cable to cable brackets, lifting cable from brackets to rail, and attaching raising rope to cable. Both starboard and port numbers work both sides when necessary. Nos. 6 and 7 hold and manipulate loose hitches of heaving lines, as described in paragraph 225*h*.

c. Afterdeck detail (fig. 84).—Noncommissioned officer in charge. Nos. 1, 2, and 3 pay out cable. No. 1 always keeps one coil ahead lifted clear and ready to pay out. After each mine is planted, move figure 8 for next mine to amidships position.

d. Recorder (*noncommissioned officer or private*).—Posted on upper deck aft. Keeps records of times, submergences, and milliammeter readings. Communicates with distribution-box boat by means of a megaphone, when necessary.

229. Mine-service practice and submine practice.—The necessary modifications in the preceding procedure, for the conduct of mine-service practice and submine practice are covered in TR 435–55.

SECTION XXVII

MAINTENANCE OF MINE FIELD

Paragraph
Repair of the group of mines 230

230. Repair of the group of mines.—*a.* If one or more mines develop faults which render them ineffective, after the mines have been planted, correct the faults with the least possible delay, taking care not to disclose the position of the group of mines or mine field. For this reason it may be necessary to do much of the repair work at night or in foggy weather.

b. In general, repairs should be carried out as follows:

(1) *Unsatisfactory electrical test.*—Raise the distribution box and test the shore cable. If the fault is in the shore cable, underrun the cable, beginning at the distribution box and working toward the shore; carefully examine the cable and test it at each joint. If the shore cable tests satisfactorily, then look for the fault either in the distribution box or the individual mine circuits from the distribution box to the mines.

(2) *Broken moorings.*—One or more mines floating in the mine field not only render these mines ineffective but disclose the position of the entire group of mines. It is dangerous to maneuver the mine planter in the mine field where there are mines planted, therefore defective mines should be removed from the mine field during the time the tide runs from the distribution box toward the line of mines, by underrunning the mine cable either from the floating mine or from the distribution box boat by means of a mine yawl until the free end of the raising rope is obtained. Pass the end of the raising rope to the mine planter, which approaches down tide from the line of mines (against the tide) and raises the anchor. If the conditions are such that there is no danger of the planter striking an adjacent mine, take the anchor and mine aboard, test the mine cable to the distribution box boat, and if satisfactory connect and plant another mine. If, however, the conditions make it dangerous to nose the planter into the line of mines far enough for this purpose, or if the mine cable does not test satisfactorily, the cable end should be released from the distribution box boat. The mine with its anchor and cable is then taken aboard, and another mine planted in its place using a distribution box boat or barge.

c. Replacing one or more mines.—As a general principle, in replacing a mine near the end of a line of mines, it is advisable to take up the mines outside of the one to be replaced and proceed with replanting in the normal manner. If a mine is to be replaced near the center of the line of mines, it is advisable to plant it from a barge or small boat, as the mine planter is likely to damage other mines in passing through the line of mines.

SECTION XXVIII

TAKING UP MINES AND SHORE CABLE

Paragraph
Taking up mines 231
Duties of planting detachment when taking up mines 232
Taking up shore cable 233

231. Taking up mines.—*a.* Under normal conditions the group of mines is taken up in the exact reverse order in which planted, with

the flow of the tide from the line of mines toward the distribution box boat. With a cross tide or a strong cross wind, the mines should be taken up in regular order from one side so that the planter will not drift onto the mines. A mine is taken up normally on the side of the planter from which the mine was planted.

b. The mine cable of a mine on the extreme end of the line of mines is received on the planter secured to a heaving line thrown from the distribution box boat as the planter passes close to the distribution box boat. A man stands on the planter with a boat hook over the side ready to receive the end of the heaving line. During rough weather it may be necessary to pass the heaving line to the planter by means of a yawl. When the heaving line is received, quickly pass it over the cathead and keep the cable leading ahead or straight down. If the cable leads astern, the bight will form a loop which may catch on any projection on the bottom, whereas if it is kept leading ahead and taut it will slide up and free itself from most obstacles. Quick work on the part of the personnel and the cooperation of the master of the planter in adjusting the speed of the vessel are necessary to keep the cable ahead. If the cable fouls anything, keep it taut but do not put a strain on it. If the end is likely to pull away, bend a heaving line on and let the cable go, and keep bending on lines until the planter can back up and get a new start ahead. Then keep the line and cable ahead and it will clear itself.

c. As the cable is pulled aboard by hand, carry it across the vessel, through a snatch block in prolongation of the cathead, and aft on the opposite side. Remove any kinks from the cable as they come in. Have a man walk along with each kink and straighten it out, and do not stop pulling the cable in while this is being done. Take the end of the cable around the deck house up to the mine davit on the other side, then begin coiling the bight and coil this end on top, and the cable will not have to be recoiled ashore for the next planting. The cable may be taken aboard by the use of the sprocket wheels and chain described in paragraph 190, the cables being wound on a cable reel under power, but this necessitates recoiling the cables ashore.

d. When the raising rope is reached pull it over the cathead with the cable, quickly haul in the bight of the rope and carry it through a snatch block and around the gypsy head of a winch, making at least four turns. Cut the end of the rope loose from the cable as soon as possible. If there be any danger of losing the rope, make it fast at once. Raise the anchor until within a few feet of the cat-

head, wash off any mud with a hose while it is being raised, and lift it aboard by the triplex block on the anchor davit.

e. At the same time the anchor is being raised have a yawl ready to secure the hook of the raising whip (single block and heavy hemp rope with a hook at one end) to the sling attached to the maneuvering ring (or the maneuvering ring itself) when it comes to the surface. Then raise the mine and swing it inboard. The block of the raising whip is attached to the mine davit, the rope running through the block to a winch or capstan. If the weather will not permit the use of a yawl for securing the raising hook to the mine, send a man over the side of the planter near the mine davit (a rope ladder may be used) for this purpose. To bring the mine to the proper place to accomplish this have a man ready to secure the mine with a boat hook and have other men ready to pull the mine forward, if necessary, by means of the cable. Instead of using a raising whip the mine may be raised by means of the triplex block attached to the mine davit.

f. In taking up mines a great number of complications may occur. Two or more mines may be entangled to such an extent that all must be taken in simultaneously; cables or ropes may become entangled in the ship's propellers; cables, ropes, or anchors may become entangled with material lying on the sea bottom; and the distribution box boat may be run down by the mine planter. It is necessary that the planting officer decide quickly the best procedure to follow as the complication arises, and that he be able to deliver his instructions so that the planting detachment or any individual will thoroughly understand the instructions given. Do not hold back on a rope until it breaks; let it slack away, bending on additional ropes until the pull ceases, or in case the pull continues buoy the end before it is finally released; this precaution will save a great amount of additional labor.

g. If the end of the cable is lost and the exact position of the mine is known, the planter takes position near the mine. Throw a sling made of raising rope over the mine; or pass one end of a long rope (two or more raising ropes tied together) to a yawl, which moves around the mine, allowing plenty of time for the rope to sink, and brings the end back to the planter. Place both ends over the cathead, through a snatch block, and around the gypsy head of a winch. Raise the mine until near the cathead, transfer it to the anchor davit, and pull in the mine cable until the raising rope is reached. Or when the mine is raised above the surface of the water, take in the cable to the raising rope and pass the rope over the cathead.

h. When the cable has been lost and the location of the mine is known only approximately, grapple for the cable with a yawl if the cable is long and the water shallow; otherwise sweep for the mooring rope by stringing about 200 feet of marline-covered wire rope between two yawls, which keep abreast of each other about 100 feet apart and drag the loop about in the vicinity of the mine. They should go slowly and allow the rope time to sink; if they go too fast or keep too far apart, the loop will be pulled to the surface. When the mooring rope has been fouled, the yawl with the shorter end of the rope stays in position and the other one goes around the mine so as to get a complete turn around the mooring rope. This must be done carefuly, making a slow sweep with plenty of slack line out, otherwise the rope will slip off. Then pass the two ends of the rope to the planter to be hauled in.

i. If the raising rope breaks or is lost, sweep for the mooring rope, and when the mine has been raised above the surface put a strong sling through the maneuvering ring and raise the mine and anchor with the boom; or transfer the mine to the anchor davit as described in *g* above, then make fast a raising rope to the mooring rope of the anchor and carry it over the cathead and through a snatch block to the gypsy head of a winch. Unshackle the mine as soon as the strain is taken up by the raising rope, and take the anchor aboard in the usual manner.

232. Duties of planting detachment when taking up mines.—The duties as given below are for taking up a mine on the starboard side. In taking up one on the port side, the port detail performs the duties prescribed for the starboard detail, and the starboard detail those for the port detail.

a. Chief planter.—In general charge on deck.

b. Port detail.—Noncommissioned officer in charge superintends clearing his own side, then assists starboard noncommissioned officer.

No. 1 catches heaving line with boat hook as it is passed from the distribution box boat. Cuts marline seizing from raising rope and cable after it comes over the cathead. Operates steam winch. Assists No. 2 in coiling raising rope.

No. 2 grasps heaving line as No. 1 catches it with boat hook and passes it over cathead. Handles raising rope to and around gypsy head of winch, making at least four turns. Assists No. 1 in coiling raising rope.

No. 3 helps to pull in cable, then operates winch or capstan for raising mine.

No. 4 helps to pull in cable, then handles fall of raising whip around winch or capstan for raising mine. (A raising whip con-

sists of a single block through which a heavy manila rope, with an iron hook at one end, has been passed. The block is attached to the mine davit, the hook engaged in the maneuvering ring or strap of the mine, and the mine quickly raised to the deck.)

No. 5 helps to pull in cable. Passes raising rope through fair-lead snatch block in prolongation of cathead. Lifts cable off cathead when anchor is secured.

Nos. 6 and 7 assist noncommissioned officer in clearing port side, then assist in hauling cable aft around port side.

No. 8 coils loose end of heaving line as he walks aft, then assists No. 8 starboard hauling cable aft around port side.

c. Starboard detail.—Noncommissioned officer in general charge.

Nos. 1, 2, 3, and 4 at cathead haul in on cable until raising rope is up.

Nos. 1 and 2 continue on raising rope and anchor.

No. 3 goes over side on guard rail and places hook of raising whip in maneuvering ring or strap of mine, if this is not done by a yawl. When mine is aboard and automatic anchor is used, engages hook of raising whip around distance weight rope.

No. 4 assists No. 3 by guiding hook of raising whip to him, both for mine and for distance weight. Is responsible for proper position of mine davit.

No. 5 has heaving line ready to pass to distribution box boat if necessary. Catches buoy rope as soon as possible and guides mine to No. 3. When anchor is aboard removes raising rope.

Nos. 6, 7, and 8 assist in hauling cable aft around port side, taking posts about 15 feet apart. No. 8 comes forward, receives Turk's-head end, and removes heaving line as he walks aft with Turk's-head.

d. After deck detail.—Noncommissioned officer in charge. Nos. 1, 2, and 3 coil cable in figure 8 as it comes to the afterdeck.

In coiling cable for replanting, care should be taken that, with the Turk's-head pointing forward, the first bight should lead aft on the side on which the mine is being raised. This will insure that, when the coil is lashed and turned upside down, the bights will be ready for paying out properly.

233. Taking up shore cable.—*a.* The shore cable is taken up in the reverse manner from that in which laid; the planter should proceed against the tide when possible. Sections of the cable, from the distribution box end to a junction box, between junction boxes, and from a junction box to the shore, are taken up separately. Place the cable reel on the jacks so the cable will be wound on over, and con-

nect the sprocket wheels and chain so as to use the steam winch for winding the cable on the reel as it is taken up.

b. The end of the cable is passed to the planter, where it is carried forward through a large snatch block and through the hole in the reel; the hole should be large enough to pass a Turk's-head through. Pull enough cable through the hole to permit the end being above water when the cable is in the tank, and staple the loose end to the outside of the reel so it will not be in the way when winding up. Wind the cable on the reel evenly, going slowly enough to do this, and have a man stand by with a hammer to knock the turns against each other if necessary.

c. If the cable gets caught on submerged obstacles, it may be necessary, in order to clear it, to take a turn around a cleat and pull on it with the planter; but before doing this, try going to each side of the present course to see if it will not clear itself. When taking up the shore section of the cable the shore detail, after releasing the end ashore, should carry the end down to the beach so there will be no possibility of the cable fouling any obstacle on the shore, while the planter halts a safe distance from shore and reels up the end.

SECTION XXIX

INSTRUCTIONS FOR MASTERS OF MINE PLANTERS

Paragraph
Information for masters 234

234. Information for masters.—*a. Precautions to be observed.*—(1) If the current flows across the mine field the planter, to avoid accidents, should pass on the *downstream* side of the yawl holding the measuring line.

(2) Care should be taken that the measuring line and buoy ropes are not caught in the propellers. If the vessel has twin screws, stop the upstream propeller as soon as the measuring line has been passed to the marking boat. Post a man with a boat hook near the planting davits, and another amidships, to hold the measuring line above the water and clear of the sides of the vessel. Hold marking buoys, and as much of the rope as possible, on the rail near the stern, and let the rope pay out slowly under tension until the propellers are past the rope, then throw the buoy and the remainder of the rope overboard.

(3) As a general rule never back either propeller when buoy rope, measuring lines, or cables are being handled overboard at or near the stem of the vessel. If it becomes absolutely necessary to reverse the propellers when paying out cable, the men paying it out must haul it in taut and keep it above the propellers and clear of them.

(4) Do not pass nearer than 25 feet to the distribution-box boat when cable is leading out from the distribution-box boat, and do not pass over any cable when it can be avoided, if the depth is less than 16 feet.

(5) After passing the distribution-box boat proceed on such a course that the cable will pay out smoothly without becoming entangled. If the cable becomes fouled and entanged, signal the distribution-box boat to let go at once, and proceed on and do not back the propellers. Mine cable should never be made fast in the distribution-box boat until after the mine is dropped. It is much better to drop the mine out of position than to endanger the propellers of the vessel. Stop the propeller nearer the distribution-box boat the moment the bow passes the distribution-box boat on its course to drop a mine.

(6) If the vessel moves *against* the current when planting, there is little danger of overturning the distribution box boat if ordinary caution is observed. Should it be necessary to plant against a cross current or with it, pass the cable end to the distribution box boat by a yawl. In this way the planter need not pass nearer than 50 or 75 yards from the distribution box boat.

(7) To avoid fouling the buoy rope or mine after the mine is dropped, put over the helm so as to throw the stern away from the mine. Have the vessel under good headway and stop the propellers until they are well past the buoy and buoy ropes of the mine. These points are important; failure to observe them may result disastrously.

(8) In laying shore cable the course of the vessel invariably should be against the current. Rather than lay cable with the current, it is advisable to postpone laying the cable until a change of tide causes a favorable direction of current. In the end, time will be saved by waiting. If any cross current is running pay off cable on the *upstream* side of the vessel. Every care must be taken that the cable does not get caught in the propellers.

(9) Special care is necessary, in planting mines, to avoid colliding with the yawls or the distribution box boat; picking up cable in the propeller; getting the mine cable tangled; and drifting over the mine after it is dropped.

b. Lead line.—(1) Soundings, to ascertain the depth of water on entering or leaving a port, or in cases where there are supposed to be less than 20 fathoms of water, are taken by the hand lead, a man being stationed on the forward deck for this purpose. The lead weighs from 7 to 14 pounds and the line is from 20 to 30 fathoms long.

(2) The lead lines are marked as follows:
At 2 fathoms from the lead with two strips of leather.
At 3 fathoms from the lead with three strips of leather.
At 5 fathoms from the lead with a white rag.
At 7 fathoms from the lead with a red rag.
At 10 fathoms from the lead with leather having a hole in it.
At 13 fathoms from the lead the same as at 3.
At 15 fathoms from the lead the same as at 5.
At 17 fathoms from the lead the same as at 7.
At 20 fathoms from the lead with 2 knots.

These are known as the MARKS. The numbers omitted, as 1, 4, 6, 8, etc., are called the DEEPS, and they are spoken of together as the MARKS AND DEEPS OF THE LEAD LINE.

(3) Soundings by the hand lead are taken while the vessel has weigh on, the leadsman throwing the lead forward and getting the depth as the vessel passes, while the line is nearly perpendicular. He communicates the soundings obtained as follows:

(*a*) If the depth corresponds with one of the above marks, he says, ***by the mark*** **5** or ***7.***

(*b*) If the depth is greater, or one-half more than any of the marks, he says, ***and a quarter,*** or ***and a half 5*** or ***7.***

(*c*) If the depth is a quarter less, he says, ***quarter less 5*** or ***7.***

(*d*) If he judges, by the distance between any two of the marks, that the depth of water is 4, 6, 8, 9, 11, 12, 14, 16, 18, or 19 fathoms, he says, ***by the deep 4, 6,*** etc.

(4) On the hand lead there are 9 MARKS and 11 DEEPS.

SECTION XXX

OPERATIONS OF DISTRIBUTION-BOX BOAT AND MINE YAWLS

Paragraph
Operations of distribution-box boat (figs. 85 and 86) 235
Operations of mine yawls 236

235. Operations of distribution-box boat (figs. 85 and 86).—*a. Laying shore cable.*—After each section of the shore cable is laid and the end passed to the distribution-box boat, the distribution-box boat gets into communication with the casemate by attaching one terminal of a boat telephone to the conductor (No. 19 if multiple cable is being used) and the other end to the cable armor or to an earth plate hanging overboard in the water, and notifies the casemate that it is ready for test. Upon instructions from the casemate the telephone is disconnected for a specified length of time, and the

conductor grounded by touching it to the cable armor. This should cause the switching relay in the casemate to trip through the contact-firing relay. The distribution-box boat now holds the dried end of the conductor in the air (if multiple cable is used the conductor under test must be separated from all others) while the casemate makes an insulation test (megger test). At the end of the specified length of time the telephone is reconnected and any leak in the conductor reported to the distribution-box boat, where every effort is made to eliminate such leak, by cutting off a section of the cable if necessary. If multiple shore cable be used, it will be necessary to pick out one good conductor to be connected to the selector

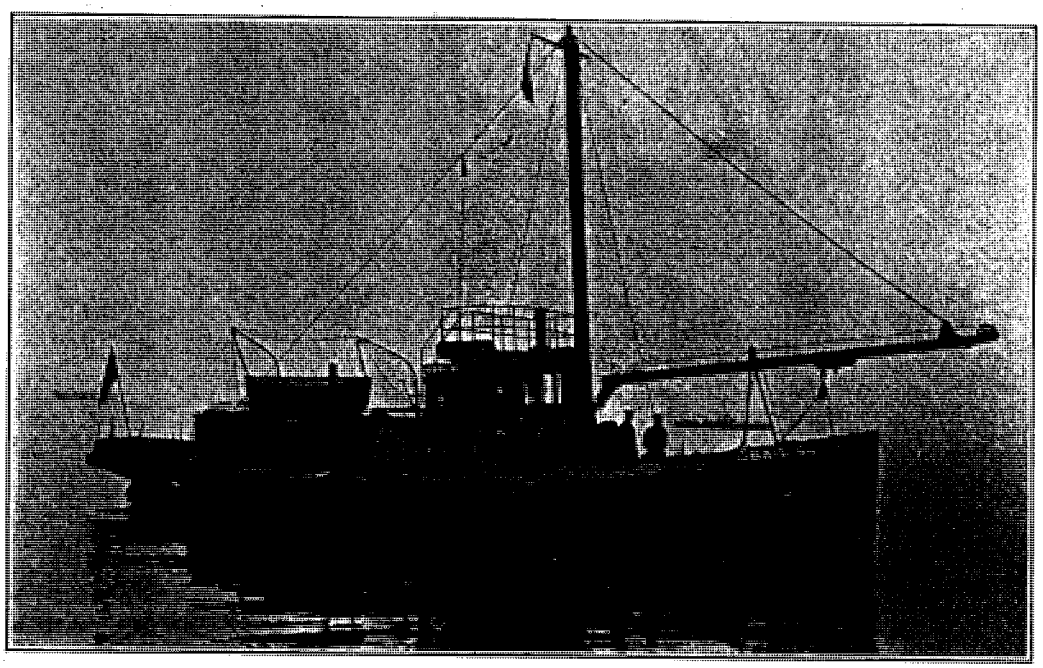

FIGURE 85.—Distribution-box boat

box. Nos. 1, 13, and 19 are picked out easily by their markings and the remaining ones are numbered in a counterclockwise direction. If any difficulty is experienced in using the boat telephone, the distribution-box boat may communicate with the casemate by means of the distribution-box boat radio set, if available.

b. Anchoring at distribution-box position.—If the mines are to be planted immediately upon completion of laying the shore cable, the distribution-box boat, after making the last junction box connection, proceeds to the position for the distribution box, takes aboard the distribution-box buoy, anchors fore and aft by means of the buoy anchor and the boat anchor, and awaits the arrival of the mine planter with the end of the cable. If the position has not been marked previously, the distribution-box boat is directed to the posi-

tion (see par. 252), where it drops overboard a buoyed 1,000-pound cast-iron anchor. When possible, the distribution-box boat should anchor perpendicular to the line of mines with the bow toward the center of the line.

c. Connecting shore cable to distribution box.—(1) The distribution box will be connected to the shore cable only when the mine cables are to be connected to the distribution box. *Under no circumstances will the distribution box be lowered into the water except with both the shore cable and mine cables connected thereto.* This is necessary in order to reduce to a minimum the chances of losing the selector box which is mounted in the distribution box, and to

FIGURE 86.—Distribution-box boat

prevent damage to the selector by the entry of water into the selector box. When the mines are taken up the distribution box will be disconnected from the shore cable, the end of the conductor sealed, the end of the shore cable fastened to the marking buoy anchor and lowered overboard and the distribution box either kept aboard the distribution-box boat or taken ashore until again ready to plant the mines.

(2) Immediately on receipt of the end of the shore cable, either from the planter or by raising the anchor to which it is attached from the water, pass the cable through a bow chock, clamp it in the cable clamp, work a Turk's-head on the end, and secure it in the distribution box. (Fig. 86.) Remove the seal from the end of the

conductor and test the cable through to the casemate. Do not connect the shore cable to the selector box until all the mines of the group of mines have been planted.

d. Preparation for planting mines.—The distribution-box boat should precede the planter to the mine field with the distribution box on the distribution-box table in the cockpit. Upon arrival at the position the marking buoy is taken aboard at the bow, the boat anchored, the marking-buoy anchor raised, and the cable end made fast to the boat and disconnected from the anchor. The marking-buoy anchor is then lowered into the water and the boat anchored both fore and aft, perpendicular to the line of mines with its bow pointed toward the position of the center mine of the group when possible. Secure the cable end to the distribution box and test the cable through to the casemate. During the planting of mines a man should stand by at all times ready to slacken away on the anchor rope if necessary, to allow for a rising tide. After the cable end is connected to the distribution box and tested, a red flag is raised to indicate to the mine planter that the distribution-box boat is ready for the planting of mines; or the distribution-box boat may get into communication with the planter by means of the distribution-box boat radio set if available.

e. Underrunning shore cable.—If the distribution box buoy is not in place when the distribution box boat reaches the position, it will be necessary to grapple for and underrun the shore cable near its end or to underrun it from the shore or from a buoy planted for this purpose. This may be done with a yawl. Raise the cable, take it aboard, and place it over a roller or rowlock in the stern. Then pull the cable over the stern and lower it over a roller or rowlock in the bow. If the planter is used to underrun cable, put a cathead in place, lower a snatch block from the cathead to a yawl by a raising rope secured to a winch, and place the cable in the snatch block. The planter moves forward slowly. When it is desired to transfer the cable to a small boat lower the snatch block into the boat.

f. Planting mines.—(1) A man stands by with a boat hook ready to receive the end of the heaving line from the planter as it passes by. When the heaving line is received, the cable end is hauled aboard, a second heaving line bent on to prevent losing the cable end if the first line should break, and the lines made fast to cleats in the cockpit. A man should stand by ready to release or cut the lines in case the cable is fouled or upon signal from the planter (one blast of the planter's whistle) to let go. In case the cable end should be lost, signal to the planter by one blast of the whistle not to drop the

mine. *Do not secure the cable to the distribution box until after the mine has been dropped.*

(2) After each mine is dropped remove the heaving lines from the cable and slip the Turk's-head into place in the distribution box, No. 10 in the slot next to the shore cable in a clockwise direction, No. 9 on the other side, and so on. Check the tag on the cable end to see that it bears the proper number. Make a voltmeter test of the mine circuit with voltmeter and four or five dry cells. Then connect the mine cable to its correspondingly numbered selector box terminal by a water-tight joint. *Do not test any mine circuit from the casemate until after all the mines of the group of mines have been planted and the mine field is clear.*

(3) When the last mine of the group of mines has been planted and connected to the selector box and the mine field is clear (planter and yawls at a safe distance from all mines of the group of mines), notify the casemate that the distribution box boat is ready for the dry test and operating test (par. 130 *d*), then disconnect the telephone and temporarily connect the shore cable to its selector box terminal. While this test is being made, check the tag on each cable end to see that it is connected to its correspondingly numbered selector box terminal. At the expiration of 10 minutes disconnect the shore cable and reconnect the telephone to receive a report on the tests from the casemate, then megaphone these readings to the mine planter when it approaches for that purpose. If the tests are satisfactory, remove the telephone, connect the shore cable to the selector box by a water-tight joint, and secure the distribution box cover in place.

(4) During submine target practice when less than 19 mines are planted, seal the ends of the unused selector box terminals with thumb joints, great care being taken to see that the joints are water-tight so that moisture can not enter the selector box.

g. Lowering distribution box.—When the distribution box is ready to be planted, lower the boom and lock the traveler on the boom in position above the distribution box table. Fasten one end of the raising rope (150 feet plus depth of water) to the cover by an anchor knot or bowline, and pass the rope through the snatch block on the traveler and around the hoisting winch. Release the shore cable from the cable clamp and chock, raise the box and engage the hook on the snatch block into the bail of the distribution box cover, and slack up on the raising rope so the hook will support the box. Move the traveler outboard to the end of the boom (backing the distribution box boat when necessary), and lock it in that position.

Raise the box slightly and disengage the hook from the bail, and lower the box slowly and carefully into the water. Remove the raising rope from the winch and snatch block, fasten the free end to the ring of the marking buoy, and cast the buoy and rope overboard.

h. Picking up mines.—(1) Pick up the marking buoy and anchor the boat in position. If the buoy has been removed, grapple for, or underrun, the cable. Lower the boom, pass the raising rope through the traveler snatch block and over the winch, and move the traveler to the outboard position. Raise the box, place it on the table in the cockpit, and remove the cover.

(2) When taking up the distribution box, carefully examine it to see that it did not turn over in going down and twist the cables around one another. If this has happened, carefully sort out the cables to avoid tangles when taking up the mines. Haul the outer cables in as far as possible by hand to be sure that each cable leads directly to its mine; and, if necessary, before passing a cable to the planter, have a yawl underrun it until assured that it leads clear to the mine.

(3) Remove the cable to the first outer mine from the distribution box, cutting the connection to the selector box on the side of the watertight joint nearer the Turk's-head. This leaves the joint attached to the selector box for later examinations, if desired. Secure the cable end to the boat with one line, bend a second heaving line on the cable and throw it to the mine planter as it passes to pick up the first mine. When the heaving line is received by the planter, release the securing line. Similarly pass each cable end to the mine planter.

(4) When the last mine cable has been passed to the planter, disconnect the shore cable from the distribution box and seal the end of the conductor. If the cable end is not to be passed to the mine planter at once, make fast the end of the cable to the marking-buoy anchor, as described in paragraph 221 *m.* and lower it overboard. Take the distribution box ashore.

i. Taking up shore cable.—The distribution-box boat raises the distribution-box marking-buoy anchor, disconnects the shore cable end, and remains in position until the cable end has been taken aboard the planter.

236. Operations of mine yawls.—*a. Marking out mine field.*—The mine yawls assist the planter in marking out the mine field as described in paragraph 222.

b. Taking soundings on line of mines.—See paragraph 223.

c. Planting mines.—(1) Two yawls, one on each side of the line, work as follows: When a mine is dropped the yawl on the corresponding side moves to it, picks up the buoy, pulls the rope taut, notes the submergence of the mine and transmits the data to the planter by megaphone, and holds up an oar or flag in prolongation of the buoy rope. The oar or flag is held in this position until the flag at M′ is lowered (see par. 249 *b* (3)). The observers at the ends of the base line take observations on this marker so that the position of the mine may be plotted accurately. This process is repeated for each mine, the yawl holding to each buoy until the next mine on its side is planted, thus serving as guides to the planter in dropping the mines. With automatic anchors the line need not be marked otherwise than in this manner.

(2) The marking buoys may be removed as each additional mine is planted next to that being marked, or at the completion of the planting of the entire group, as directed.

(3) When the last mine has been planted and plotted, the mine yawls should move promptly to a safe distance from all mines so that the mines may be tested without unnecessary delay.

d. Laying and picking up cable.—In laying shore cable one or more yawls may be required to carry the end of the cable ashore by coiling a part of cable in the yawl and paying out as the shore is approached. In shallow water the junctions in the shore cable are made by the yawl crew. In pulling up cable the yawl may be required to underrun a section of the cable or to break the joints in the cable at the junction box. See paragraph 235 *e*.

e. Safety.—The third mine yawl, which may make fast to the buoy line at No. 10 mine, will keep its engine running at all times, ready to proceed instantly to the assistance of a man overboard, or to meet any other call for assistance or messenger service which may arise. In any case, one yawl will keep its engine running at all times for this purpose. Also, any yawl operating in the mine field, no matter what duty it may be performing, may be called upon at any time to assist in the rescue of persons overboard.

SECTION XXXI

HANDLING SMALL BOATS

	Paragraph
Handling a boat in a current	237
Taking a cable end ashore	238
Coming alongside a ship	239
Picking up a buoy	240
Mooring to a buoy	241
Locating position on the water	242
Anchoring at a required point	243
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237. Handling a boat in a current.—Considerable practice is needed to handle a boat well. In any of our harbors slack water lasts but a short time. The tidal currents vary from 2 to 5 knots an hour, and in many harbors they change direction at different stages of the tide. Coxswains should be trained to use the current as an aid instead of letting it hinder them. The progress of a boat in a current will be the resultant of the forward impulse of the boat

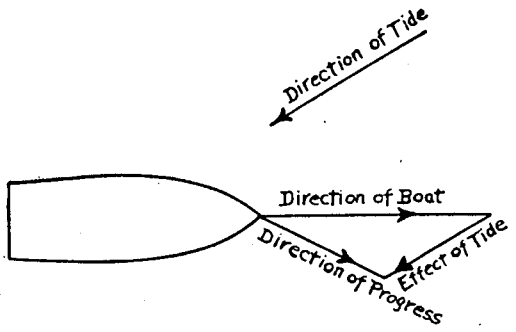

FIGURE 87.—Progress of boat due to direction of boat and tide

and the effect of the tide and wind (fig. 87). Men should be taught to estimate the strength and direction of the tide from the inclination of buoys, the wake of piles, etc.

238. Taking a cable end ashore.—Referring to Figure 88, if it is desired to land the end of a cable at A, do not head the boat for A or the tide will carry it so that it will land somewhere in the vicinity of B. Turn the boat so that it will make an angle with the direction of the tide, move ahead just enough to keep the stem on the line C-A, and the current will carry it to the shore at A.

239. Coming alongside a ship.—Head the tide at an angle as explained in paragraph 238, keep the stem abreast of the desired point, and let the current carry the boat over toward the ship. Go

on the lee side, have a man ready to fend off, and put a fender out. Go alongside another small boat in the same manner. If men are standing up at work in either of the boats, it is important that they should not bump hard.

240. Picking up a buoy.—Come up to the buoy against the tide, take the buoy inboard, and keep the boat going ahead until all the slack mooring line is on board. Attempting to pick up the buoy while going with the tide results in all of the mooring line being stretched out taut, which makes it impossible to take the buoy on board.

241. Mooring to a buoy.—Lead the mooring rope through the bow chock, and do not take it in amidships or the boat will yaw from side to side and probably turn beam to the sea; on a rough

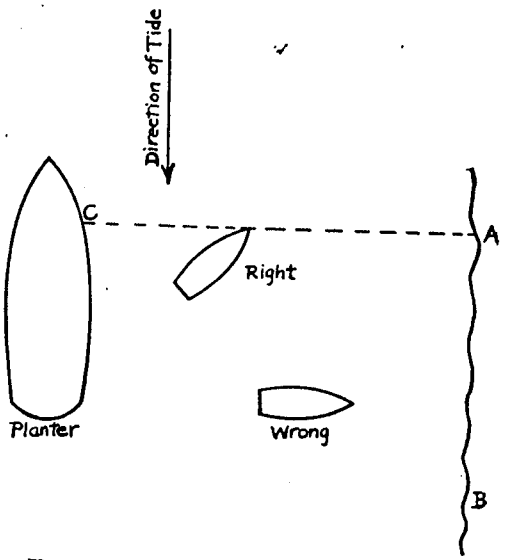

FIGURE 88.—Taking cable end ashore

day this may cause swamping when the rope is taut. When a boat is moored in a tideway it will obey its helm to a certain extent the same as though going ahead. Use of this fact can be made in keeping it headed in the right direction or getting it in a more desirable position.

242. Locating position on the water.—Look around for two immovable objects in line. Two sets of such bearings intersecting at the boat are necessary to locate it. To hold this position without anchoring, keep head to the tide and move ahead just enough to neutralize it. The accurate taking of a position is very important when grappling or sweeping to recover lost material.

243. Anchoring at a required point.—Go against the tide beyond the point, let go the anchor and pay out line until the tide carries the boat back to the exact position. Be sure that the anchor

is heavy enough, and lead the anchor line through a bow chock so that it leads straight ahead from the bow. It is important to be able to anchor in a position accurately when the boat is to be used as a marker or point of reference. Pay out line as the tide comes in. A mooring line from three to six times as long as the depth of the water is needed, depending upon the strength of the tide.

244. Towing.—When towing a heavy object across the current, have plenty of spare line aboard the towing boat. If carried off the course, back the boat toward the towed object, take in the slack line and start off again on the right course, paying out enough towline to obtain room to maneuver. If it is desired to turn around, slack the towline, make it fast in the bow of the boat, and go ahead until the boat is turned around.

245. General instructions.—*a.* Never let slack line drag from a mine yawl; it will surely catch in the propeller. Always take on board the slack in a towline when backing toward the object towed. Always stop the propeller when near a line in the water. When casting over a mine buoy do not start the engine until the tide has drifted the boat clear.

b. In crossing the bow of a boat which heads the tide, allow sufficient space for the current to drift you down and still allow you to keep clear.

c. The anchor rope, to withstand a storm, should be six times as long as the greatest depth likely to be used as an anchorage. For a mine yawl about a 1-inch diameter hemp rope should be sufficiently large.

d. A boat must never go out at night without regulation running lights.

e. Before leaving the shore in foggy weather, provide the boat with a foghorn and a compass, and calculate as nearly as possible the bearings of the landing it is desired to make. Take the opposite of this upon returning, making due allowance for tide and wind in both cases.

f. To ride out a gale, make the boat take the seas head-on, assisting by means of a steering oar if necessary.

g. Remember, in making a landing, that the heavier the boat is laden the longer she will keep her way.

h. When being towed, make the towing vessel give you a line instead of using your own, and fasten it so it can be cast off in a hurry. Carefully avoid weighing down the bow. Use a short towline when the boat is empty, and a long one when it is laden. If the

boat's painter is being used for a towline, have a knife ready for cutting it if it becomes necessary.

i. Never go close under a steamer's stern unless it is absolutely unavoidable.

PART SEVEN

FIRE CONTROL AND POSITION FINDING AND MINE PRACTICE

	Paragraphs
SECTION XXXII. Fire control and position finding	246–255
XXXIII. Mine practice	256–259

SECTION XXXII

FIRE CONTROL AND POSITION FINDING

	Paragraph
Fire control and fire direction	246
Conduct of fire	247
Position-finding system	248
Mine plotting	249
Commands and reports	250
Modifications for target practices	251
Location of distribution boxes	252
Fire-control equipment	253
Signal Corps equipment	254
Ordnance Department equipment	255

246. Fire control and fire direction.—*a.* As applied to submarine mine defense, fire control includes the exercise of all the tactical and technical functions of command properly pertaining to the mine group commander. Primarily it consists in the fire direction which will insure that any hostile element which enters the mine field is either attacked by mine fire, or that attack by mine fire is withheld, in order to carry out the battle orders which have been received by the mine group commander from the groupment, fort or harbor defense commander, or to carry out the decision of the mine group commander in the event that the existing tactical situation is not provided for in orders from higher authority.

b. Secondarily, fire control consists in the use of such personnel of the mine group detachment and of such available installations as are necessary to execute the functions of surveillance and protection of the mine field.

247. Conduct of fire.—As applied to submarine mine defense, conduct of fire comprises the technical decisions and the commands and means to put them in effect, necessary to secure effective attack on targets assigned by the mine group commander. Conduct of

fire over a given mine field is a function of the mine battery commander charged with the operation of that mine field, and includes decisions as to method and time of fire and designation of mines to be fired. Whenever the casemate apparatus is set for delayed contact fire or contact fire, the mine group commander will insure that measures are taken first to notify all cooperating naval units of the fact.

248. Position-finding system.—*a. Necessity and use therefor.*—A position-finding system is required to plot the exact locations of the mines as they are planted, and for surveillance, fire control, and conduct of fire.

b. Different systems in use.—Since controlled mines ordinarily are located well within the range of visibility from shore, the position-finding system provided should be one which is well adapted to short range work. The three systems which have been installed for submarine mine purposes, are, in the order of preference, the terrestrial horizontal base system, the vertical base system, and the self-contained horizontal base system. For discussion of these systems see TR 435–221.

249. Mine plotting.—*a. Plotting detail.*—The plotting detail, under usual conditions, consists of the following personnel:

Plotter.
No. 1, assistant plotter.
No. 2, primary arm setter.
No. 3, secondary arm setter.
Nos. 4 and 5, recorders.

b. Plotter.—(1) The plotter is in immediate charge of the plotting room. He is responsible to the range officer for the adjustment of the plotting-room devices and for the police of the plotting room. He receives the reports of the observers and individual members of his detail and reports to the range officer, ***Sir, range section in order,*** or reports defects that can not be remedied without delay.

(2) The plotter wears a head set, bridged with that of No. 2, on the reader's line to M′. When a target is assigned by the mine group commander (or by the battery commander), the assignment is repeated by the M′ reader, when the plotter calls the plotting room and casemate to attention, and repeats the target assignment, and with No. 2 and No. 3 moves to a position at the plotting board covered by the designated target area, in readiness to plot the target position at the first reading. As soon as M′ and M″ observers have reported ***on target,*** the plotter announces ***next bell—time one.*** In mine position finding time numbers are assigned successively *to each 15-second observing interval.*

(3) *Plotting the mine field.*—After each mine is planted, and the mine yawl has pulled alongside and raised an ore or flag to mark the mine, the M′ reader reports to the plotter ***mine marked,*** and a flag is raised at M′, whereupon the plotter commands ***READ, NEXT TWO BELLS.*** The two readings are taken as a check. At each reading, the plotter places the targ accurately at the intersection of the arms and marks on the plotting board the position of the plotted point. If the two readings do not check within 10 yards, readings are repeated until two successive readings do so check. As soon as the mine plot has been made and checked, the plotter commands ***LOWER FLAG,*** which is repeated by M′ reader to the man at the halyards. After each mine is plotted, the plotter writes its number to the shoreward side of the plotted point and incloses the plotted point in a small circle. After the group is completed the plotter enters the group number in Roman numerals opposite the center of the group on the seaward side. After the entire mine field is plotted the whole plot is entered in drawing ink, and two intersecting lines are drawn on the board, along the station arms, and their azimuths entered, for the purpose of subsequent reorientation of the plot.

(4) *Tracking a target.*—As soon as No. 2 and No. 3 have set their respective station arms and signaled "Set," the plotter places the target accurately at the intersection of the arms, and marks on the plotting board the position of the plotted point. When the track has approached sufficiently near to the mine field to warrant a prediction in observation fire, and if it is desired to predict, the plotter signals "Clear," after marking the last plotted point, when the arm setters quickly move their arms so as to clear the track and probable course of the target.

(5) *Procedure in observation fire.*—At the command ***COMMENCE TRACKING*** by the mine group commander or battery commander, the plotter repeats the command, which is then repeated by the assistant plotter to the casemate electrician. (See par. 133.) Similarly, when the command ***OBSERVATION FIRE*** is received, this command is repeated, and when the target has approached to within 30 to 45 seconds of the mine field, the plotter, after signaling "Clear," quickly prolongs the track to the mine field, notes the group which will surely include the track of the target, and announces them, as for instance, "Group 3." This announcement is repeated by the assistant plotter to the casemate electrician. Then prior to the next bell, the plotter reads the travel of the target in yards during the observing interval, using a prediction scale with modified graduations, or a mine prediction ruler, and announces the travel to the

assistant plotter. On the next bell, the assistant plotter starts the stop watch, and the plotter accurately predicts the course of the target and commands (for instance) ***NUMBER 9 MINE, READY,*** which is repeated by the assistant plotter to the casemate electrician. The plotter then measures the distance in yards from the last plotted position of the target to the designated mine, and calls this distance to the assistant plotter, who, using this distance as one argument, and the travel in 15 seconds, previously announced, as the other argument, obtains the time to fire. Using the stop watch, at one second less than the determined time, the assistant plotter gives to the casemate electrician the command ***FIRE.*** Previously, the reader at M′ will have heard the plotter announce the group and mine numbers, and repeats these announcements so that they can be heard by the mine group commander and battery commander. As soon as the assistant plotter has given the command ***FIRE,*** the plotter reports over the reader's line, "Mine fired," and this announcement is repeated by the reader at M′. Observation fire will not be conducted by use of the group commander's telescope set on a predicted point, with the command ***FIRE*** given from M′ as the target crosses the vertical cross wire.

(6) *Procedure in delayed contact fire and in contact fire.*—In either of these methods of fire, as soon as the casemate electrician has reported the group and number of the mine which has been struck (or fired), the plotter will have the primary arm brought up to the targ held on the plotted position of the mine, when No. 2 will report to the M′ reader the group and number of the mine struck (or fired) and the azimuth of the mine from M′. (See par. 26 *a* and *b*, and also 250 *b* and *c*.) The azimuth and range of each mine may be tabulated in the M′ station to avoid delay in the transmission of these data.

c. No. 1, assistant plotter.—(1) No. 1 wears a head set on the line to the mining casemate, and transmits commands and reports as indicated in *b* (5) and (6) above.

(2) No. 1 operates the mine prediction ruler as prescribed in Ordnance Pamphlet No. 1946, and assists the plotter in predicting for observation fire as prescribed in *b* (5) above.

d. No. 2, primary arm setter.—(1) No. 2 wears a head set bridged with that of the plotter, on the reader's line to M′.

(2) No. 2 performs the following duties as described in *b* above:

(*a*) At assignment of target moves, with primary arm, to part of plotting board covered by the designated target area.

(*b*) In plotting mines or targets sets primary arm at azimuth announced by M′ reader, and as soon as he has done so, calls or signals "Set." A suitable signal is to tap lightly on the azimuth circle. After each setting he records the azimuth and the corresponding time number. In order to avoid errors due to backlash in the index box, the hundredths of a degree should always be set by moving the index pointer up to the proper graduation on the index dial in the same direction. For a right-hand board this direction should be that of increasing azimuth, and for a left-hand board should be that of decreasing azimuth.

(*c*) At the signal "Clear" given by the plotter, No. 2 quickly unlocks the index box and swings the primary arm to one side, so as to clear the track and future course of the target.

(*d*) In delayed contact fire, when a mine has been struck (or fired), No. 2, with the assistance of the plotter, determines the azimuth from M′, and reports to M′ as prescribed in *b* (6) above.

e. No. 3, secondary arm setter.—(1) No. 3 wears a head set on the reader's line to M″.

(2) After the assignment of a target, when M″ observer reports over the intelligence line to M′ ***on target,*** this report is repeated by M″ reader and No. 3.

(3) When the plotter announces ***next bell—time one*** this report is repeated by No. 3 to M″ reader.

(4) With respect to M″ readings and the secondary arm, No. 3 performs duties similar to those indicated for No. 2 in *d* (2) above.

(5) In plotting by the vertical base system, or by the self-contained horizontal base system, after the reader at the instrument has called the range, No. 3 repeats it to the plotter, and then records the range and the corresponding time number.

f. Nos. 4 and 5, recorders.—(1) No. 4 and No. 5, respectively, record the reports, announcements, and commands of the plotter and the assistant plotter, noting for each record the nearest corresponding time number, and in addition, during mine service practice and submine practice, under the direction of the plotter, record such additional data as are required in the conduct of practice and the submission of reports.

(2) No. 4 and No. 5 will be trained to substitute for No. 1, No. 2, or No. 3 whenever necessity requires.

250. Commands and reports.—The principal commands and reports required in connection with the several systems of position-finding and plotting-room operations, as well as the regulations governing indication and identification of targets, are set forth in TR 435–221. In addition, the following procedure for commands and reports will govern.

a. Delayed contact fire.—The mine battery commander commands ***DELAYED CONTACT FIRE—GROUP(S)*** (such number)—(so many) ***SECONDS DELAY.*** This command is transmitted via M′ reader, plotter, and assistant plotter to the casemate electrician, whose procedure is prescribed in detail in paragraph 131.

b. Contact fire.—The mine battery commander commands ***CONTACT FIRE—GROUP(S)*** (such number). This command is transmitted via M′ reader, plotter, and assistant plotter to the casemate electrician, whose procedure is prescribed in paragraph 132. For action when a mine is fired, see paragraph 249 *b* (6).

c. Use of the mine field in tactical surveillance.—To use the mine field itself in conducting surveillance, without danger of firing a mine, the mine battery commander commands ***SURVEILLANCE—D. C. ONLY.*** This procedure is the same as in delayed contact fire except that the casemate electrician *does not start the D. C.-A. C. motor generator*, nor close switches No. 9 and No. 8 on power panel.

d. To cut off A. C. from the mine field.—The mine battery commander commands ***CUT OFF A. C.*** The procedure is as prescribed in paragraph 131 *m*. The casemate electrician's report is repeated to M′.

e. To cut off D. C. from the mine field.—The mine battery commander commands ***CUT OFF D. C.*** The procedure is as prescribed in paragraph 131 *n*. The casemate electrician's report is repeated to M′.

f. To close stations.—At the command ***CLOSE STATIONS,*** repeated to observing stations, plotting room, and casemate, the senior chief of detail at each station sees that instruments are secured and covered, that the switches controlling electric circuits are left open, windows and doors closed and fastened, and personnel dismissed.

251. Modifications for target practices.—The necessary modifications for the preceeding plotting-room operations, in the conduct of mine-service practice and submine practice, are covered in TR 435–55.

252. Location of distribution boxes.—*a.* The accurate location and marking of the positions for distribution boxes by the distribution box boat are controlled by the range section. For distribution

box boats which have been provided with the authorized radio installation, the process is relatively simple. The desired positions of the distribution boxes are plotted on the plotting board. The distribution box boat proceeds to the mine field with the requisite number of marking buoys, buoy ropes, and 1,000-pound cast-iron anchors. While under way, the distribution box boat is tracked and plotted, and by directions from the plotter, transmitted by radio, alters its course so as to approach one of the required positions, and in ample time reduces speed so as to permit accurate location before planting. By similar means, the distribution box boat is directed successively to the several positions of the other distribution boxes.

b. If the distribution box boat is not equipped with radio, the operation is frequently extremely difficult. One method is to proceed to each distribution box position by the following successive steps:

(1) Before leaving the dock, the coxswain is instructed as to a course to follow which will approach the first box position.

(2) Then the range section tracks and plots the course of the distribution box boat, and when it is seen that the distribution box boat, in following its indicated course, has approached the nearest that it will to the required position, it is directed by a simple signal, such as the lowering of a flag, to stop, and the distribution box boat is then plotted.

(3) By the use of one of four signals, the distribution box boat is then directed on a course either due north, east, west, or south, until it is directly opposite the box position, when it is directed by another such change of course on a rectangular coordinate to the box position, where it is halted. This approach by rectangular coordinates will generally be found to be not only the simplest method, but the one involving the least chance of confusion in reading signals from shore. Its successful employment depends upon the exercise of judgment on the part of the plotter in allowing for the time necessary for the distribution box boat to lose headway after the "stop" signal is given. A convenient means for use in directing the distribution box boat on rectangular coordinates is a piece of transparent celluloid or xylonite with intersecting north-south and east-west lines, and a graduated arc centering at the intersection, the arc so graduated that when the primary arm is brought up to the intersection, superimposed over the plotted position of the distribution box boat, and the graduation on the arc brought to the same reading as the index box of the primary arm at the fiducial edge thereof, the cross lines are accurately oriented.

253. Fire-control equipment.—Other than casemate equipment and megaphones, the equipment used for fire control, fire direction, and position finding in the submarine mine service, is furnished by the Signal Corps and the Ordnance Department.

254. Signal Corps equipment.—*a.* Fire-control equipment consists of telephones and accessories. See Signal Corps Manual No. 8. Description of essential telephone circuits is included in Section XIII.

b. Radio equipment and operation.—See Signal Corps Training Manual for Radio Operators, No. 27.

c. Message Center operation.—See Signal Corps Training Manuals for Message Center Specialist, Students No. 24, and Instructors No. 25.

255. Ordnance Department equipment.—*a.* The authorized items of equipment for submarine mine use, supplied by the Ordnance Department, are as follows, the publication describing the construction, adjustments, and use of each being indicated opposite each item:

Item	Descriptive publication
Observation telescope (seacoast), M1908	W. D. Document No. 1032, October, 1911.
Azimuth instrument, M1910	Ordnance Pamphlet No. 1656, Dec. 14, 1911.
Depression position finder	Ordnance Pamphlet No. 1875, revision of May 5, 1915.
Do	Ordnance Pamphlet No. 1876, revision of Jan. 25, 1917.
Submarine Plotting Board, M1906	Ordnance Pamphlet No. 1669, revision of Dec. 13, 1909.
Mine prediction ruler	Ordnance Pamphlet No. 1946, revision of Aug. 25, 1909.

b. In addition, a ruler with scale, as indicated in paragraph 249 *b* (5), an orienting scale such as described in paragraph 252 *b* (3), and any other device authorized by the harbor defense commander are authorized for local improvisation.

SECTION XXXIII

MINE PRACTICE

	Paragraph
Submine practice	256
Service mine practice	257
Reminder lists for service mine practice	258
Improvised target for submine and service practice	259

256. Submine practice.—*a. Object.*—The object of submine practice is to insure training of the range, planting, and loading sections for service practice.

b. When held.—When smoothness and accuracy have been attained in group drills, submine target practice should be made a part of the training. It should be held as often as is necessary to

attain sufficient smoothness and accuracy for holding service mine practice.

c. Supervision.—Submine practice will be conducted under the general supervision of the group commander.

d. Preparation of matériel.—See paragraph 212.

e. Planting.—The submine is planted exactly as the service mine except that the bottle buoy is carefully lowered to the water after the mine buoy has been cast overboard.

f. Rules for practice.—(1) Submine practice is held in the same manner and under the same general rules as service mine practice. The same safety precautions will be observed and, in addition, extreme care will be exercised in handling small boats in the vicinity of the mines so as not to foul the submines.

(2) In case a submine is not fired before the mine is taken up, the submine charge will be removed by a small boat as soon as the mine floats after the anchor leaves the bottom and before the mine is brought inboard.

257. Service mine practice.—The details for the conduct and scoring of service mine practice are prescribed in TR 435–55.

258. Reminder lists for service mine practice.—Each unit and detachment commander should prepare a reminder list, enumerating the necessary details of preparation, and data to be recorded, for service mine practice, before the practice occurs, in order to insure that no necessary action is overlooked.

259. Improvised target for submine and service practice.—The details of an improvised target which may be constructed locally are shown in Figures 89 and 90.

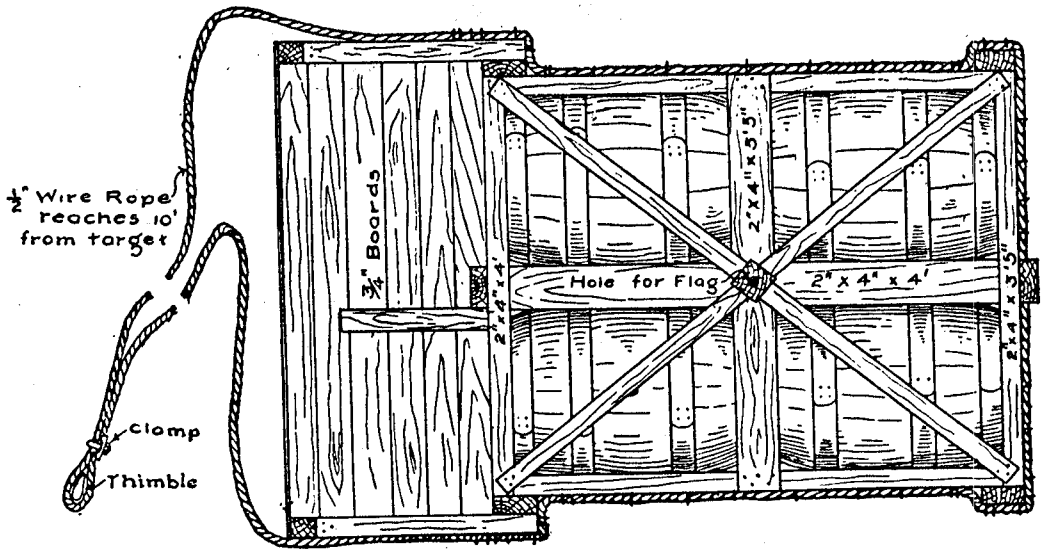

FIGURE 89.—Improvised mine target, plan

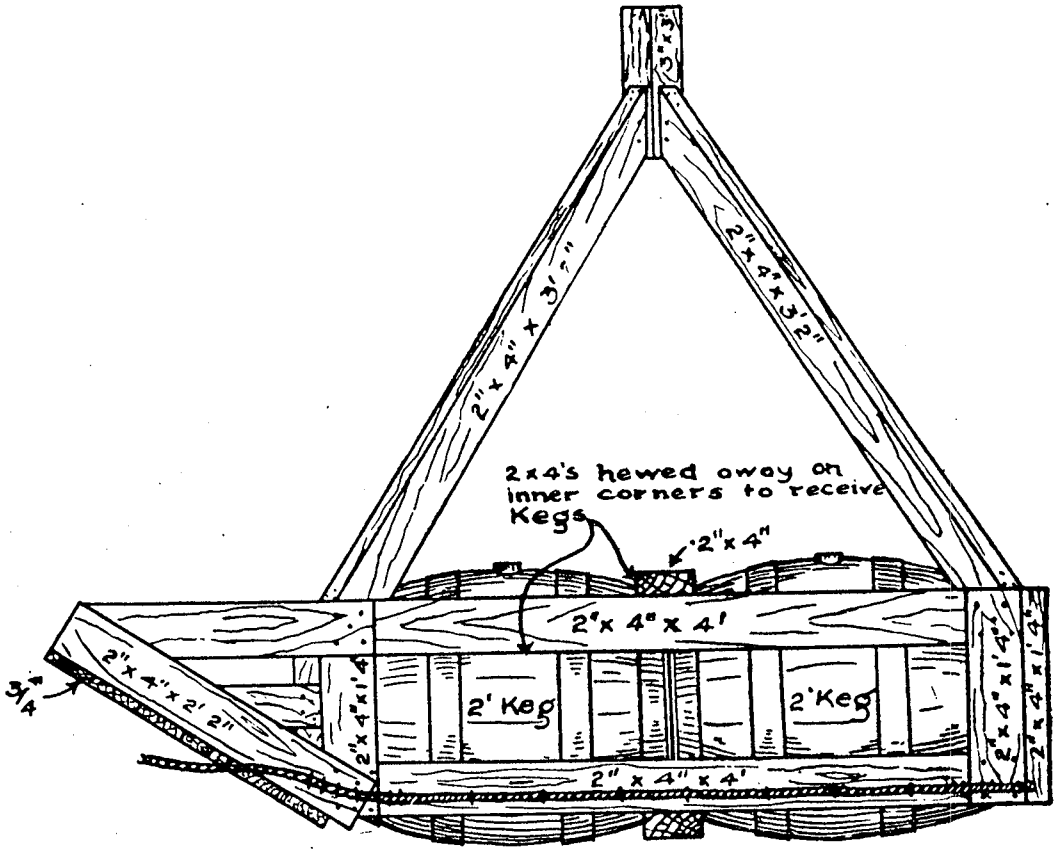

FIGURE 90.—Improvised mine target, elevation

APPENDIX A

UTENSILS AND EXPENDABLE STORES

Paragraph
Utensils 260
Wrenches issued by the Submarine Mine Depot 261
Expendable stores 262

260. Utensils.

Alcohol lamp.—For use in vulcanizing joints.

Anvil.—50-pound.

Axe.—5-pound.

Ball peen hammer.—8-ounce, machinists.

Battery brush.—For use in cleaning the plates of lead storage batteries.

Bench vise.—Heavy, with 5½-inch jaw.

Binder for cable test records.—11⅜ inches by 9 inches.

Boat hook.

Boat pump.

Breast drill and drills.—Double speed, 15 straight shank twist drills from $\frac{1}{16}$ to ½ inch by 32ds.

Calking iron.

Carpenter's tool chest with tools, tray, hasp and staple, and padlock with chain.—It should contain the following—

13 bits, auger, ¼ to 1 inch by 16ths.
1 bit, expansive, ½ inch to 1½ inches, with 2 cutters.
1 brace, ratchet.
6 chisels, carpenter's, ¼ inch to 1½ inches by 4ths.
1 hammer, claw, 16-ounce.
2 handles, chisel, extra.
1 handle, claw hammer, extra.
1 knife, drawing, 8-inch, folding.
1 level, carpenter's.
1 oilstone, 8-inch, in hardwood case.
1 plane, jack.
1 plane, smooth.
1 rule, 2-foot, folding.
1 saw, compass, 12-inch.
1 saw, hand, 26-inch, 8-point.
1 saw, rip, 28-inch, 5½-point.
1 saw set.
1 square, steel, 24-inch.

TM 2160–20
260

Claw hatchet.

Cold chisel.—9-inch with a 1-inch cutting edge.

Crowbar.—10-pound, wedge point.

Dust brush.

Files.—6-inch slim taper, triangular; 6-inch flat bastard.

Gasoline torch.—1-quart, brass.

Glue pot.—Cast-iron.

Grappling iron.—5-prong, light.

Grindstone.

Hacksaw frame and blades.—Adjustable, with 8-inch, 10-inch, and 12-inch blades.

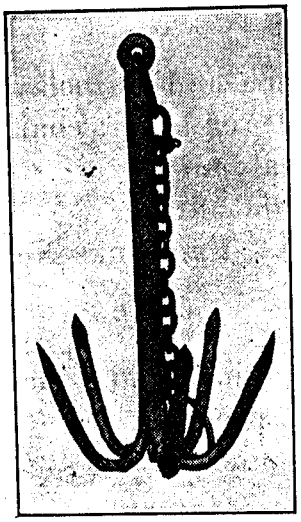

FIGURE 91.—Grappling iron

Iron scraper.

Khotal lamp.—*a. Description.*—This is a kerosene lamp used for heating the vaporizer of the Hornsby-Akroyd oil engine, and for heating melting and glue pots. It is made of brass and consists of an oil reservoir, four brass burners, a filler cap, an air valve mounted on top, and an air pump on the side.

b. Operation.—To start the burners, after filling the reservoir with kerosene through the filler cap, open the air valve, fill the small cups under the burners with alcohol, and light the alcohol. After the burners are heated thoroughly, close the air valve and pump air into the reservoir with a few strokes of the air pump. To put out the burners, open the air valve, which releases the air pressure in the reservoir and cuts off the supply of kerosene to the burners.

c. Heating frame.—This is about 14 inches high and consists of an iron base ring upon which the lamp is placed, and

three vertical rods supporting an iron grate upon which the melting or glue pot is placed.

Ladle, iron.

Letter and number dies.—Steel.

Life buoy.

Life preservers.

Loading funnels.—Copper, large and small.

Loading scoops.—Aluminum or copper.

Mallets.—Hickory, large and small.

Marlinespike.—Steel, 12-inch.

Measuring tape.—100-foot, metallic.

Megaphone.

Melting pot.—Cast-iron.

Monkey wrenches.—8-inch and 15-inch.

Padlock with chain.—Heavy brass; chain and 2 keys.

Paintbrushes.—Flat; oval; sash.

Pliers.—6 and 8 inch, side-cutting.

Portable platform scales.—Fairbanks No. 11.

Scissors.—8-inch.

Scratchbrush.—Steel wire.

Screw drivers.—10-inch, 6-inch and 3-inch.

Smith's hammer.—Cross peen.

Soldering copper.—½-pound.

Sounding lead.—8-pound, octagon.

Spring balance scales.—200-pound and 800-pound.

Stillson wrench.—18-inch.

Submarine mine knife.—Two blades.

Tackle blocks.—Double and single.

Tar oil barrel.—30-gallon, steel.

Tool box.

261. Wrenches issued by the Submarine Mine Depot.

Code No.	Description of wrench	Where used
1335	Single-head, open end, 1 1/16-inch opening short diameter.	Automatic anchor, Model 1910.
1336	Single-head, open end, 1⅜-inch opening short diameter.	Do.
1337	T socket, 1⅜-inch opening short diameter, 18 inches long.	Do.
1463	Double-head, open end, 1⅛-inch and 1½-inch openings, 13½ inches long.	Automatic anchor, Model 1916.
1464	T socket, 2 7/32-inch opening short diameter, 12 inches long.	Do.
1612	T socket, 1 1/32-inch opening short diameter, 3 inches long.	Storage battery, Type D-5.

Code No.
1662
1839
2065
2323
2324
2325
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Code No.	Description of wrench	Where used
1662	T socket, 1 1/16-inch opening short diameter, 3 inches long.	Storage battery, Type E–7.
1839	T socket, brass with insulated handle, 5/8-inch opening short diameter, 15 inches long.	Operating board.
2065	Double-head, open end, 1 1/16-inch and 1 1/4-inch openings, 11 1/2 inches long.	Junction boxes; distribution boxes; brass follower of Model 1910 compound plug.
2323	Single-head, open end, 1/2-inch opening, 3 1/2 inches long.	Hornsby-Akroyd oil engine.
2324	Single-head, open end, 19/32-inch opening, 4 1/2 inches long.	Do.
2325	Single-head, open end, 1 1/16-inch opening, 5 1/2 inches long.	Do.
2326	Single-head, open end, 13/16-inch opening, 6 1/2 inches long.	Do.
2327	Single-head, open end, 7/8-inch opening, 7 1/2 inches long.	Do.
2328	Single-head, open end, 1 1/16-inch opening, 9 inches long.	Do.
2329	Single-head, open end, 1 9/32-inch opening, 11 3/4 inches long.	Do.
2330	Single-head, open end, 1 7/16-inch opening, 13 inches long.	Do.
2331	Single-head, open end, 1 21/32-inch opening, 14 3/4 inches long.	Do.
2332	Single-head, open end, 2 1/32-inch opening, 18 1/2 inches long.	Do.
2333	Single-head, open end, special wrench, 19/32-inch opening, 4 1/2 inches long.	Do.
2334	Single-head box wrench, 17/32-inch square opening, 7 inches long, for filter cock.	Do.
2510	Double-head, open end, No. 38, 1 1/16 and 1 7/16-inch openings, 13 1/2 inches long.	5-kilowatt set, General Electric.
2511	Hook spanner, No. 405, 7 1/4 inches long	Do.
2512	Hook spanner, No. 406, 8 1/2 inches long	Do.
2513	Hook spanner, No. 407, 9 3/4 inches long	Do.
2514	Double-head, open end S, No. 662, 17/32 and 5/8-inch openings, 5 inches long.	Do.
2515	Double-head, open end S, No. 663, 19/32 and 3/4 inch openings, 6 1/4 inches long.	Do.
2516	Double-head, open end S, No. 664, 3/4 and 15/16 inch openings, 7 1/2 inches long.	Do.
2517	Single-head hexagonal box wrench, No. 802, 5/8-inch opening small diameter, 5 inches long.	Do.
2518	Double-face, double-handle, tit wrench, for generator coupling and flywheel nuts.	Do.
2519	Double-handle tit wrench for governor, 4 inches long	Do.
2520	Magneto wrench	Do.
2521	Spark plug wrench	Do.
2861	Double-head, open end, 7/16 and 1/2 inch openings, 4 1/2 inches long.	5 kilowatt set, Sturtevant.
2862	Double-head, open end, 9/16 and 5/8 inch openings, 5 1/2 inches long.	Do.
2863	Double-head, open end, 3/4 and 7/8 inch openings, 6 1/2 inches long.	Do.
2864	Single-head, open end, 1 1/8-inch opening, 9 inches long.	Do.
2865	Double-head, open end, 2 3/4 and 3 inch openings, 17 inches long.	Do.
2866	T coupling bolt wrench, flat end, 15/16 inch wide, 10 3/4 inches long.	Do.

Code No.	Description of wrench	Where used
2867	T tit wrench, 4½ inches long	5 kilowatt set, Sturtevant.
2868	Carburetor jet socket wrench, 1¼ inches long, with handle.	Do.
2869	Valve cap wrench (plug)	Do.
2870	Double-head magneto wrench, one open end, one box end, 3 inches long.	Do.
3023	T socket, 15/16-inch opening short diameter, 4 inches long.	Cable clamp bolt of mine case cap; clamp bolts small junction box; clamp bolts 7-conductor distribution box.
3024	Double-head, open end, 2 1/16 and 1 5/16 inch openings, 10½ inches long.	Studbolt nuts on mine case; cable clamp bolt on mine cap.
3025	Double-head, open end S, 2 1/16 and 1 3/16 inch openings, 11½ inches long.	Studbolt nuts on mine case; steel follower on compound plug.
3485	Double-head, open end, ⅝ and 1 3/16 inch openings	Connecting bolts and steel followers of compound plugs; brass follower of old model and Model 1908 compound plugs.
3486	Special socket with separate lever handle, 2¾-inch opening short diameter, 6¾ inches across.	Plug proper.
3488	Pin spanner, 2¾ inches center to center of pins, 8 inches long.	Brass fuze can for Model 1910 compound plug.
3489	Hook spanner, 15 inches long	Fuze can cap for Model 1910 compound plug.
3490	Flat semihexagonal, 9¼ inches	Connecting collar for Model 1910 compound plug.
3865	Clamp wrench, 24 inches long, central threaded part 2 3/16 inches diameter, with clamp bolt.	Transformer end plate.
4225	Single-head, open end, 1 3/32-inch opening short diameter, 5 inches long.	Hexagonal nuts for securing fuzes to selector box; selector pole piece nuts.
4226	Single-head, open end, ¼ inch-opening, 2⅜ inches long.	Conical head locking screw nut on selector.
4512	L socket wrench, 5/16-inch opening, 7⅛ inches long	Selector box cover screws and cover lifter.
4528	Single-head, open end, ¾-inch opening, 5½ inches long.	Selector box followers.

262. Expendable stores.

Alcohol.—Denatured.
Asbestos wick packing.—For alcohol lamp.
Asphaltum varnish.
Cotton duck.—12-ounce.
Cotton line.—Cod line, No. 4; sounding line, No. 10; measuring line No. 16.
Cotton waste.
Cup grease.—No. 3.
Drier.—For use in mixing paints.
Emery paper.
Friction tape.—Rubber, ¾-inch.
Glue.
Graphite.—Flake.
Graphite paint.—Ready mixed.
Lampblack.
Lead pencils.

Linen tags.
Loading wire.—Rubber insulated, stranded, copper.
Lubricating oil.—Class A, medium.
Lye.
Manila hemp ropes.—⅝-inch diameter and 1-inch diameter.
Marking crayon.—Light red.
Marline.
Metal polish.
Nails.—8, 10, 20, 40, and 50 penny.
Oakum.
Paraffine.
Paste soap.
Pumice stone.
Raw linseed oil.
Red lead.
Rubber cement.
Rubber tape.
Rubberoid.
Sandpaper.
Sapolio.
Slushing oil.—Grade B, medium.
Socket alloy.
Soldering paste.
Spar varnish.
Steel color paint.
Target cloth.
Tarred hemp rope.
Tin foil.
Toweling.
Turpentine.
Twine.
White lead.
Wire solder.

APPENDIX B

REFERENCES, FORMS, AND INDEX

Paragraph
References to official publications 263
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263. References to official publications.—The following official publications of the War Department are referred to in this manual, as having some bearing on the problems of submarine mine defense:

Joint Action of the Army and the Navy.
AR 90–70.
AR 90–150.
AR 90–155.
AR 90–160.
TR 75–10.
TR 160–10.
TR 163–5.
TR 185–5.
TR 210–5.
TR 435–20.
TR 435–55.
TR 435–105.
TR 435–210.
TR 435–211.
TR 435–300.
TR 435–330.
TR 1160–15.
Signal Corps Manual No. 8, Installation and Maintenance of Fire-Control Systems at Seacoast Fortifications.
W. D. Doc. No. 1032, Observation Telescope (Seacoast) M. 1908.
Ordnance Pamphlet No. 1656, Azimuth Instrument, M 1910.
Ordnance Pamphlet No. 1669 (Submarine Plotting Board, M. 1906).
Ordnance Pamphlet No. 1875, Depression Position Finder.
Ordnance Pamphlet No. 1876, Depression Position Finder.
Ordnance Pamphlet No. 1946, Mine Prediction Ruler.

264. Forms.—*a.* For instructions concerning the forms for record of cable test and their preparation, see paragraphs 28 to 31, inclusive, TR 1160–15.

b. The forms required in connection with reports of mine service practice are illustrated in TR 435–55. Of these forms, Form No. M–2, Planter Record, and Form No. M–4, Loading Room Record, will regularly be used in connection with mine training as well as in mine service practice.

c. Form for casemate storage battery record.—This form, illustrated below, is supplied by the Submarine Mine Depot in sheets of suitable size and punching to permit filing in the same type of post binder that is issued for filing the record of cable test. The casemate storage battery record will be kept by the casemate electrician, and the completed record for each month will be kept on file for inspection for a period of two years.

CASEMATE STORAGE-BATTERY RECORD

For month of _____, 19__. Fort _____

Casemate No._____ Battery type _____

Days water added and other remarks, enter on back of form.

To correct specific gravity for temperature, add 1 point for each 3° above 70°, and deduct 1 point for each 3° below 70°.

Signature of recorder _____ C. A. C.

Daily readings

Day of month	Pilot cell (No. _____)					Voltage of battery
	Temperature			Specific gravity (not corrected)		
	Air	Electrolyte				
		Before charge	After charge	Before charge	After charge	
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						
26						
27						
28						
29						
30						
31						

Charging record

No. of cell	Day of month, number of hours charged, temperature of pilot cell		Day of month, number of hours charged, temperature of pilot cell		Day of month, number of hours charged, temperature of pilot cell		Day of month, number of hours charged, temperature of pilot cell	
	Cell specific gravity		Cell specific gravity		Cell specific gravity		Cell specific gravity	
	Before	After	Before	After	Before	After	Before	After
1								
2								
3								
4								
5	✓							
6								
7								
8								
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40								

d. Form for record of casemate tests.—This form, illustrated below, is supplied by the Submarine Mine Depot in sheets of suitable size and punching to permit filing in the same type of post binder that is issued for filing the record of cable test. Each sheet of the record of casemate tests is intended to cover one complete test of from one to six operating boards with their selector boxes, either connected to mines in the mine field, or to a bank of 19 mine transformers in the casemate. The form is adapted to record the tests made either in mine field operations or for the required weekly maintenance test. All records of casemate tests will be kept on file for a period of one year.

RECORD OF CASEMATE TESTS

Fort _____ Casemate No. _____ Date _____ 19__

Operating board and selector box	No. ____			No. ____			No. ____			No. ____			No. ____			No.____		
Mine No.	Par. 124, TM 2160–20—Mil. amp. reading	Obs. firing—O. K.	Con. firing—O. K.	Par. 124, TM 2160–20—Mil. amp. reading	Obs. firing—O. K.	Con. firing—O. K.	Par. 124, TM 2160–20—Mil. amp. reading	Obs. firing—O. K.	Con. firing—O. K.	Par. 124, TM 2160–20—Mil. amp. reading	Obs. firing—O. K.	Con. firing—O. K.	Par. 124, TM 2160–20—Mil. amp. reading	Obs. firing—O. K.	Con. firing—O. K.	Par. 124, TM 2160–20—Mil. amp. reading	Obs. firing—O. K.	Con. firing—O. K.
1																		
2																		
3																		
4																		
5																		
6																		
7																		
8																		
9																		
10																		
11																		
12																		
13																		
14																		
15																		
16																		
17																		
18																		
19																		
20																		
Par. 119, TM 2160–20—D. C. volts																		
Par. 120, TM 2160–20—A. C. volts																		
Par. 121, TM 2160–20—O. K																		
Par. 122, TM 2160–20—O. K																		
Par. 123, TM 2160–20—O. K																		
Par. 126, TM 2160–20—Megohms																		
Par 128*d* (2), TM 2160–20—Hours operated																		

Par. 125, TM 2160–20: A. C. ground, ohms _____. D. C. ground, ohms _____.

NOTES.—1. Where instrument readings are indicated, the values should be entered. Where "O. K." test is indicated, the fact should be recorded by a check mark. 2. The "Wet test," paragraph 128, TM 2160–20, and not the "Dry test," paragraph 127, TM 2160–20, should be recorded. 3. Enter remarks and repairs executed on back of form.

Recorder, _____, C. A. C.

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BY ORDER OF THE SECRETARY OF WAR:

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Chief of Staff.

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C. H. BRIDGES,
Major General,
The Adjutant General.

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