TM 11-425

WAR DEPARTMENT TECHNICAL MANUAL

BAROGRAPHS

ML-3-A, ML-3-B

ML-3-C, ML-3-D

WAR DEPARTMENT • 20 JULY 1944

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TM 11–425, Barographs ML–3–A, ML–3–B, ML–3–C, and ML–3–D, is published for the information and guidance of all concerned.

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G. C. MARSHALL,
Chief of Staff.

OFFICIAL:
J. A. ULIO,
Major General,
The Adjutant General.

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I Bn 1: T/O 1–627; 1–637
For explanation of symbols see FM 21–6.

DESTRUCTION NOTICE

WHY —To prevent the enemy from using or salvaging this equipment for his benefit.

WHEN—When ordered by your commander.

HOW —1. Smash—Use sledges, axes, handaxes, pickaxes, hammers, crowbars, heavy tools.
2. Cut—Use axes, handaxes, machetes.
3. Burn—Use gasoline, kerosene, oil, flame throwers, incendiary grenades.
4. Explosives—Use firearms, grenades, TNT.
5. Disposal—Bury in slit trenches, fox holes, other holes. Throw in streams. Scatter.

USE ANYTHING IMMEDIATELY AVAILABLE FOR DESTRUCTION OF THIS EQUIPMENT

WHAT—1. Smash—Case and entire instrument.
2. Break—Clock mechanism, pen arm, and levers.
3. Burn—Chart and technical manual.
4. Bury or scatter—All of the above pieces after breaking.

DESTROY EVERYTHING

CONTENTS

SECTION I

DESCRIPTION

1. GENERAL. **a.** Barographs ML–3–A, ML–3–B, ML–3–C, and ML–3–D are portable precision instruments (also known as microbarographs) which measure and register changes in atmospheric pressure.

b. Some of the early Barographs ML–3–A have only one dash pot; the other Barographs ML–3–A and Barographs ML–3–B, ML–3–C, and ML–3–D have two dash pots. Otherwise there are no essential differences between the instruments covered in this manual. The various suffix letters result from refinements in design, the general appearance, function, and operation are the same for all.

c. Throughout this manual, basic type nomenclature followed by an asterisk within parentheses (Barograph ML–3–(*)) refers to Barographs ML–3–A, ML–3–B, ML–3–C, and ML–3–D, or any one of them.

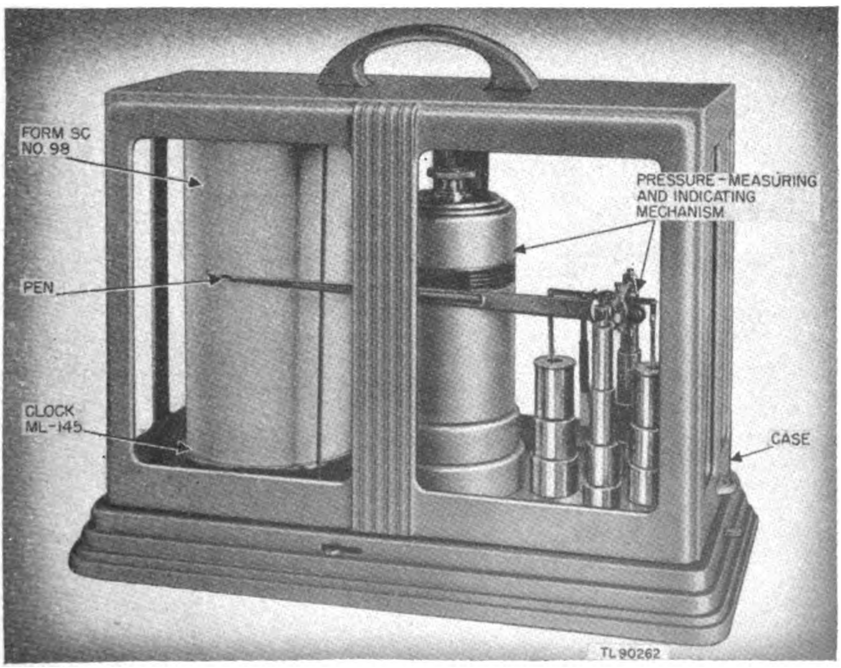

Figure 1. Barograph ML–3–(*).

2. COMPONENT PARTS. **a.** The component parts of Barograph ML–3–(*) (fig. 1) are:

1 pressure-measuring-and-registering mechanism mounted in a case.
1 pen.
1 bottle of dash-pot fluid.
1 Clock ML–145.

b. Additional items used with Barograph ML–3–(*) which must be procured separately, are—

Item	*Signal Corps stock No.*
Ink, special register, green	7A1100
purple	7A1101
red	7A1102
Oil, watch, grade No. 1	6G1339
Form SC No. 98	6D98
Mounting ML–178, special mounting to absorb shocks	7A1199–178

3. CASE (fig. 1). **a.** The case of Barograph ML–3–(*) consists of a low raised base and a high hinged cover held closed by a catch.

b. The base is metal and is approximately 13 inches long by 7 inches wide. The underside is provided with a removable cover plate, and four rubber feet.

c. The cover is a metal frame approximately 9 inches high. It has glass windows on all sides, and a carrying handle is fixed in the center of the solid top.

4. PRESSURE-MEASURING MECHANISM (figs. 2 and 3). **a.** The pressure-measuring mechanism of Barograph ML–3–(*) consists of a pressure-sensitive unit which actuates a recording pen through a system of levers.

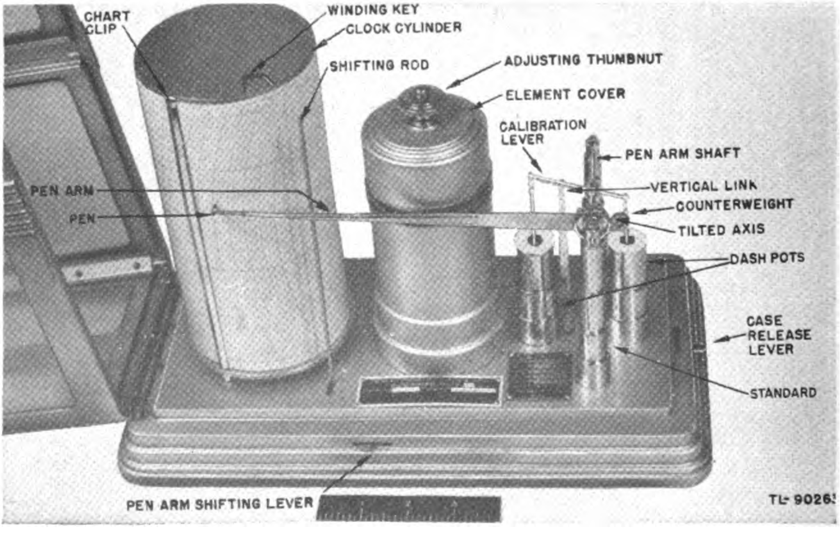

Figure 2. Barograph ML–3–(*), cover open.

b. The *pressure-sensitive unit* consists of two bellows made of very thin hard brass. The bellows are suspended inside a high dome-like cover (*element cover*) mounted over a large hole which is located approximately in the center of the base of the instrument case.

(1) The two bellows are screwed together at one end to constitute a single unit. One end of the unit is provided with a threaded bolt (*element post*) and the other end is provided with a slotted stud.

(2) The under side of the top of the pressure-sensitive unit cover is provided with a nub holding a coil spring (*element spring*). The element post of the unit extends through a hole in the nub. An *adjusting thumbnut* is screwed on the post to hold the unit, which the spring keeps firmly suspended downward within the cover. The element post is keyed to the nub to prevent the unit turning sideways. The lower end of the unit is free to move vertically.

c. The *lever system* consists of an *element link;* a *magnification lever* and *bimetal temperature compensation shaft;* a *vertical link;* a *calibration lever* and *dash pots;* a *pen arm shaft* and *standards;* and a *pen arm.*

(1) One end of the element link (fig. 3) is attached to the stud at the bottom of the pressure-sensitive unit. The other end is fitted into a slot in the magnification lever (fig. 3) which extends horizontally below

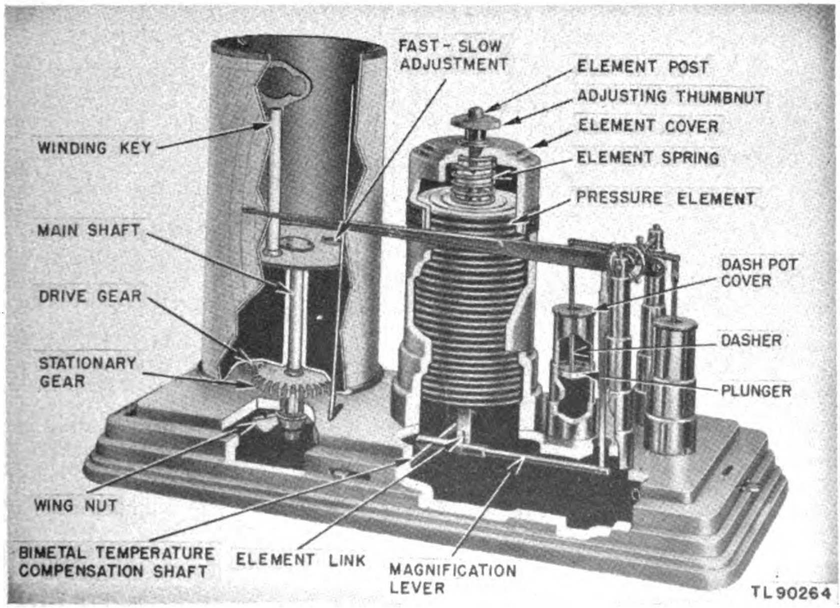

Figure 3. Barograph ML–3–(*), exposed view of mechanism.

the pressure-sensitive unit. The slotted hole in the element link is engaged by a pivot screw through the magnification lever.

(2) One end of the magnification lever (fig. 4) is clamped to the middle of the bimetal temperature compensation shaft, which has its ends fitted in bearings mounted on the under side of the case. The magnification lever extends from the shaft and across the bottom of the pressure-sensitive unit where the element link attaches to the unit, and ends below a small hole in the base.

(3) The vertical link (fig. 3) extends vertically through the small hole. The lower end of the vertical link is attached to the end of the magnification lever, and the upper end is attached about midway on one side of the calibration lever.

(4) The calibration lever (fig. 2) is inserted through the pen arm shaft. It extends at right angles on each side of that shaft, more on the side to which the vertical link is attached than on the other, and is held in position by a set screw. The ends of the calibration lever are attached to dash pots.

(*a*) Each dash pot (fig. 3) consist of a cylinder with a removable cover, a piston, and a connecting rod.

(*b*) Each dash pot cylinder is mounted immediately below an end of the calibration lever.

(*c*) Each piston is a thin sheet-metal, cone-shaped *plunger* that is fitted inside the dash pot cylinder.

(*d*) A connecting rod (*dasher*) is attached to the top center of each plunger, and extends through a hole in the removable cover of the dash pot cylinder. The upper end of each dasher is attached to an end of the calibration lever.

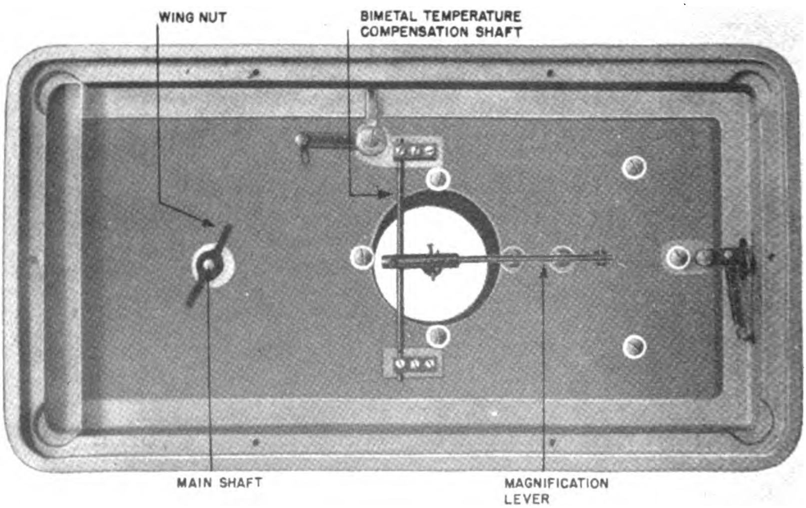

Figure 4. Barograph ML–3–(*), bottom view.

(5) The ends of the pen arm shaft are supported by standards (fig. 2) mounted on the base.

(6) The pen arm has one end attached to the pen arm shaft by a *tilted-axis* arrangement (fig. 2). The other end of the long arm is free and is partially balanced by a *counterweight* attached to the opposite side of the axis.

d. The *recording pen* is a nickel-silver nib pen clamped to the free end of the pen arm. The pen arm holds the pen in position to bear against the record chart. A vertical *shifting rod* (fig. 2) is mounted on the base near the free end of the pen arm. This rod is attached to the *pen arm shifting lever* provided at the front of the base, and can be moved laterally to hold the pen arm and pen away from the chart.

5. CLOCK ML–145 (fig. 3). **a.** Clock ML–145 consists of—

(1) A clock movement housed in a high cylinder.
(2) A chart clip.
(3) A main shaft and stationary gear, with wing nut.
(4) A winding key.

b. The cylinder is metal, and is the drum for the record chart. The chart clip holds the chart on the cylinder.

c. The clock movement is the 8-day type and is fixed within the lower portion of the cylinder. The winding key attaches to the top of the clock and is reached through the open upper end of the cylinder.

d. The main shaft and gear fit into the hole provided in the base of the instrument case. The wing nut (figs. 3 and 4) screws on the threaded end of the main shaft to hold the gear stationary on top of the base.

e. The center hole in the bottom of the clock unit fits over the main shaft. The clock's drive gear engages the stationary main shaft gear and causes the chart cylinder to rotate once about every 4½ days.

SECTION II

INSTALLATION AND OPERATION

6. UNPACKING. **a.** Barograph ML–3–(*) is packed with the pen in place on the pen arm, and the pen arm tied to the shifting rod. The main shaft and stationary gear of Clock ML–145 are fastened in place in the case. The dash pot fluid and the cylinder containing the clock movement are packed separately.

b. Unpack the instrument carefully. Avoid any shock or jar. *Barograph ML–3–(*) is a delicate precision instrument and must be treated accordingly.*

c. If necessary to repack Barograph ML–3–(*) for shipment after it has been in use, proceed as follows:

(1) Turn the adjusting thumbnut of the pressure-sensitive unit counterclockwise (to the left) to move the pen to the bottom of the chart. Then lift the pen by hand to the top of the chart and tie the pen arm to the shifting lever (par. 17a(2)).

(2) Remove the clock cylinder from the instrument.

(3) Use an eyedropper to remove the fluid from the dash pots.

7. ASSEMBLING. **a.** Pull the case release lever (on the right when facing the front of the instrument) and open the hinged cover all the way over until the top left edge is resting safely on the table or shelf.

b. Untie the pen arm from the shifting rod, and make sure that the pen arm is *in front* of the rod. Push the shifting lever (at the front of the base) *to the right* to hold the pen arm as far to the front as possible.

c. Put the clock cylinder on the base by slipping the bottom center hole over the main shaft. Lower the cylinder carefully and turn it slightly until the clock drive gear is felt to engage the stationary gear on the base.

8. FILLING DASH POTS. **a.** The dash pot fluid supplied is a low-temperature oil to be used in the dash pots located below the ends of the calibration lever (fig. 2). The instrument will give an erratic record if the dash pots are not filled.

b. Fill each dash pot as follows:

(1) Use an eyedropper to extract the fluid from the shipping container.

(2) Lift the dash pot cover and put the fluid into the pot with the eyedropper. Fill it to within 3/8 inch of the top.

(3) Rock the calibration lever *slowly and carefully* to move the dash pot plungers so all air bubbles will be expelled.

(4) Lower the dash pot cover and seat it properly.

9. LOCATION. **a.** Locate Barometer ML–3–(*) on a level surface. It is important that the instrument be mounted in as level a position as practicable because gravity is the only force that holds the pen against the chart (par. 17e).

b. The instrument must be located where it cannot be disturbed easily or jarred accidentally.

(1) If the instrument is subjected to excessive vibration when on a desk or table, provide a substantial level shelf mounted on a solid wall.

(2) A sponge-rubber pad placed under the instrument will help protect it against vibration. Mounting ML–178 (par. 2b) is a special shock mounting for Barograph ML–3–(*).

c. The temperature of the area where Barograph ML–3–(*) is located must be as constant as possible.

(1) Keep direct or reflected sunlight from the barograph.

(2) Do not locate the instrument near a stove or a radiator.

(3) Protect the instrument from drafts or sudden movements of air.

10. INSTALLING CHART. **a.** Always remove the clock cylinder from Barograph ML–3–(*) to install or change a chart.

(1) Open the case (par. 7a).

(2) Push the shifting lever to hold the pen away from the cylinder.

(3) Lift the clock cylinder vertically from the shaft and remove it from the case.

Caution. If the cylinder holds a chart on which there is a record, handle it carefully to avoid smearing the ink.

b. Remove the chart clip by pulling it vertically from the bottom slot and top notch of the cylinder. Carefully remove the used chart, if there is one, and lay it in a safe place.

c. Take a new chart and make a notation (not in the margin) of the date it is being installed, mark one of the .00 reference lines according to the local pressure range (par. 13b (2)), and install the chart as follows:

(1) Lay the left-hand side of the chart on the cylinder so the actual beginning of the chart is lined up with the right-hand sides of the bottom slot and the top notch of the cylinder, and so the lower edge of the chart is snug against the bottom flange of the cylinder (fig. 5 ①).

(2) Wrap the chart clockwise around the cylinder, taking care to keep the beginning firmly in place and the bottom edge against the flange. Lap the chart end over the beginning (fig. 5 ②).

(3) Hold the chart clip so the outside of the curve is toward the chart. Insert the straight end of the clip into the slot at the bottom of the cylinder, lay the clip flat against the lapped portions of the chart, and push the hooked top down to engage the top notch of the cylinder (fig. 5 ③).

d. Examine the pen each time the chart is changed, and clean it if necessary (par. 20b).

11. WINDING CLOCK. **a.** Wind the clock every time while the cylinder is removed from Barograph ML–3–(*) to install a chart (par. 10). *Never wind the clock while the cylinder is in place in the instrument.*

b. The winding key is reached through the open top of the cylinder.

c. Wind in the direction indicated by the arrows beside the key.

(1) Approximately 12 to 14 half-turns of the key will fully wind a run-down clock.

(2) Approximately 7 to 8 half-turns will be sufficient for the periodic winding every time the chart is changed.

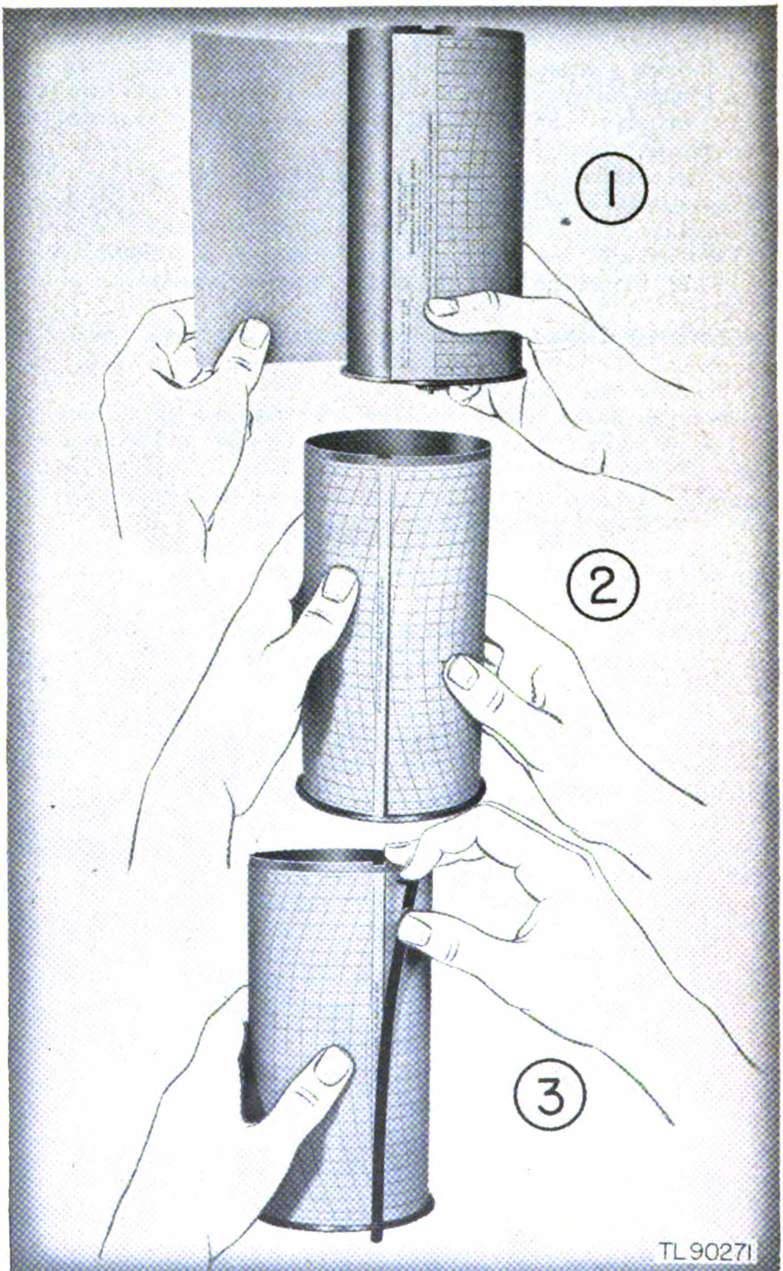

Figure 5. Installing chart on Clock ML–145.

12. REPLACING CYLINDER. **a.** After installing a chart or winding the clock, put the cylinder back on the shaft in the case.

(1) Before lowering the cylinder all the way so the gears mesh, note the local time and turn the cylinder so the corresponding curved vertical (time) line on the chart is lined up approximately with the pen.

(2) Lower the cylinder all the way and make certain that the drive gear of the clock meshes with the stationary gear on the base.

b. Set the pen accurately on local time (par. 13a).

13. PEN ADJUSTMENT. **a. Time Setting.** (1) Move the shifting lever to bring the pen in contact with the chart (fig. 2).

(2) Turn the clock cylinder so the *correct* curved vertical time line is immediately below the pen. When turning the cylinder, turn it counterclockwise to take up any backlash in the clock gear train. If necessary, turn the cylinder clockwise past the correct position and then return it counterclockwise.

b. Pressure Setting. This is a most important operating adjustment. Its purpose is to get the pressure-sensitive unit (par. 4b) in agreement with a local standard barometer. This is necessary so the record furnished by Barograph ML–3–(*) will be accurate.

(1) Determine the pressure indicated by the local standard barometer.

(2) Consider the local pressure *range* and select one of the chart's zero horizontal lines (marked .00) to represent *whole inches* of local pressure.

(3) Turn the knurled adjusting thumbnut at the top of the element cover (fig. 2). This nut pulls the pressure-sensitive unit up or lets it down, and thus moves the pen through the connecting system of levers. (Barograph ML–3–D has a locknut which must be released before the thumbnut can be turned.)

(4) Turn the thumbnut slowly until the pen touches the chart's horizontal line (fig. 2) that, with reference to the .00 line selected in (2) above, corresponds with the pressure indicated by the local standard barometer.

(5) Lightly tap the base of Barograph ML–3–(*) while turning the thumbnut. This will compensate for the lag in response due to the effect of the dash pots, and insures accuracy of the setting.

(6) If there is much variation between the local pressure range and the sea-level pressure range (28 to 31 inches of mercury) for which Barograph ML–3–(*) is calibrated, a calibration error will be introduced that is greater than the specified tolerance of 0.02 inch of mercury. Under such circumstances, the instrument must be sent to a depot for recalibration. *Do not attempt to recalibrate it in the field.* The procedure requires test chambers in which pressure and temperature can be controlled.

14. INKING PEN. **a.** Use a special-registering ink (par. 2b) that will remain fluid at low temperatures.

b. Ink the pen of Barograph ML–3–(*) as follows:

(1) Move the shifting lever to lift the pen from the chart.

(2) Put a drop of the ink, such as would normally cling to the end of a fine wire, between the nibs of the pen. The pen barrel never should be more than half full.

(3) Start the ink flow by drawing a piece of cellophane or lint-free paper, such as a piece of chart paper, between the nibs of the pen to wet the inside surfaces. Do not bend or deform the nibs or allow any particles of paper to remain between them.

(4) Remove any ink from the outside surfaces of the pen.

c. Move the shifting lever to place the pen in contact with the chart. Close the cover of the case; the instrument then is ready to measure and record changes in atmospheric pressure. Keep the cover tightly closed to protect the working parts against dust and dirt as much as possible (par. 19).

15. READING CHART. **a.** The chart (W. D. S. C. Form No. 98) used with Barograph ML–3–(*) is graduated in inches of mercury at 2½ times actual scale.

(1) The complete pressure range that can be measured by the barograph is 2½ inches of mercury.

(2) In order to register small changes in air pressure, the barograph is designed so a change in barometric pressure of 1 inch of mercury is expanded to cover an actual vertical distance of 2½ inches on the chart.

(3) Consequently, the complete range of the instrument requires the 6¼-inch height provided by W. D. S. C. Form No. 98.

b. The chart furnishes a record of changes in air pressure compared with time. Pressure and time are measured by the pressure-sensitive unit and Clock ML–145, respectively, of Barograph ML–3–(*).

(1) The chart is divided vertically (fig. 2) by curved lines, representing time.

(*a*) The curved lines are separated from each other by the distance that the chart is moved by the clock in 1 hour.

(*b*) Every third vertical line is identified by a particular hour designation printed in the top and bottom margins of the chart.

(*c*) The lines are curved to agree wtih the arc that must be traversed by the pen working at the end of the pivoted pen arm.

(2) The chart is divided horizontally (fig. 2) by lines representing pressure.

(*a*) The horizontal lines are separated from each other by the distance the pen moves vertically in registering a pressure change of 0.02 inch of mercury.

(*b*) Every fifth horizontal line represents 0.1 inch of mercury and is marked by its decimal number with reference to the .00 line below it (par. 13b).

c. The vertical components of the ink-trace on the chart indicate changes in pressure occurring during the time intervals indicated by the horizontal length of the trace.

(1) Pressure readings are taken to the nearest 0.01 inch of mercury, which is one-half the distance between adjacent horizontal lines of the chart.

(2) Pressure-tendency readings are estimated to the nearest 0.005 inch.

SECTION III

FUNCTIONING OF PARTS

16. PRESSURE-SENSITIVE UNIT (fig. 6). **a.** The inside of each of the two bellows of the pressure-sensitive unit (par. 4b) is partially exhausted of air and is fitted with an internal spring to prevent collapse.

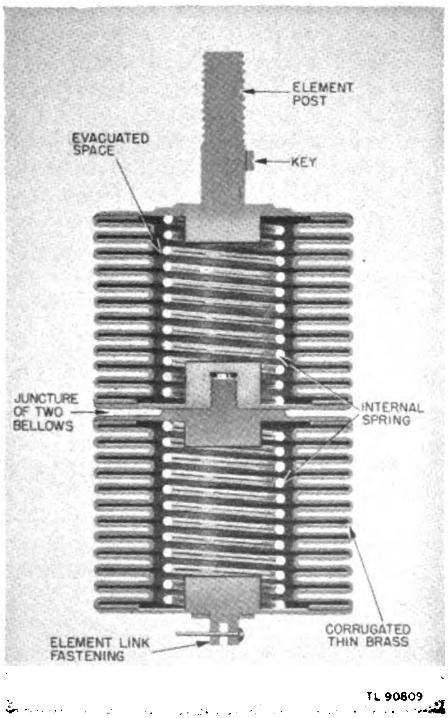

Figure 6. Pressure-sensitive unit, cross-section view.

b. The internal springs and the residual air in the bellows combine to exert a thrust equal to the atmospheric pressure on the bellows.

(1) As atmospheric pressure decreases, the springs and residual air tend to expand the bellows. The springs and air exert diminishing force as they expand, until the pressure exerted inside the bellows is in equilibrium with the reduced outside pressure.

(2) As atmospheric pressure increases, the bellows and the springs and air inside them are compressed. The springs and air exert increasing force

as they are compressed, until the pressure exerted inside the bellows is in equilibrium with the increased outside pressure.

c. The residual air inside the bellows also acts to compensate for temperature effects.

(1) The springs inside the bellows tend to become slightly weaker with increase in temperature.

(2) The residual air tends to expand and exerts a stronger pressure with increase in temperature.

(3) Thus, by controlling the amount of residual air left in the bellows during manufacutre, the weakening effect of increased temperature on the springs is compensated for.

17. LEVER SYSTEM. **a.** The lever system (par. 4c) has a slight overbalance which causes the pivot screw in the magnification lever to rest always in the bottom of the slot in the element link (fig. 3) when the instrument is in operation.

(1) The unbalanced portion of the weight of the pen arm is borne by the bottom of the element link slot. As the bellows expand with reduced atmospheric pressure, the free end of the pen arm drops of its own weight and the pivot screw continues to bear against the bottom of the element link slot.

(2) The slotted end of the element link prevents damage when the pen arm has dropped its limit or is tied to the shifting lever in shipment. Further expansion of the bellows in these circumstances cannot exert a pressure on the lever system because of the element link slot, which slides by the pivot screw in the magnification lever.

b. The bimetal temperature compensation shaft (fig. 4) is designed to compensate for temperature effects on the instrument.

(1) The shaft is made of a strip of invar and a strip of brass, welded together lengthwise.

(2) The coefficients of expansion of invar and brass are different; consequently the shaft bends or bows slightly under the influence of temperature.

(3) The ends of the shaft are fitted in fixed bearings which, since one end of the magnification lever is clamped to the middle of the shaft, constitute the fulcrum of that lever.

(4) As the shaft bows under the influence of temperature, it has the effect of changing the effective length of the magnification lever by varying the distance between the element link (where the *effort* is applied to the lever) and the *fulcrum* without changing the position of the latter. Thus proper adjustment of the shaft compensates for the effect of temperature.

c. The distance that the pen arm moves in response to a given movement of the magnification lever is dependent upon the distance between two points on the calibration lever (fig. 2). They are the point where the vertical link is attached to the calibration lever; the point where the lever attaches at right angles through the pen arm shaft.

(1) Shortening the distance between the two points *increases* the distance the pen arm will move in response to a given movement of the magnification lever.

(2) Lengthening the distance between the points *decreases* the motion of the pen arm relative to the magnification lever.

(3) This permits adjustment of the calibration lever for various pressure ranges. The set screw is provided on the pen arm shaft to maintain the proper adjustment.

d. The tendency of movable parts of the instrument to jump and cause the pen to register an erratic record when disturbed by external vibrations is retarded by fastening the ends of the calibration lever to plungers working in a viscous fluid (fig. 3).

(1) The apex of each cone-shaped plunger points down in the fluid. Any air trapped below the plunger will tend to rise and escape through the space between the side of the plunger and the wall of the dash pot.

(2) The clearance between the plunger and the dash pot wall also is the space through which the dash pot fluid must flow as it is displaced by the movement of the plunger.

(3) The clearance is only about 0.006 inch. Consequently the plunger can be forced down only slowly. Since each end of the calibration lever is attached to such a plunger, any rapid vertical motion transmitted to the lever system is damped.

e. The tilted axis (fig. 7) fixes the pen arm so it must move in a vertical plane in response to movements of the pen arm shaft, and at the same time causes the pen to bear against the chart or permits free motion in a curved horizontal plane.

(1) Assuming the longitudinal axis of the pen arm horizontal, the pivots of the tilted axis are inclined about 45° from the vertical in a plane perpendicular to the horizontal axis of the pen arm shaft. Thus any sidewise movement of the end of the pen arm must occur in a concave curved plane, and gravity will tend to keep the end of the pen arm at the lowest point in that curve.

(2) The chart cylinder is located so the lowest point of the theoretical concave curved path occurs *within* the chart cylinder. Consequently, the pen at the end of the pen arm bears against the chart with a pressure resulting from the pull of gravity. Correct pen pressure depends upon the barograph being level.

18. CLOCK MOVEMENT. **a.** The clock movement rotates itself and the chart cylinder in which it is mounted around on the main shaft fastened to the base of the barograph.

b. The large spur gear on the main shaft remains stationary with the shaft when the shaft is fastened properly to the base.

c. The off-center drive gear of the clock engages the stationary gear when the chart cylinder is in position on the main shaft.

d. The spring mechanism of the clock rotates the drive gear, which revolves itself around the circumference of the stationary gear.

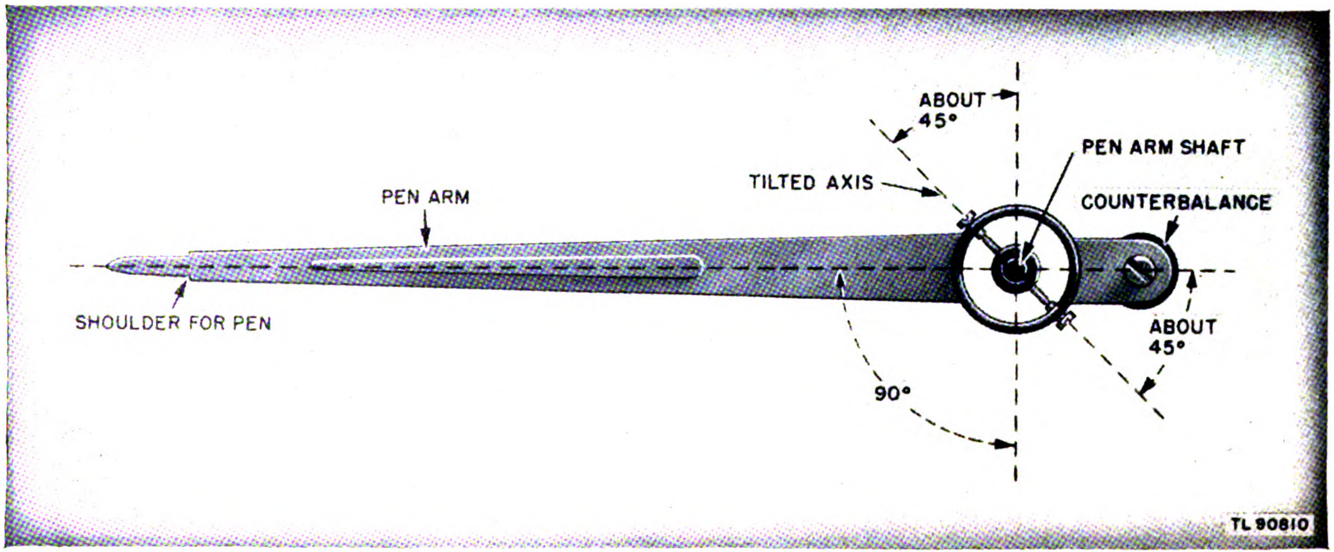

Figure 7. Tilted axis of pen arm.

SECTION IV

MAINTENANCE

NOTE. Unsatisfactory performance of this equipment will be reported immediately on W. D., A. G. O. Form No. 468. If form is not available, see TM 38–250.

19. DUSTING. Keep the working parts of Barograph ML–3–(*) free of dust. Carefully use a clean camel's hair brush for the purpose.

20. CLEANING PEN. **a.** Whenever the pen is not making a fine line on the chart, draw a piece of cellophane or lint-free paper between the nibs (par. 14b (3)).

b. If that does not improve the line, wash the pen with alcohol or water. (1) Hold the pen arm with one hand to relieve the tilted axis of strain, and slide the pen from the end of the pen arm with the other hand. Be careful not to bend the pen arm.

(2) Lightly scrape off any dried ink from the outside of the pen before washing it.

(3) Dry the outside of the pen with a clean cloth. Dry the inside by drawing clean lint-free paper between the nibs.

(4) Replace the pen and seat it against the shoulder provided on the pen arm, again holding the pen arm with the other hand to protect the tilted axis from strain.

(5) Ink the pen (par. 14).

c. The ink in the pen will tend to absorb moisture in humid weather (par. 21a) and may completely fill the pen barrel and run down the pen arm. Use a small piece of blotting paper and remove *all* the ink from the pen. Then refill it (par. 14).

21. DASH POTS. **a.** Watch the level of the fluid in the dash pots. It is hygroscopic and will tend to absorb moisture in periods of high relative humidity, such as foggy weather or prolonged periods of mist or light rain.

b. Keep the level of the fluid about 3/8 inch below the top of the dash pot. Remove excess fluid with an eyedropper, and add new fluid whenever the level falls below 3/8 inch from the top. Completely empty the dash pot whenever the fluid becomes excessively diluted by absorption of moisture, and replace with new fluid.

22. LUBRICATING. **a.** Barograph ML–3–(*) requires little lubrication. Be sparing in the use of oil. Too much oil tends to collect dust and consequently increases friction of the moving parts, which defeats the purpose of lubrication.

b. Use grade No. 1 watch oil (par. 2b) or special preservative lubricating oil (specification AXS–777). Apply the amount that clings to the end of a very fine wire to the following parts:

(1) The three pivots on the calibration lever (fig. 2).

(2) The bearings at the ends of the bimetal temperature compensation shaft (fig. 4).

(3) The element link and the vertical link pivots on the magnification lever (fig. 3).

Caution. Remove the clock cylinder from the case and use an eyedropper to remove the fluid from the dash pots before turning the instrument upside down to reach parts to be lubricated.

23. CLOCK ML–145. a. FAST-SLOW Adjustment. If Clock ML–145 runs fast or slow, adjust it by the regulator provided near the winding key on the top of the clock case.

(1) Open the sliding window of the regulator.

(2) Move the regulator arm toward FAST if the clock has been running slow, or toward SLOW if it has been running fast.

(3) Each graduation of the regulator represents 42 seconds in 24 hours.

(*a*) The clock will *speed up* 42 seconds per day, or about 5 minutes per week, for *each* graduation that the regulator is moved toward FAST.

(*b*) The clock will *slow down* 42 seconds per day, or about 5 minutes per week, for *each* graduation that the regulator is moved toward SLOW.

(4) Since the chart cylinder cannot be set as close as 5 minutes to local time (par. 13a), an adjustment of the clock regulator within one graduation of correct time will be satisfactory.

b. Repair. Do not attempt to repair the clock movement or to adjust it in *any way* except as instructed in a above. *Never remove the clock movement from the chart cylinder in which it is mounted.* Send the complete unit, including the shaft and gear on the instrument base, to a depot for repair.

(1) Move the shifting lever to the right to hold the pen away from the chart.

(2) Lift the cylinder from the shaft.

(3) Unscrew the wing nut (figs. 3 and 4) and remove the shaft and gear from the base. Screw the wing nut and washer back on the removed shaft.

(4) Pack the cylinder and the shaft and gear very carefully. The shaft and gear will be necessary to test the clock after repair.

24. MOISTUREPROOFING AND FUNGIPROOFING. Barograph ML–3–(*) does not require moistureproofing or fungiproofing.

25. RECALIBRATION (FOR DEPOT USE ONLY). a. Purpose. Barograph ML–3–(*) requires recalibration for use at a pressure range that varies considerably from the range for which the instrument was calibrated originally (par. 13b (6)).

b. Equipment. Recalibration of Barograph ML–3–(*) can be accomplished *only* with special test chambers in which the temperature and pressure can be controlled.

c. Preliminary pressure calibration. Put the instrument in a pressure chamber in which a pressure range of 2½ inches of mercury within the limits prescribed by the intended location is available. Adjust the instrument to that range, as follows:

(1) Loosen the set screw that holds the calibration lever in position through the pen arm shaft.

(2) Slide the calibration lever to increase or decrease the recording range to agree with the pressure range in the test chamber (par. 17c).

(*a*) This preliminary adjustment may be approximate since it will be necessary to calibrate again for pressure after compensating for temperature.

(*b*) Tighten the set screw.

d. Temperature compensation. (1) Check the instrument for temperature effects, as follows:

(*a*) Subject the instrument to a temperature of 100° F. for 1 hour. Observe the position of the pen and note the pressure as indicated by a standard barometer.

(*b*) Place the instrument in a cold chamber at 32° F. for 1 hour, again observing the pen position and noting the pressure.

(2) If the two positions of the pen differ by more than 0.04 inch of mercury after taking into consideration any change in pressure indicated by the standard barometer, the instrument must be adjusted for temperature (par. 17b).

(3) Loosen the screw that clamps the magnification lever to the bimetal temperature compensation shaft (fig. 4).

(4) Rotate the bimetal temperature compensation shaft enough to compensate for the error. Turning the shaft through 90° compensates for an error of 0.1 inch of mercury.

(*a*) If the pen indicates a higher pressure at 32° F. than at 100° F., turn the shaft clockwise, as viewed in figure 3.

(*b*) If the pen indicates a lower pressure at 32° F. than at 100° F., turn the shaft counterclockwise.

(5) Tighten the clamping screw, and retest as instructed in (1) above. Repeat procedure in (3) and (4) above if necessary.

e. Final pressure calibration. (1) Return the instrument to the pressure chamber.

(2) Repeat the procedure described in c above, this time sliding the calibration lever to the *exact* position through the pen arm shaft to make the recording range of the instrument agree with the pressure range in the test chamber.

(3) Finally, tighten the set screw to hold the calibration lever in the correct position.

SECTION V

SUPPLEMENTARY DATA

26. MAINTENANCE PARTS LIST FOR BAROGRAPH ML-3-(*).

NOTE. Order maintenance parts by stock number, name, and description. Only maintenance parts can be requisitioned.

Signal Corps stock No.	Name of part and description	3d echelon	4th echelon	5th echelon	Field depot	Depot	Station	Region	Quan. per major unit
7A203( )	Barograph ML-3-(*): 2½-1 microbarograph; 4-day movement.	----	----	----	----	----	----	(*)	1
7A203/A1	Arm, pen	(*)	(*)	(*)	----	(*)	----	(*)	1
7A1208	Pen, nib type with ink space.	(*)	(*)	(*)	----	(*)	(*)	(*)	1
7A857	Fluid, dash pot (bottle sufficient for one renewal).	----	----	----	----	----	(*)	(*)	1
7A585	Clock ML-145, with shaft, gears, wing nut, and winding key.	(*)	(*)	(*)	----	(*)	(*)	(*)	1
7A203/C1	Clip, chart	----	----	----	----	----	----	(*)	1
7A302A/2	Glass, 4¾ by 7½ by approximately 0.090″ thick.	(*)	(*)	(*)	----	(*)	----	----	4
7A1100	Ink, special register, green, ¼-oz bottle.	----	----	----	----	----	(*)	(*)	1
7A1101	Ink, special register, red, ¼-oz bottle.	(*)	(*)	(*)	----	(*)	(*)	(*)	1
7A1102	Ink, special register, purple, ¼-oz bottle.	----	----	----	----	----	(*)	(*)	1
6D98	W. D. S. C. Form No. 98, 4-day, box of 100.	(*)	(*)	(*)	----	(*)	(*)	(*)	1
6G1339	Oil, watch, grade A1, nongum 1-oz bottle.	(*)	(*)	(*)	----	(*)	(*)	(*)	1

*Indicates availability.

U. S. GOVERNMENT PRINTING OFFICE: 1944

TM 11-426

WAR DEPARTMENT TECHNICAL MANUAL

THERMOGRAPHS ML-77 AND ML-277

WAR DEPARTMENT • 17 JULY 1944

TECHNICAL MANUAL

THERMOGRAPHS ML-77, ML-77-A, AND ML-277

CHANGES No. 1 } WAR DEPARTMENT
WASHINGTON 25, D. C., 14 November 1945

TM 11-426, 17 July 1944, is changed as follows:

The title of this manual is changed to read: THERMOGRAPHS ML-77, ML-77-A, AND ML-277.

1. PURPOSE (Superseded). Thermographs ML-77 and ML-77-A (fig. 1), and ML-277 (fig. 2) are self-contained instruments for producing a continuous permanent record of temperature on a paper chart. The record normally covers a period of 1 week, but provision is made for a daily record for special circumstances. Thermographs ML-77 and ML-77-A are identical and are used in all atmospheric temperatures above −50° F.; all references to Thermograph ML-77 in this manual also apply to Thermograph ML-77-A. Thermograph ML-277 is usable for temperatures as low as −80° F. and therefore is intended only for Arctic regions.

2. COMPONENT PARTS. a. Thermograph ML-77.

* * * * * * *

(2) (Superseded.) The items listed below must be procured separately. They are used with Thermograph ML-77 but are not supplied as part of the equipment.

Item	*Signal Corps stock No.*
Ink, special register, purple	7A1101
*Thermograph Chart ML-234 (range −50° to +80° F.)	7A5291-234
*Thermograph Chart ML-235 (range −20° to +110° F.)	7A5291-235

b. Thermograph ML-277.

* * * * * * *

(2) (Superseded.) The items listed below must be procured separately. They are used with Thermograph ML-277 but are not supplied as part of the equipment.

* The temperature range of Thermograph ML-77 is 160° (−50° to +110° F.), but the *recording range* at any setting of the adjusting thumbnut is only 130°. Note that each of the charts for Thermograph ML-77 covers 130°, one chart beginning at the lower end (−50°) of the temperature range, and the other chart ending at the highest end (+110°), so that between the two charts the entire temperature range of the thermograph can be utilized.

Item	Signal Corps stock No.
Ink, low-temperature	7A1099
† Thermograph Chart ML–233 (range −80° to +50° F.)	7A5291–233
† Thermograph Chart ML–234 (range −50° to +80° F.)	7A5291–234

Figure 2.—Thermograph ML–277, development model (the temperature element of the production model does not have radiation fins (see fig. 6)).

Figure 4.—Thermograph ML–77—top interior view, showing clock spindle, clock change gears with cover removed, and indicating mechanism.

4. COMPARISON OF THERMOGRAPHS ML–77 AND ML–277. Primarily, Thermograph ML–277 differs from Thermograph ML–77 in three respects: the temperature element, the vertical link and accessories (ink, clock, and charts), and the range of operation. In all other * * * thermographs are identical.

* * * * * * *

Note. (Superseded.) Clock ML–279, which is used with Thermograph ML–277, is similar to Clock ML–79–A, the only difference being that Clock ML–279 is more loosely assembled for ability to perform at low temperatures and is lubricated with a low temperature oil.

* * * * * * *

b. Temperature element.

* * * * * * *

(2) *Thermograph ML–277* (fig. 6). The temperature element * * * the pen arm. The bimetallic strip * * * and best exposure.

c. Temperature charts. (Superseded.) (1) Thermograph Charts ML–233, ML–234, and ML–235, each cover a temperature range of 130° on their vertical scales, with each graduation representing 1° F. and with each 10° F. interval labeled. Time is read on the horizontal scale of each chart, with each division representing an interval of 2 hours.

(2) Thermograph Charts ML–233, ML–234, and ML–235 are identical in all respects except for the labeling of the temperature graduations. Thus, any of the charts will fit on Thermograph ML–77 or ML–277, but because the ranges of labeled graduations vary with the charts, the chart to be installed each week must be selected with a view to the anticipated range of temperatures over which the thermograph is to operate, and with a view to the range limitations of the thermograph itself. (See par. 1.) The pen of the thermograph must be set to read in agreement with the graduations on the chart selected. (See par. 11b.)

* * * * * * *

† The temperature range of Thermograph ML–277 is 160° (−80° to +80° F.), but the *recording range* at any setting of the adjusting thumbnut is only 130°. Note that each of the charts for Thermograph ML–277 covers 130°, one chart beginning at the lower end (−80°) of the temperature range, and the other chart ending at the highest end (+80°), so that between the two charts the entire temperature range of the thermograph can be utilized.

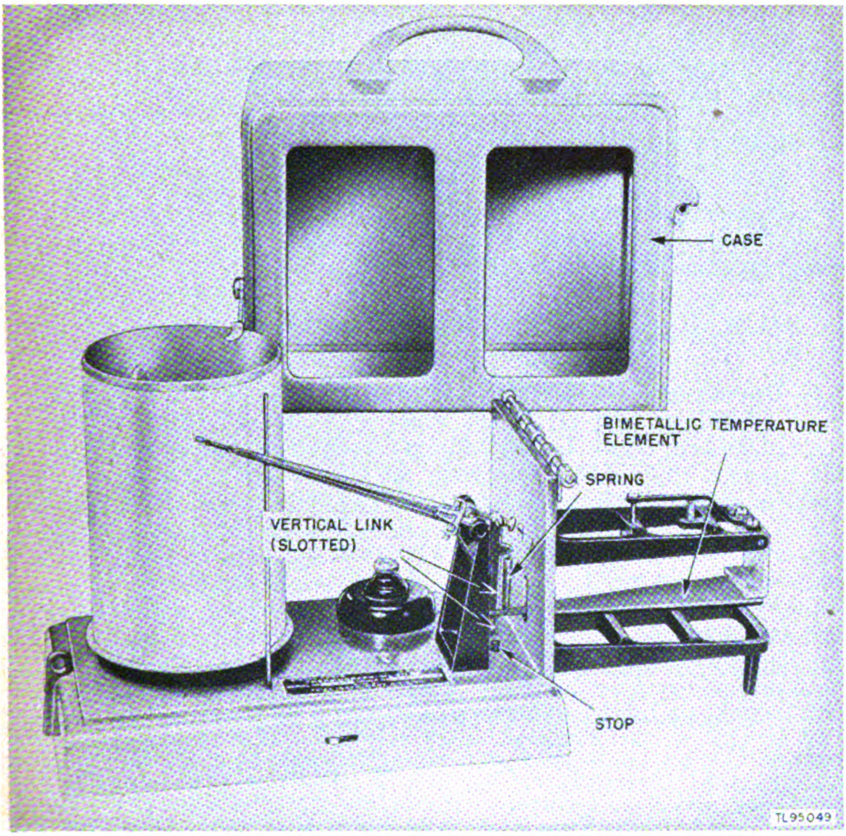

Figure 6.—Thermograph ML–277, production model, shown with case removed. (The development model (fig. 2) had radiation fins along the sides of the temperature element.)

11. ADJUSTING PEN TO TEMPERATURE. a. (Superseded.) Use Thermometer ML–7 or the dry bulb thermometer of Psychrometer ML–24 as a standard for comparison of the thermograph reading. If the thermograph is not located in an instrument shelter, hold the thermometer as near as possible to the temperature element of the thermograph. If the instruments are in an instrument shelter, leave the thermograph and the thermometer in their normal positions in the shelter. Allow sufficient time for both the thermograph and the thermometer to reach temperature equilibrium with the surrounding air. In making comparative readings, particularly when the temperature of the air is low, take care to prevent body heat from heating the instruments.

b. Turn the temperature * * * lowers the pen. **If the instruments are not installed in an instrument shelter, be sure to perform** this adjustment in a location where there is good circulation of air around the temperature element and standard thermometer. *Never* use the * * * of the thermograph. Adjust the reading of the thermograph to the reading of the thermometer whenever charts are changed.

14. TEMPERATURE ELEMENT.

* * * * * * *

b. Thermograph ML–277.

* * * * * * *

(2) Rescinded.

15. VERTICAL LINK AND CALIBRATING MECHANISM.

* * * * * * *

b. Thermograph ML–277. (1) *Vertical link.* The vertical link, * * * above 80° F.

(*a*) *Spring.* The spring (fig. 6) keeps the pin, which engages the vertical link, in contact with the upper end of the slot in the vertical link over the entire range of the temperature chart in use.

* * * * * * *

SECTION IV

MAINTENANCE

Note (Superseded): Failure or unsatisfactory performance of equipment used by Army Ground Forces and Army Service Forces will be reported on WD AGO Form 468 (Unsatisfactory Equipment Report); by Army Air Forces on AAF Form 54 (Unsatisfactory Report). If either form is not available, prepare letter containing the data elicited by the appropriate one of the sample forms shown in figures 9 and 10 without reproducing copies of the forms.

17.1. MEANING OF PREVENTIVE MAINTENANCE (Added). Preventive maintenance is a systematic series of operations performed periodically on equipment in order to maintain top efficiency in performance, to minimize unwanted interruptions in service, and to eliminate major break-downs. To appreciate the meaning of the term *preventive maintenance,* it is necessary to distinguish preventive maintenance from trouble shooting and repair. The primary function of preventive maintenance is to prevent major break-downs and the consequent necessity of repair. The primary function of trouble shooting and repair is to locate and correct existing defects. The importance of preventive maintenance cannot be overemphasized. The usefulness of Thermograph ML–77 or ML–277 depends upon its continuous operation at highest possible accuracy. Consequently, users and repairmen of thermograph equipment must maintain equipment properly.

Note. The operations in paragraphs 18, 20, 21, 22, 23, and 24 are first and second echelon (organization operators and repairmen) maintenance. The operations in paragraphs 19 and 25 are higher echelon maintenance.

17.2. DESCRIPTION OF PREVENTIVE MAINTENANCE TECHNIQUES (Added). **a. General.** Most of the parts of any piece of equipment require routine preventive maintenance. Those requiring maintenance differ in the amount and kind required. Because maintenance techniques cannot be applied indiscriminately, definite and specific instructions are needed. The remainder of this paragraph contains information which will serve as a guide for personnel assigned to perform the six basic maintenance operations, namely: Feel, Inspect, Tighten, Clean, Adjust, and Lubricate. The standard lettering system for the six operations is as follows:

F—Feel *
I—Inspect
T—Tighten
C—Clean
A—Adjust
L—Lubricate *

The first two operations establish the need for the other four. The selection of operations is based on a general knowledge of field needs. For example, in dusty localities dust will filter into the equipment no matter how much care is taken to prevent it. Rapid changes in weather (such as heavy rain followed by blistering heat), excessive dampness, snow, and ice tend to cause corrosion of exposed surfaces and parts. Without frequent inspections and the necessary tightening, cleaning, and lubricating operations, equipment becomes undependable and subject to break-down when it is most needed.

b. Inspect. Inspection is the most important operation in the preventive maintenance program. A careless observer will overlook the evidences of minor trouble. Although these defects may not interfere with the performance of the equipment, valuable time and effort can be saved if they are corrected before they lead to major break-downs. Make every effort to become thoroughly familiar with the indications of normal functioning, in order to be able to recognize the signs of a defection. Inspection consists of carefully observing all parts of the equipment, noticing their color, placement, state of cleanliness, etc.

c. Tighten, clean, and adjust. These operations are self-explanatory. Specific procedures to be followed in performing them are given where necessary throughout the succeeding paragraphs in this section.

Caution: Screws, bolts, and nuts should not be tightened carelessly. Fittings tightened beyond the pressure for which they are designed will be damaged or broken.

19. (Superseded.) **OILING CLOCK MOVEMENT OF THERMOGRAPH ML–77 OR ML–277.** The clock movement of Thermograph ML–77 or ML–277 is to be oiled *only* at an instrument repair depot.

---

* The Feel and Lubricate operations are not applicable to Thermograph ML–77 or ML–277.

a. Exposures above 0° F. Use Oil, Clock and Watch (OCW) for exposures above 0° F.

b. Exposures below 0° F. Use Oil, Lubricating Preservative, Special (PS), for subzero exposures.

c. Clock shaft. Cover the upright shaft with a light film of Grease, Lubricating, Special (GL), but take care that no grease gets on the pinion or gear.

24. (Superseded.) **RESETTING RANGE OF THERMOGRAPH ML–77 OR ML–277 IN THE FIELD.** If the daily range of temperatures as indicated by the thermograph differs persistently from the daily range as indicated by the maximum and minimum thermometers by as much as 2°, in a range of 20° or less, the instrument is out of calibration. Accurate recalibration can be made *only* at a repair depot. Field personnel, however, sometimes can bring the instrument back into calibration by resetting the range adjustment. If the range as indicated by the thermograph is *less* than the range indicated by the thermometers, the pen arm is swinging over too short an arc and the sweep of the pen arm should be increased. If the range as indicated by the thermograph is *greater* than that indicated by the thermometers, the pen arm is swinging over too long an arc, and the sweep should be decreased.

a. Increasing sweep of pen arm. If the pen arm is swinging over too short an arc, proceed as follows (fig. 8):

(1) Loosen the setscrew in the calibrating block.

(2) Turn the calibrating nut clockwise to move the vertical link nearer the horizontal shaft. This increases the sweep of the pen arm. Two or three turns of the calibrating nut may be necessary to take care of a 2° or 3° variation in the temperature range.

(3) Tighten the setscrew after the adjustment is made.

(4) Reset the temperature adjusting thumbnut to the existing temperature.

(5) Observe the temperatures recorded by the thermograph long enough to get a maximum and a minimum reading. If the range still is incorrect, repeat the procedure until the required accuracy is obtained.

b. Decreasing sweep of pen arm. If the pen arm is swinging over too long an arc, proceed as instructed in a (1) through (5) above, except turn the calibrating nut to move the vertical link *away* from the horizontal shaft. This shortens the sweep of the pen arm.

26.1. UNSATISFACTORY EQUIPMENT REPORT (Added). **a. AGF or ASF equipment.** When trouble in equipment used by Army Ground Forces or Army Service Forces occurs more often than repair personnel feel is normal, War Department Unsatisfactory Equipment Report (WD AGO Form 468) should be filled out and forwarded through channels to the Office of the Chief Signal Officer, Washington 25, D. C. If the form is not available, prepare letter containing the data elicited by the sample form shown in figure 9 without reproducing copies of the form.

b. AAF equipment. When trouble in equipment used by Army Air Forces occurs more often than repair personnel feel is normal, Army Air Forces Form 54 should be filled out and forwarded as directed on the form. If the form is not available, prepare letter containing the data elicited by the sample shown in figure 10 without reproducing copies of the form.

WAR DEPARTMENT

UNSATISFACTORY EQUIPMENT REPORT

FOR	TECHNICAL SERVICE: Signal Corps	MATERIEL	DATE: 25 Jun 44
FROM	ORGANIZATION: 00th Field Artillery Observation Battalion		STATION: APO 000, New York, N.Y.
TO	NEXT SUPERIOR HEADQUARTERS: Commanding General, X Corps	STATION: APO 00, New York, N.Y.	TECHNICAL SERVICE: Signal Corps

COMPLETE MAJOR ITEM

NOMENCLATURE: Wind Transmitter ML-0-Z	TYPE		MODEL
MANUFACTURER: A.B.C. Company	U. S. A. REG. NO.	SERIAL NO.: 0000	DATE RECEIVED: 10 Jun 44
EQUIPMENT WITH WHICH USED (If applicable): Wind Equipment SCM-00			

DEFECTIVE COMPONENT—DESCRIPTION AND CAUSE OF TROUBLE

PART NO.: 7A000.1	TYPE: Anemometer head	MANUFACTURER: X.Y.Z. Corporation	DATE INSTALLED: 10 Jun 44

DESCRIPTION OF FAILURE AND PROBABLE CAUSE (If additional space is required, use back of form): Field coils failed (probably because of humid conditions)

DATE OF INITIAL TROUBLE	TOTAL TIME INSTALLED			TOTAL PERIOD OF OPERATION BEFORE FAILURE					
	YEARS	MONTHS	DAYS	YEARS	MONTHS	DAYS	HOURS	MILES	ROUNDS
15 Jun 44	--	--	5	--	--	--	106	--	--

BRIEF DESCRIPTION OF UNUSUAL SERVICE CONDITIONS AND ANY REMEDIAL ACTION TAKEN: Operation in tropics. Unit oven-dried 8 Feb 44.

TRAINING OR SKILL OF USING PERSONNEL			RECOMMENDATIONS (If additional space is required, use back of form)
POOR	FAIR	GOOD	
		X	Redesign generator shaft.

ORIGINATING OFFICER

TYPED NAME, GRADE, AND ORGANIZATION: John A. Doe, Capt., FA, Asst S-3 00th FA Observation Battalion	SIGNATURE: John A. Doe

FIRST ENDORSEMENT

TO CHIEF	TECHNICAL SERVICE	OFFICE	
NAME, GRADE, AND STATION		STATION	DATE

Instructions

[illegible]

W.D., A.G.O. Form No. 468
30 August 1944

This form supersedes W. D., A. G. O. Form No. 468, 1 December 1943, which may be used until existing stocks are exhausted.

TL 97890A

Figure 9.—Sample filled-out Unsatisfactory Equipment Report (AGO Form 468).

WAR DEPARTMENT
AAF Form No. 54
(Revised 3-15-43)

WAR DEPARTMENT
ARMY AIR FORCES
UNSATISFACTORY REPORT
(See AAF Reg. 15-54 for Information on Proper Use of this Form)

TO BE FILLED IN BY STATION	
STATION SERIAL No.	DATE SUBMITTED
14 PAD 44	5 Jan 44

LEAVE BLANK		
A. S. C. SERIAL No.	REFER TO	CLASS

STATION	ORGANIZATION
Panama Air Depot	909th Signal Co Depot Avn

SUBJECT OF REPORT	Property Class—Item	Manufacturer	AAF Order or Shipping No.
	Radio Set SCR-588-B, U.S. Ser. #50	R.E.L.	

AIRCRAFT—Model & AAF Serial No.	ENGINE—Model & AAF Serial No.	UNIT OR ACCESSORY—Type, Model and Serial No.
		Antenna Control MC-388-B

PART

Name	Part Drawing, Serial and Specification No.
Plate Transformer, R.E.L. #14033	Item T1, Fig 21, Power Turning Gear Bk

Time in Use	Quantity on Hand	Quantity Known Defective	No. Previous Failures	Manufacturer	Inspector's No. or Identification
1450 hours	3	1	2	Hammond	X31752

Indicate by "X" Disposition of Exhibit: [ ] Photographed and Prints Enclosed [X] Held for Instructions [ ] Sent Under Separate Cover [ ] Sent in Attached Package [ ] Repaired and Returned to Service [ ] Disposed of (Explain Below.) [ ] To Overhaul Facility (INITIALS)

GIVE COMPLETE DETAILS, PROBABLE CAUSES AND RECOMMENDATIONS BELOW:
(Use Only Applicable Spaces Above—Avoid Unnecessary Repetition)

EXPEDITE

1. This organisation has experienced three (3) plate transformer failures in the Thyratron control of an Early Warning Ground Radar Set, SCR-588-B, located in the vicinity of Panama. This set has been in operation for approximately nine (9) months, twenty-four (24) hours a day, except when shut down for brief periods during which time the set was given a complete preventive maintenance check-up. This set has had an inspection by an engineer from the PAD monthly and no abnormal operating conditions were observed.

2. While the Thyratron is not equipped with the Thyratron Fan Modification Kit, No. 588B-A2, the operating temperature was not abnormal due to air conditioning of the room and also to the removing of the Thyratron side panels. The operating room was maintained at 72° and humidity at 50%.

3. After being in service for about two months, the transformer became very hot, smoke poured out, and antenna became inoperative. Upon investigation, one secondary of the transformer was found to have had shorted turns. The circuit and all relative parts and components were thoroughly checked afterward and proved in proper working condition. This transformer had been impregnated against moisture. This part had been manufactured by the Hammond Company. The two previous defective parts had been manufactured by the Canadian Transformer Company.

4. It is the opinion of this organisation that the fault lies in imporper design of the transformer. As a substitute, four small receiver type transformers were installed externally, which proved operationally satisfactory.

ROUTING: SEND ORIGINAL AND TWO COPIES DIRECT TO COMMANDING GENERAL, HQ. AIR SERVICE COMMAND, PATTERSON FIELD, FAIRFIELD, OHIO.

TL19932

Figure 10.—Sample filled-out Unsatisfactory Report (Army Air Forces Form 54).

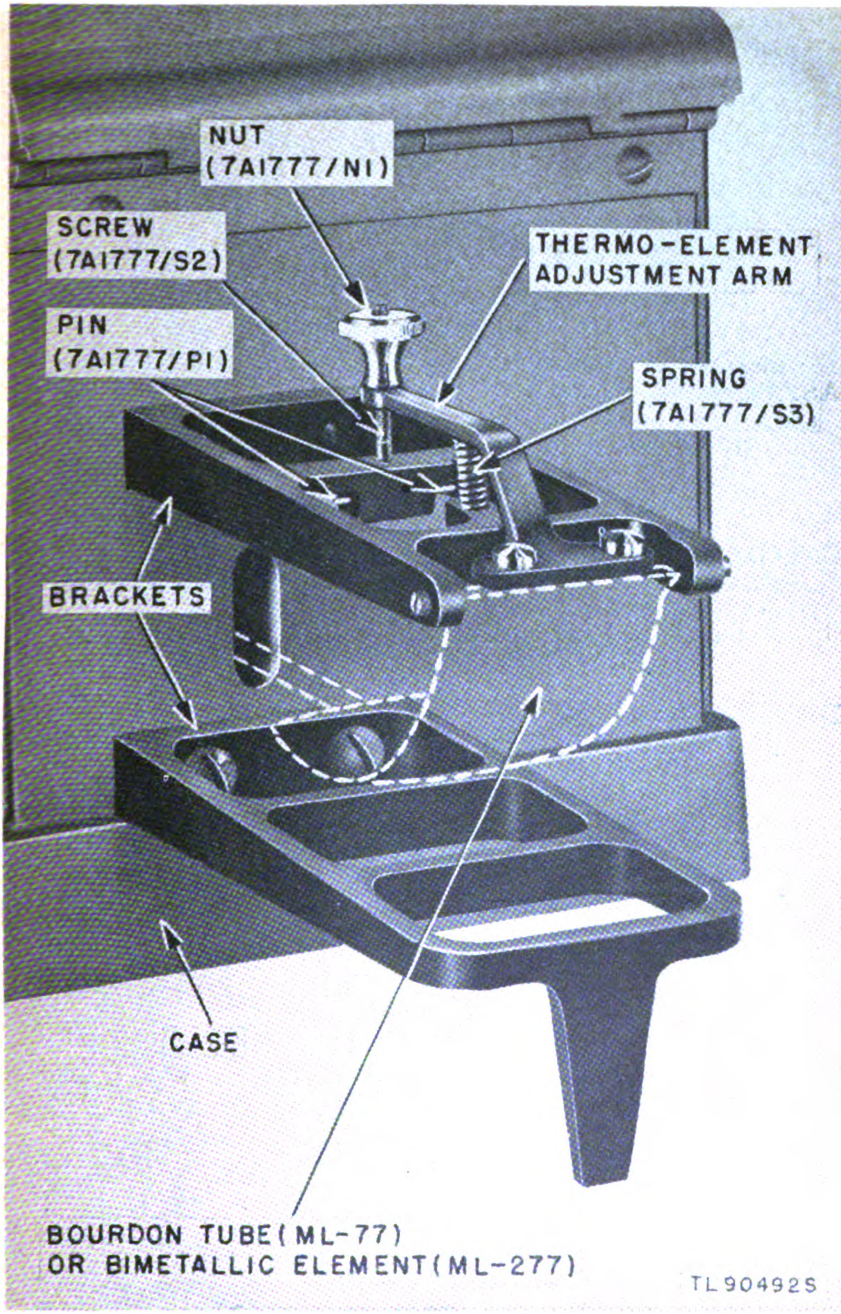

Figure 11.—Thermograph ML–77 or ML–277, thermo-element adjusting arm and bracket.

29. MAINTENANCE PARTS FOR THERMOGRAPHS ML–77 AND ML–277 (Added). The following information was compiled on 16 June 1945. The appropriate pamphlets of the ASF Signal Supply Catalog for Thermographs ML–77 and ML–277 are:

Organizational Spare Parts:
SIG 7–ML–77
SIG 7–ML–277

Higher Echelon Spare Parts:
SIG 8–ML–77
SIG 8–ML–277

Fixed Plant Maintenance List:
SIG 10–900, Meteorological Equipment

For an index of available catalog pamphlets, see the latest issue of ASF Signal Supply Catalog SIG 2.

[AG 300.7 (23 Jul 45)]

BY ORDER OF THE SECRETARY OF WAR:

G. C. MARSHALL
Chief of Staff

OFFICIAL:
EDWARD F. WITSELL
Major General
Acting The Adjutant General

DISTRIBUTION:
AAF (5); AGF (5); ASF (2); T of Opns (5); Dept (2); Base Comd (2); Island Comd (2); Arm & Sv Bd (1); S Div ASF (1); Tech Sv (2); SvC (2); Air Tech SvC (2); Dep 11 (2); Lab 11 (2); T/O & E 1–627 Regional Control Hq (1); 11–107 (3); 11–127 (3); 11–587 (3); 11–592 (3); 11–597 (3).
Refer to FM 21–6 for explanation of distribution formula.

U. S. GOVERNMENT PRINTING OFFICE: 1945

WAR DEPARTMENT TECHNICAL MANUAL

TM 11-426

THERMOGRAPHS

ML-77 AND ML-277

WAR DEPARTMENT • 17 JULY 1944

United States Government Printing Office
Washington : 1944

WAR DEPARTMENT,
WASHINGTON 25, D. C., 17 July 1944.

TM 11-426, Thermographs ML-77 and ML-277, is published for the information and guidance of all concerned.

[A. G. 300.7(16 Jun 44).]

BY ORDER OF THE SECRETARY OF WAR:

G. C. MARSHALL,
Chief of Staff.

OFFICIAL:
J. A. ULIO,
Major General,
The Adjutant General.

DISTRIBUTION:
Armies (5); Corps (5); Sv C (5); Depts (5); Def Comds (2); IBn 1(100); IC 44 (3); Arm and SV Boards (2); Sig C Dep (2); AGF Repl Dep (Sig Sec) (2); Sig C Labs (2); Sig C Rep Shops (2); Air Forces (2); PE (2); C of Tech Sv (2).
IBn 1: T/O & E 1-627.
IC 44: T/O & E 44-312; 44-316.
For explanation of symbols, see FM 21-6.

CONTENTS

DESTRUCTION NOTICE

WHY—To prevent the enemy from using or salvaging this equipment for his benefit.

WHEN—When ordered by your commander.

HOW—SMASH—Use sledges, axes, handaxes, pickaxes, hammers, crowbars, heavy tools.
CUT—Use axes, handaxes, machetes.
BURN—Use gasoline, kerosene, oil, flame throwers, incendiary grenades.
EXPLOSIVES—Use firearms, grenades, TNT.
DISPOSAL—Bury in slit trenches, fox holes, other holes. Throw in streams. Scatter.

USE ANYTHING IMMEDIATELY AVAILABLE FOR DESTRUCTION OF THIS EQUIPMENT

WHAT—SMASH—Clock ML–79–A, carrying case, linkage system, temperature elements, ink and oil bottles, gears.
CUT—Temperature charts, Bourdon tube.
BURN—Temperature charts.
BEND—Pen, linkage system, Bourdon tube, spring clip.
BURY or SCATTER—Any or all of the above after destroying their usefulness.

DESTROY EVERYTHING

SECTION I

DESCRIPTION

1. PURPOSE. Thermographs ML–77 (fig. 1) and ML–277 (fig. 2) are self-recording thermometers, each producing a continuous record of temperature over a period of time. Thermograph ML–277 is used in Arctic climates. Thermographs ML–77 and ML–277 each produce either a weekly or a daily record.

2. COMPONENT PARTS. a. Thermograph ML–77. (1) The component parts of Thermograph ML–77 are:

One temperature measuring-and-recording mechanism, mounted in case.
One clock ML–79–A.
One pen.

(2) The items listed below must be procured separately. They are used with Thermograph ML–77, but are not supplied as part of the equipment.

Item	*Signal Corps stock No.*
Ink, special register, green	7A1100
Ink, special register, purple	7A1101
Ink, special register, red	7A1102
Oil, watch, grade No. 1	6G1339.1
Form SC–120–A	6D120A
Temperature charts, range −50° F. to +80° F.	7A1797/C2

b. Thermograph ML–277. (1) The component parts of Thermograph ML–277 are:

One temperature measuring-and-recording mechanism, mounted in case.
One Clock ML–279.
One pen.

(2) The items listed below must be procured separately. They are used with Thermograph ML–277, but are not supplied as part of the equipment.

Item	*Signal Corps stock No.*
Ink, low-temperature	7A1099
Oil, low-temperature	7A1977/01
Temperature charts, range −50° F. to +80° F.	7A1797/C2
Temperature charts, range −80° F. to +50° F.	7A1797/C1

3. DIMENSIONS AND WEIGHT. The over-all dimensions of Thermographs ML–77 and ML–277 are identical. The dimensions are: length, 13⅞ inches; width, 5⅝ inches; height, 8⅜ inches. Each thermograph

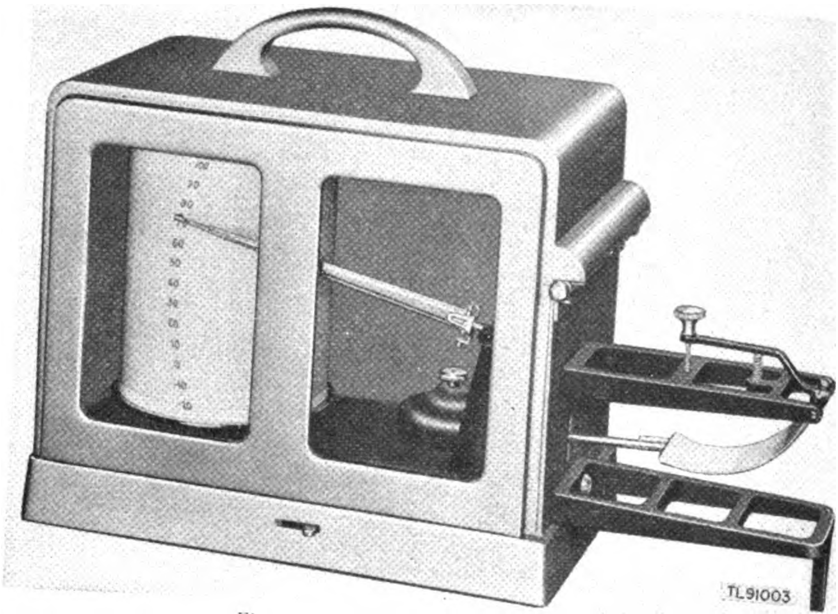

Figure 1. Thermograph ML–77, with case.

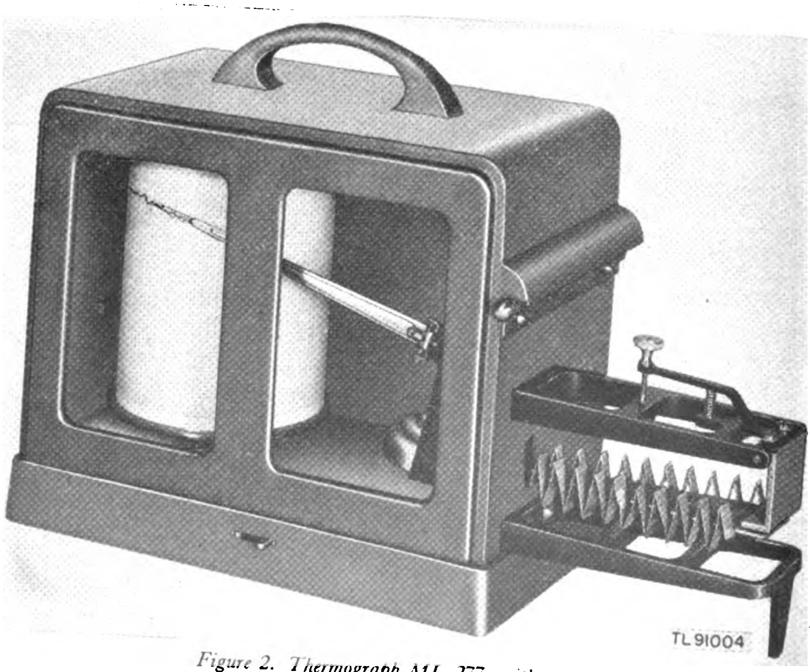

Figure 2. Thermograph ML–277, with case.

case, including Clock ML–79–A, weighs about 10 pounds when unpacked and about 15 pounds when packed.

4. COMPARISON OF THERMOGRAPHS ML–77 AND ML–277. Primarily, Thermograph ML–277 differs from Thermograph ML–77 in three respects: the temperature element, the vertical link and accessories (par. 15), and the temperature charts. In all other details the thermographs are identical.

a. Clock ML–79–A (fig. 3). Clock ML–79–A is a jeweled clock which is contained within a brass cylinder. The clock operates 8 days on one winding and makes one revolution weekly or daily, depending upon the particular set of gears in use. There is an opening for the main clock shaft through the center of the clock unit. The shafts for the weekly and

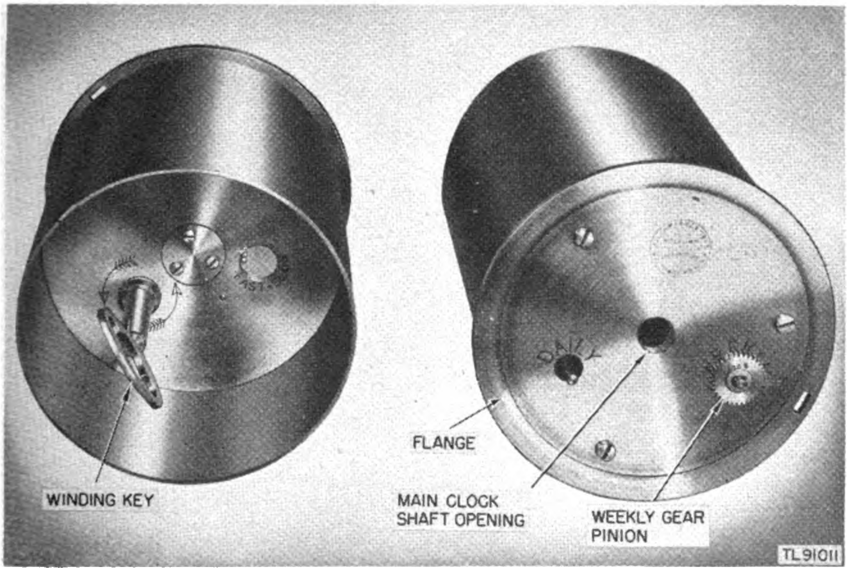

Figure 3. Clock ML–79–A, top and bottom views.

daily gear pinions are on the under side of the clock, to the left and right of the main clock-shaft opening. The winding key and the FAST-SLOW adjustment window are located inside the top of the clock.

NOTE: Clock ML–279, which is used with Thermograph ML–277, is identical with Clock ML–79–A, except that it has been previously lubricated with a special lubricating oil.

(1) *Gears.* Two sets of gears, a weekly set and a daily set, are provided. The weekly set is marked 176E, and completely rotates the cylinder once in 176 hours. The large weekly stationary gear is mounted on the main clock shaft (fig. 4). The small weekly drive gear is fastened on the clock shaft labeled WEEKLY (fig. 3). The set of daily gears is kept under the clock change-gear cover. This set is marked 29F., and completely rotates the cylinder once in 29 hours. The daily gears are not normally used.

(2) *Cylinder.* The brass cylinder which contains the clock movement is $3\frac{5}{8}$ inches in diameter at the center, $3\frac{15}{16}$ inches in diameter at the bottom

flange, and 5⅛ inches high (5¼ inches high with the flange). The spring chart clip, which fits through a slot in the cylinder flange and fastens over a notch in the top rim, holds the temperature chart firmly in place.

b. Temperature element. (1) *Thermograph ML–77* (fig. 5). The temperature element of Thermograph ML–77 is a liquid-in-metal thermometer

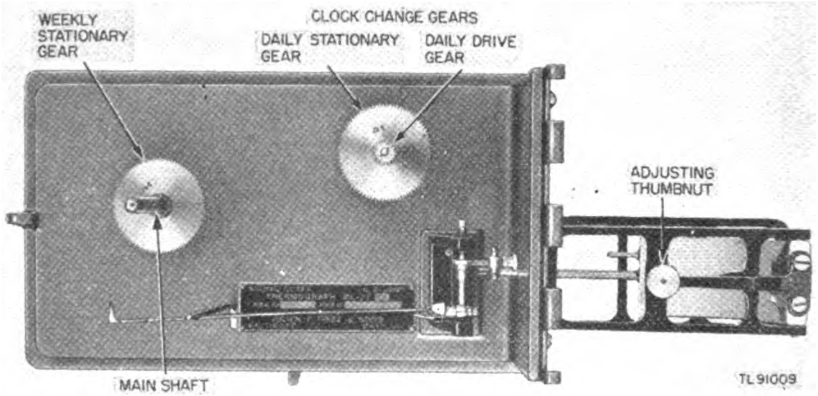

Figure 4. Thermograph ML–77—top interior view, showing clock spindle and indicating mechanism

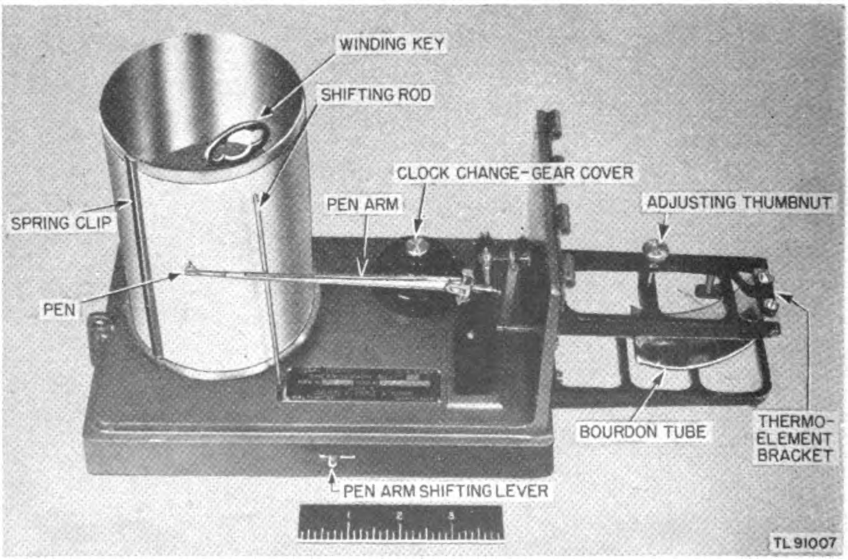

Figure 5. Thermograph ML–77, case removed.

called a Bourdon tube. The liquid used is alcohol. One end of the Bourdon tube is fixed to a rigid thermo-element bracket, while the other end is connected through a system of linkages to the pen arm. The tube is made of thin phosphor bronze and has a gold-plated external surface to minimize the effects of radiations. The tube is oval in cross-section and is sealed at both ends. It is mounted outside the case on a bracket support to provide for maximum ventilation and best exposure.

(2) *Thermograph ML–277* (fig. 6). The temperature element of Thermograph ML–277 is a tapered bimetallic strip composed of invar and brass welded together. One end of the temperature element is fixed to the rigid thermo-element bracket, while the other end is connected through a system of linkages to the pen arm. A radiation fin is attached to each side of the temperature element. The bimetallic strip is mounted outside the case on a bracket support to provide for maximum ventilation and best exposure.

c. Temperature charts. (1) *Thermograph ML–77.* Form SC–120–A (fig. 7) is the weekly chart. On the vertical scale, each division represents 1° F. Temperature divisions are labeled in steps of 10°. The chart covers a temperature range of −20° F. to +110° F. Time is read on the horizontal scale. Each division on the horizontal scale represents a time interval of 2 hours. For temperatures below −20° F., readjust the thermograph

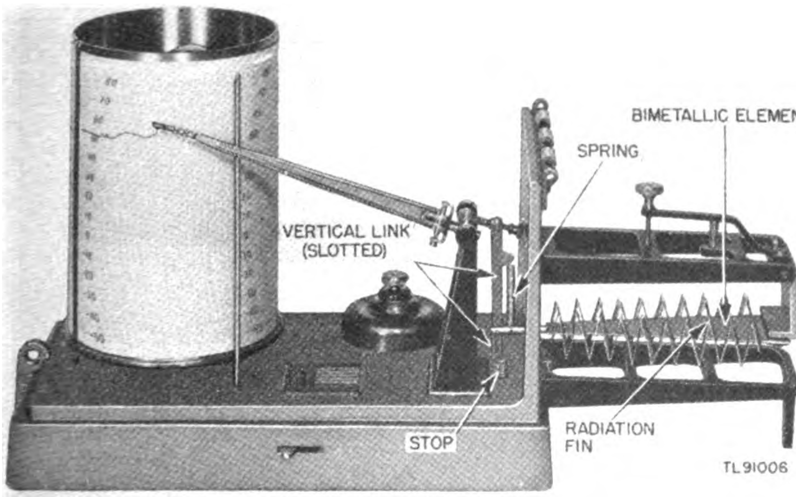

Figure 6. Thermograph ML–277, case removed.

(par. 11*b*.) and use a temperature chart, range −50° F. to +80° F. (See (2) below.)

(2) *Thermograph ML–277.* Thermograph ML–277 uses two kinds of charts. One chart is graduated in labeled intervals of 10° from −80° F. to +50° F. The other chart ranges from −50° to +80° F. Each chart extends over a range of 130° F., but by use of both charts a total range of 160° F. may be accommodated. Two charts are necessary, since arctic temperatures may rise above +50° F. and fall below −50° F. at the same station. Time is read on these charts in the same way as on Form SC–120–A (see (1) above).

d. Pen. The recording pen is made of nickel-silver. The point of the pen is formed by two triangular nibs which fit closely together. The barrel is a round reservoir which holds a week's supply of ink. The pen is held firmly on the pen arm by a set of front and rear clamps on the top of the pen.

e. Special register ink. The ink readily absorbs and retains moisture. It is available in three colors: green, purple, and red. The ink contains alcohol and glycerine to maintain a liquid state at low temperatures.

f. Pen arm. The pen arm is a pointed, horizontal rod which is located in front of the shifting rod (see *g.* below), and is attached to the horizontal shaft. The length of the pen arm from the tip of the spiked end to the center of the horizontal axis is 14 centimeters or 5.51 inches. The pen arm is free to swing inward about an inclined vertical axis (fig. 8). The pen arm carriage is fitted to the horizontal axis so that the pen arm is tilted a few degrees inward at the top.

g. Shifting rod. The shifting rod, controlled by the pen-arm shifting lever on the frame base of the instrument (fig. 5), is a vertical rod which passes through the platform of the instrument and stands beside the cylinder.

h. Carrying case. The recording mechanism is covered by a glass-paneled, sheet-metal case which is hinged with a removable pin on the upper right-hand side. When the cover is raised, stops on the hinge prevent the cover from resting on the temperature-adjusting thumbnut. A hook on the left-hand side of the case fits into a ring at the base of the instrument and keeps the case closed (figs. 1 and 2). The handle on the case permits the case to be carried from place to place.

SECTION II

INSTALLATION AND OPERATION

Caution: Thermographs ML–77 and ML–277 are delicate precision instruments. Handle them carefully at all times.

5. UNPACKING THERMOGRAPH ML–77 OR ML–277. Unpack the thermograph carefully. The carrying case and the cylinder containing the clock mechanism are packed separately. Be careful not to jolt or drop the package containing the clock.

6. LOCATING THERMOGRAPH ML–77 OR ML–277. **a.** Place the thermograph in a position where the sun will not shine on it and where the temperature element is exposed to freely circulating air. Be sure that the thermograph is protected against vibration and temperature radiation effects. Normal location of the thermograph is in Shelter ML–41 on the back, left-hand side of the shelter floor where it will not interfere with other instruments.

b. Locate a standard thermometer near Thermograph ML–77 or ML–277 for comparison with, and for correction of, the thermograph.

7. INSTALLING CHART. **a.** Cut the bottom edge of the chart carefully along the trimming line.

b. Fit the chart on the cylinder so that the margin is in line with the notch and flange slot on the cylinder (fig. 7 (1)).

c. Wrap the chart around the cylinder until the left-hand end can be lapped over the right-hand margin. The ends of the chart must meet so that the temperature lines are in correct alignment (fig. 7 (1) and (2)). Make sure that the chart fits snugly against the bottom flange of the cylinder.

NOTE: Keep the fingers off the face of the chart as much as possible. Fingerprints cause the ink to spread and make a ragged trace.

d. Fasten the spring clip which holds the chart in place. Push the clip as far down as possible to keep the chart from slipping (fig. 7 (3)).

e. If a daily chart is required and is not available, convert a weekly chart to a daily record by letting three divisions represent 1 hour. This will not provide an absolutely accurate time record, but it will be accurate enough for most purposes.

8. WINDING CLOCKS ML–79–A AND ML–279. Wind the clock before replacing the cylinder on the shaft. Use the winding key located inside the top of the cylinder (fig. 3).

a. Make 12 half-turns of the key if the clock is wound once a week.

b. Make a 14 half-turns of the key if the clock is wound when the move-

Figure 7. Replacing chart.

ment is completely run down, Clocks ML–79–A and ML–279 run down completely in 9 days.

Caution: Never wind Clocks ML–79–A and ML–279 too much.

9. INSTALLING CYLINDER. **a.** Push the pen-arm shifting lever to the extreme right. This adjusts the shifting rod so that the pen arm is in a nonrecording position and is out of the way.

b. Lower the cylinder onto the clock shaft. Be careful to eliminate the possibility of a time-lag error (see (1), (2), and (3) below). The major adjustment for time is made as the cylinder is lowered onto the clock shaft, before the clock gear is engaged.

(1) Use the shifting rod to move the pen close to the chart.

(2) Turn the cylinder on its axis until the pen falls a trifle to the right of the correct time as shown on the chart. Lower the clock until the gears mesh.

(3) Turn the clock unit *counterclockwise* until the pen indicates the proper time. Setting must be made by turning the cylinder counterclockwise to take up backlash in the clock gear train. If the pen does not rest on the correct time, the operation should be repeated until an exact adjustment is made.

Caution: Be certain that the pen does not catch on the edge of the chart or on the spring clip. This will bend the pen arm. Keep the pen arm in front of the shifting rod at all times.

10. INKING PEN. **a.** Be sure that the tip of the pen arm rests under the front and rear clamps of the pen. Make sure that the pen is seated against the shoulder of the pen arm. If necessary, adjust the position of the pen so that the over-all length of the pen arm is proper (14 centimeters or 5.51 inches).

b. In the space between the nibs of the point place a drop of special recording ink (the amount that ordinarily clings to the end of a small wire or to the applicator in the ink bottle). Fill the round reservoir of the pen about half-full of recording ink.

c. If necessary, start ink flowing by carefully drawing a piece of cellophane or lint-free paper, such as chart paper, between the nibs. Be careful not to bend or damage the points. Make sure that no particles are caught between points.

d. Remove all ink on the outer surface of the pen or pen arm. Ink on these points collects dirt and dust and produces too broad a record line.

11. ADJUSTING PEN TO TEMPERATURE. **a.** Hold Thermometer ML–7 or any standard thermometer as near as possible to the temperature element of the thermograph.

b. Turn the temperature adjusting thumbnut (fig. 5) until the reading of Thermograph ML–77 or of Thermograph ML–277 is adjusted to the reading of the standard thermometer (par. 17). Turning the adjusting thumbnut clockwise raises the pen; turning the adjusting thumbnut counterclockwise lowers the pen. Make this adjustment in a location where there is a good circulation of air around the temperature element and standard thermometer. *Never* use the link and lever assembly to adjust the pen to correct temperature; such procedure changes the calibration of the thermograph. Adjust the reading of the thermograph to the reading of the thermometer whenever charts are changed and when the thermograph develops a temperature error of 5° or more.

12. CHANGING CYLINDER SPEED. To control the speed of rotation of the cylinder and to change from a weekly to a daily record, perform the following operations:

a. Move the pen away from the chart (par. 9a).

b. Remove the cylinder from the shaft.

c. Release the shaft by unscrewing the wingnut on the under side of the frame base.

d. Remove the weekly gear from the shaft.

e. Replace this gear with the larger of the two daily gears from under the gear change cover.

f. Replace the shaft and tighten the wingnut securely.

g. Remove the pin which holds the small gear on the clock shaft marked WEEKLY, and then pull the gear from the shaft (fig. 3). Install the smaller of the spare change gears on the clock shaft labeled DAILY. *Be sure to replace the pin and washer.*

NOTE: Weekly gears are marked 176E. Daily gears are marked 29E.

h. Make sure that the gear fits tightly on the clock shaft, since the driving force of Clock ML-79-A or ML-279 depends on this condition. To correct a loose fit, carefully squeeze the slotted sleeve of the gear with a pair of pliers before pressing the gear onto the shaft.

13. READING TEMPERATURE. Read the temperature directly from the chart to the nearest degree.

SECTION III

FUNCTIONING OF PARTS

14. TEMPERATURE ELEMENT. a. Thermograph ML–77. As the temperature rises, the liquid in the Bourdon tube expands and causes the tube to straighten. When the tube straightens, its free end moves downward and causes the pen arm to move upward. In response to a decrease in temperature, the liquid in the Bourdon tube contracts and increases the curvature of the tube. The free end of the tube rises, causing the pen arm to fall and to record the lower temperature.

b. Thermograph ML–277. (1) The bimetallic temperature strip changes its shape with temperature variations because the two metals expand and contract at unequal rates. When the temperature rises, the temperature element moves downward and forces the pen arm up. When the temperature falls, the free end of the temperature element moves up, causing the pen arm to move down and to record the low temperature.

(2) The radiation fins provide a quick transference of heat to the bimetallic strip. As a result, the temperature element reacts faster to the temperature of the moving air.

15. VERTICAL LINK AND CALIBRATING MECHANISM. a. Thermograph ML–77. (1) *Vertical link.* The vertical link, connecting the free end

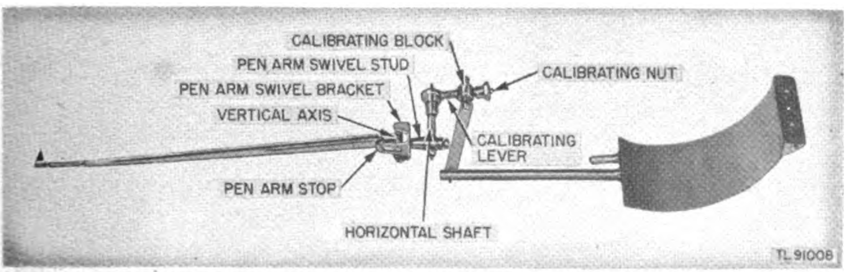

Figure 8. Thermograph ML–77, Bourdon tube, linkage system, and pen.

of the Bourdon tube to the calibrating lever and pen-arm swivel stud on the horizontal shaft, transfers the motion of the Bourdon tube (par. 14a) to the pen arm (fig. 8).

(2) *Calibrating mechanism.* The calibrating mechanism (fig. 8) regulates the sweep of the pen arm.

(*a*) A movable calibrating block attaches the vertical link to the calibrating lever and provides a means of adjusting the effective length of the calibrating lever.

(*b*) The calibrating nut, acting against a coil spring, moves the calibrating block lengthwise on the calibrating lever.

(*c*) A setscrew secures the calibrating block to the calibrating lever.

b. Thermograph ML–277. (1) *Vertical link.* The vertical link, connecting the free end of the bimetallic strip to the calibrating lever and pen-arm swivel stud on the horizontal shaft, transfers the motion of the bimetallic temperature element to the pen arm. The slot in the link allows the temperature element to move down against a spring when Thermograph ML–277 is exposed to temperatures above 80° F.

(*a*) *Spring.* The spring keeps the pin, which engages the vertical link, in contact with the upper end of the slot in the vertical link over the entire range of the temperature chart in use.

(*b*) *Stop.* The stop (fig. 6) prevents undue strain on the link and lever system when the temperature element, at any adjustment within its range (par. 4c (2)), is exposed to temperatures of 140° F. or less. Since the stop limits the extent of the downward motion of the vertical link, the pen never leaves the cylinder.

(2) *Calibrating mechanism.* The calibrating mechanism of the Thermograph ML–277 is identical with that of Thermograph ML–77 (see a (2) above).

Note: Except for the temperature elements and vertical link arrangements, the functioning of parts for Thermographs ML–77 and ML–277 is identical.

16. PEN AND PEN ARM. The pen and pen arm make a visible record of temperature changes on the chart. Capillarity controls the flow of ink from the barrel.

a. Pen arm swivel bracket (fig. 8). The pen-arm swivel bracket holds the vertical axis. This bracket is mounted on the pen-arm swivel stud which is attached by a setscrew to the front end of the horizontal shaft. The swivel bracket is turned so that the vertical axis tilts inward a few degrees to provide constant pressure of the pen point against the chart.

b. Pen-arm stop (fig. 8). The pen-arm stop prevents the pen arm from swinging out too far and provides a safe limit to the outward motion of the pen arm when the point is lifted from the chart.

17. ADJUSTING THUMBNUT. The adjusting thumbnut sets the pen on the chart to correspond to the air temperature. This thumbnut acts against a coil spring and moves the bracket attached to the temperature element. When the bracket is moved, the tube rotates about the fixed end and changes the position of the pen on the record chart (figs. 5 and 6).

SECTION IV
MAINTENANCE

NOTE: Unsatisfactory performance of Thermograph ML–77 or ML–277 will be reported immediately on W. D., A. G. O. Form No. 468. If form is not available, see TM 38–250.

18. GENERAL. a. Keep Thermographs ML–77 and ML–277 clean and free from dust and dirt. Dust the temperature element with a soft cloth about once a week. Handle the Bourdon tube carefully; slight bending will damage it.

b. Keep the cover closed except when adjustments are being made. When adjustments are required, dust the thermograph with a soft brush.

NOTE: Under normal conditions, if Thermographs ML–77 and ML–277 are given the care necessary for preserving such precision instruments, no further servicing will be required.

19. OILING THERMOGRAPH ML–77 OR THERMOGRAPH ML–277. a. Oiling pivots. After continued long use, or after a period when the air has been unusually dusty, wipe the pivots of the pen arm and of the horizontal shaft clean with a soft cloth, and then apply a small drop of grade No. 1 watch oil to Thermograph ML–77 or low-temperature oil to Thermograph ML–277. Apply to each pivot only the amount of oil that will cling to the end of a fine wire. Too much oil tends to collect dirt and dust. Resulting excess friction hinders the performance and accuracy of the thermograph.

b. Oiling clock movement. The clock movements of Thermograph ML–277 and Thermograph ML–77 should be oiled only at the instrument repair depot.

(1) *Exposures above 0° F.* Oil, Lubricating, Special, Specification AXS–777, should be used. If it is not available, grade No. 1 watch oil may be used for exposures above 0° F.

(2) *Exposures below 0° F.* (*a*) Use Oil, Lubricating, Special, Specification AXS–777, for the entire lubrication during subzero weather. This special lubricating oil remains in liquid form to —90° F.

(*b*) Cover the upright shaft with a light film of vaseline, but take care that no grease gets on the pinion or gear. Grease, Lubricating, Special, Specification AXS–637, may be substituted for vaseline.

20. MAINTAINING PEN AND PEN ARM. a. To adjust a pen which fails to make a fine, clear line, remove the pen from the pen arm and clean the pen after removing it from the pen arm.

(1) Hold the pen arm with one hand, and gently pull off the pen with the other.

(2) Wash the pen with soap and water. Scrape off dried ink which does not dissolve in soap and water, and then wash the pen again.

NOTE: Wash and scrape ink from the pen carefully. Scratches on the sides of the nibs near the point will change the usual capillary action of the pen. The nibs must fit closely together.

(3) If the pen fails to give a satisfactory record line after washing, replace it with a new pen.

b. If the pen has a point which is too blunt to draw a fine line, replace it with a new pen. If a new pen is not available, sharpen the rounded point on an oilstone.

c. Be sure the pen-arm swivel stud is next to the bevel at the end of the horizontal shaft (fig. 8).

d. Check the angle at which the vertical axis is tilted. If the vertical axis is tilted inward too much, it will cause excessive pressure. If the vertical axis is not tilted inward enough, the trace will be too light and may not be continuous.

e. If the pen arm rides on the shifting rod, either the shifting rod is bent, or the pen arm is set in too far on the horizontal shaft. The pen arm must be at the front edge of the shoulder of the shaft. To adjust the position of the pen arm, loosen the setscrew in the pen-arm swivel stud (fig. 8), and move the pen arm to the correct position.

21. INKING. Fill the barrel of the pen only half-full of ink. In foggy weather or during periods of prolonged mist and rain, the ink will absorb moisture and the barrel will overflow if it has been filled to capacity. If the pen barrel overflows because of the presence of excess moisture in the air, proceed as follows:

a. Empty the barrel with a small piece of blotting paper. Otherwise, the ink left in the barrel is diluted and makes an illegible record.

b. Fill the barrel with *new* ink.

NOTE: Thermograph ML–277 uses a special low-temperature ink. If this ink runs at higher temperature ranges, substitute the ink used in Thermograph ML–77.

22. REPLACING CHART. Move the pen away from the chart, and then lift the cylinder from the shaft. Remove the chart by sliding the clip upward and out of the lower slot. If the chart contains a record, handle the chart carefully to avoid smearing the trace. (See par. 7 and fig. 7 for detailed instructions for installing new chart.)

NOTE: After replacing the chart, always check the temperature indicated by the pen against a standard mercurial thermometer and readjust the adjusting thumbnut if necessary (par. 11 b).

23. CLOCK UNIT.

Caution: Never remove the clock from the cylinder in which it is mounted.

a. Winding clock. Wind Clocks ML–79–A and ML–279 once a week, preferably at the time the charts are changed (par. 8).

b. Correcting time. Open the sliding window marked FAST-SLOW in the top of the clock case, and adjust the regulator (fig. 3). Each graduation on the regulator represents 42 seconds in 24 hours.

(1) To increase the speed of rotation, move the regulator one graduation toward the FAST end. The speed of rotation increases 42 seconds per day or almost 5 minutes per week.

(2) Move the regulator one graduation toward the SLOW and to decrease the speed of rotation. The speed of rotation decreases 42 seconds per day or almost 5 minutes per week.

NOTE: Since the graduations on the chart do not permit a setting as close as 5 minutes, adjustment of the regulator within one graduation of correct time will be satisfactory.

c. Correcting binding gears. (1) Friction between the clock drive gear and the daily or weekly pinion causes the clock to stop. To correct this condition, proceed as follows:

(*a*) Remove the cylinder from the shaft.

(*b*) Loosen slightly the three screws at the base of the cylinder (fig. 3).

(*c*) Note that the pinion shaft can now be shifted somewhat. Move the shaft to a position where no friction occurs at any point throughout an entire revolution.

NOTE: When the small gear has been moved correctly, backlash will occur when the cylinder is in any position.

(*d*) Tighten the three screws at the proper setting.

(2) Stiffening of lubricating oil in the bearings may cause the clock to stop in extremely cold weather.

(*a*) Take the instrument indoors, temporarily, to a temperature above freezing.

(*b*) When the clock is warm, try to start it by rotating it carefully on its axis.

d. In tropics. At least once every 3 months, send the clock unit with its shaft and gears to an instrument repair depot for cleaning and oiling.

e. Repairing poorly functioning clock. *Do not attempt to repair or adjust the clock mechanism of a poorly functioning clock.* Remove the cylinder, the shaft, and the large external gear. Pack them, and send them to an authorized repair depot. Be sure to include the shaft and gears, since they are necessary to test the clock.

f. Precautions. (1) Do not drop or subject the clock to mechanical shocks.

(2) Do not leave the clock movement exposed to excessive moisture. Excessive moisture causes rust and rust causes friction which stops the clock.

(3) When transporting the thermograph from one location to another or when returning it to a depot for repairs, pack the clock separately. Use enough packing material to protect the clock from shocks and vibration.

24. CALIBRATING THERMOGRAPH ML–77 OR ML–277 IN FIELD.

If Thermograph ML–77 or Thermograph ML–277 is set at one temperature or registers one temperature accurately, but, unless adjusted, does not register accurately a second temperature within a range of 5° of the first, recalibration is necessary. Accurate calibration is possible only at repair depots where the necessary equipment is available (par. 25). In the field, however, it is possible to recalibrate in the following manner:

a. Increasing sweep of pen arm. If the thermograph reading is too low for temperatures at the top of the chart and too high for temperatures at the bottom of the chart, the pen arm is swinging over too short an arc. To correct this condition, proceed as follows (fig. 8):

(1) Loosen the setscrew in the calibrating block.

(2) Turn the calibrating nut clockwise to move the vertical link nearer the horizontal shaft. This increases the sweep of the pen arm. Two or three turns of the calibrating nut may be necessary to take care of a 2- or 3-degree variation in temperature range.

(3) Tighten the setscrew after the adjustment is made.

(4) Reset the temperature adjusting thumbnut to the existing temperature.

(5) Observe temperatures recorded by the thermograph long enough to get a maximum and a minimum reading. If the range is still incorrect, repeat the procedure until the required accuracy is obtained.

b. Decreasing sweep of pen arm. If the thermograph reading is too high for temperatures at the top of the chart and too low for temperatures at the bottom of the chart, the pen arm is swinging over too large an arc. To correct this condition, proceed as in *a* above, with the exception that the calibrating nut must be turned to move the vertical link *away* from the horizontal shaft. This shortens the sweep of the pen arm.

25. CALIBRATION AT DEPOT. a. Thermograph ML–77.(1) Suspend the thermograph over a water bath maintained at 32° F.

(2) Tilt the thermograph slightly so that the temperature element and part of the base are immersed in the water. Make sure that the clock and shaft do not get wet.

(3) Allow enough time for the unit to react, and then set the pen at 32° F. with the adjusting thumbnut.

(4) Remove the thermograph and place it in a water bath maintained at 100° F.

(5) Wait for the temperature element to react to temperature, and then read the chart.

(6) If the reading is not 100° F., shift the calibrating block to expand or contract the range as necessary.

(*a*) To increase the range, loosen the setscrew in the adjustment clamp and turn the calibrating nut *clockwise*.

(*b*) To decrease the range, turn the calibrating nut *counterclockwise*.

NOTE: Two or three turns of the calibrating nut may be necessary to compensate for a 2° or 3° variation from 100° F.

(*c*) Turn the calibrating nut until the pen moves halfway between the highest recorded temperature of the instrument and the 100° F. mark.

(7) Reset the pen to 100° F. with the temperature-adjusting thumbnut.

(8) Insert the thermograph in the bath and observe results.

(9) Additional adjustments may be necessary before the instrument is accurately calibrated. When calibration is completed, tighten the setscrew in the adjustable clamp.

b. Thermograph ML–277. The calibration of Thermograph ML–277 is identical to the calibration of Thermograph ML–77, with the exception that the baths for Thermograph ML–277 are maintained at temperatures of 32° F. and 75° F.

26. MOISTUREPROOFING AND FUNGIPROOFING. Moistureproofing and fungiproofing are not required for Thermographs ML–77 and ML–277.

SECTION V
SUPPLEMENTARY DATA

27. MAINTENANCE PARTS LIST FOR THERMOGRAPH ML-77.

NOTE: Order all maintenance parts by stock number, name, and description. Only maintenance parts can be requisitioned.

Signal Corps stock No.	Name of part and description	†Station stock	Quantity per unit
7A1777......	Thermograph ML-77: recording F. thermometer; includes Clock ML-79-A and case.	....	1
7A1777/1....	Arm: pen..........................	....	1
7A579A/C1 ..	Clip: chart; brass; 5/16" wide x 4½" (approx.) long; bends at both ends; Friez part No. ST-379-2; used with Clock ML-79-A and ML-279 (for thermograph record chart).	*	1
7A579A......	Clock ML-79-A: 8-day; cylinder, 93-mm diam. x 130-mm long, w/clock movement inclosed; has spindle gears and attaching nut; makes one revolution in 7 days or one revolution in 1 day; weighs 3.5 lbs; p/o Thermograph ML-77.	*	1
6D120A	Form SC No. 120-A: range, —20° F. to +110° F.	*	1
7A1777/G1...	Glass: 3 7/16" x 5⅝", approximately 0.090" thick.	....	2
7A1102......	Ink: special register; red; ¼-oz. bottle...	*	1
7A1100......	Ink: special register; green; ¼-oz. bottle..	*	1
7A1101......	Ink: special register; purple; ¼-oz. bottle.	*	1
7A1777/N1...	Nut: arm; Friez part No. HT-15 (used with Thermographs ML-77 and ML-277).	....	1
6G1339.1....	Oil: watch; grade No. 1; nongum; 1-oz. bottle.	*	1
7A1208......	Pen: nib type; front and rear clamps...	*	1
7A1777/P1...	Pin: arm: Friez part No. HT-19 (used with Thermographs ML-77 and ML-277).	....	1
7A1777/S2...	Screw: arm; Friez part No. HT-14 (used with Thermographs ML-77 and ML-277).	....	....

See footnotes at end of table.

27. MAINTENANCE PARTS LIST FOR THERMOGRAPH ML-77—Continued.

Signal Corps stock No.	Name of part and description	†Station stock	Quantity per unit
7A1777/S3...	Spring: arm; Friez part No. HT-16 (used with Thermographs ML-77 and ML-277).	....	1

†Parts not stocked in station stock are carried in region or depot stock. (Consult ASF catalog Sig 10-900).
*Indicates stock available.

28. MAINTENANCE PARTS LIST FOR THERMOGRAPH ML-277.

NOTE: Order maintenance parts by stock number, name, and description. Only maintenance parts can be requisitioned.

Signal Corps stock No.	Name of part and description	†Station stock	Quantity per unit
7A1797......	Thermograph ML-277: recording F. thermometer; temperature range $-80°$ F. to $+80°$ F.; includes Clock ML-279 and case; similar to Thermograph ML-77 w/special bimetal temperature element for a standard Bourdon tube; requires special low-temperature ink and clock oil; for use in Arctic region.	....	1
7A1777/1....	Arm: pen...........................	....	1
7A1797/C2...	Chart: thermograph record sheet; range $+80°$ F. to $-50°$ F.; weekly (used with Thermograph ML-277).	*	1
7A1797/C1...	Chart: thermograph record sheet; range $+50°$ F. to $-80°$ F.; weekly (used with Thermograph ML-277).	*	1
7A579A/C1 ..	Clip: chart; brass; 3/16" wide x 4½" (approx.) long; bends at both ends; Friez part No. ST-379-2; used with Clock ML-79-A and ML-279 (for thermograph record chart).	*	1
7A591-279...	Clock ML-279: Spec. 174-1; cylinder, 93-mm diam. x 130-mm long, w/clock movement inclosed; has spindle gears and attaching nut; adjustable to make one revolution in 7 days or one revolution in 1 day; similar to Clock ML-79-A, except modified and tested for operation at $-80°$ F.; weighs 3.5 lbs.; p/o Thermograph ML-277.	*	1

See footnotes at end of table.

28. MAINTENANCE PARTS LIST FOR THERMOGRAPH ML-277—Continued.

Signal Corps stock No.	Name of part and description	†Station stock	Quantity per unit
7A1777/G1...	Glass: 3⁷⁄₁₆" x 5⅜" x (approx.) 0.090"...	....	2
7A1099......	Ink: special-register; used for low-temperature operation; 1-oz. bottle; Friez model No. 50 (used with Thermograph ML-277).	*	1
7A1797/L1...	Link: vertical; Friez part No. 43127 (used with Thermograph ML-277).	....	1
7A1777/N1...	Nut: arm; Friez part No. HT-15 (used with Thermographs ML-77 and ML-277).	....	1
7A1797/O1 ..	Oil: low-temperature; 1-oz. bottle; Friez part No. 501199 (used with Thermographs ML-77 and ML-277).	*	1
7A1208......	Pen: nib type; front and rear clamps...	*	1
7A1777/P1...	Pin: arm; Friez part No. HT-19 (used with Thermographs ML-77 and ML-277).	....	1
7A1777/S2 ...	Screw: arm; Friez part No. HT-14 (used with Thermographs ML-77 and ML-277).	....	1
7A1777/S3 ...	Spring: arm; Friez part No. HT-16 (used with Thermographs ML-77 and ML-277).	....	1
7A1797/S1 ...	Spring: for vertical link; Friez part No. AF-193.	....	1
7A1797/E1...	Element: temperature; bimetal; with corrugated radiation vanes; Friez part No. 43126.	....	1

† Parts not stocked in station stock are carried in region or depot stock. (Consult ASF catalog Sig 10-900).
* Indicates stock available.

O

TM 11-427

WAR DEPARTMENT TECHNICAL MANUAL

BAROMETERS

ML-102-B, ML-102-D, ML-102-E, ML-102-F, AND ML-316/TM

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WAR DEPARTMENT • NOVEMBER 1944

TECHNICAL MANUAL

BAROMETERS ML–102–B, ML–102–D, ML–102–E, ML–102–F, ML–102–G, AND ML–316/TM

CHANGE No. 1

DEPARTMENT OF THE ARMY
WASHINGTON 25, D. C., 17 June 1952

TM 11–427, 13 November 1944, is changed as follows:
The title of the manual is changed to read:

BAROMETERS ML–102–B, ML–102–D, ML–102–E, ML–102–F, ML–102–G, AND ML–316/TM

Section I. DESCRIPTION

Note (Added). Barometer ML–102–G is similar to Barometer ML–102–D. All information in this technical manual pertaining to Barometer ML–102–D applies equally to Barometer ML–102–G unless otherwise specified herein.

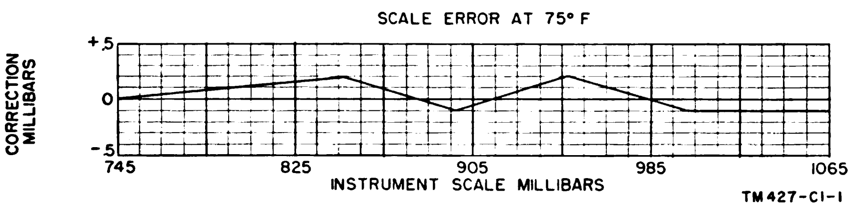

Figure 6.1 (Added). *Barometer ML–102–G, scale calibration curve.*

13. Reading Barometers ML–102–D and ML–316/TM

*   *   *   *   *   *   *

b. Temperature Correction.

*   *   *   *   *   *   *

(3) To correct the observed reading for temperature:

(*a*) Locate the indicated * * * of this graph. Note the point on the correction curve which is vertically above or below this pressure value.

(*b*) Read the value of the correction to be applied per degree Fahrenheit (above or below 75° F.) from the point on the vertical scale of the graph, corresponding to the point on the curve.

*   *   *   *   *   *   *

(6) (Added) For Barometer ML–102–G, additional accuracy may be obtained by applying the corrections determined from the scale calibration curve for each instrument, as illustrated in figure 6.1.

AGO 4211B—June 950999°—42

(*a*) Locate the indicated pressure on the horizontal scale of this graph. Note the point on the correction curve which is vertically above this pressure value.

(*b*) **R**ead the value of the correction to be applied to that pressure from the point on the vertical scale of the graph corresponding to the point on the curve. If the correction is plus, it is to be added to the otherwise corrected pressure; if it is minus, the correction is to be subtracted.

* * * * * * *

15. Errors of Aneroid Barometer

Factors which introduce * * * *errors*, and *drift*.

* * * * * * *

c. Scale Errors.

* * * * * * *

(4) The dials of * * * making pressure measurements. **However, when using Barometer ML-102-G, an increase in accuracy may be obtained by applying a correction obtained from the scale calibration curve (fig. 6.1).**

* * * * * * *

Figure 9. Barometer ML-102-D (or ML-316/TM ***or ML-102-G (serial numbers below 2033)****), aneroid mechanism.*

18. Barometers ML-102-D, ML-102-G, and ML-316/TM (fig. 9.)

a. Mechanism.

(1) The mechanism of Barometers ML-102-D, **ML-102-G (serial numbers below 2033)**, and ML-316/TM is built upon a triangular-shaped aluminum base plate. **A rectangular base plate is provided on ML-102-G, serial numbers higher than 2033 (fig. 9.1).** The difference in range of the **three** instruments is achieved by changing the spring rate of the pressure sensitive cell. The aneroid element * * * at the end.

(2) The movement of * * * gear sector lever. **In Barometer ML-102-G, serial numbers higher than 2033 (fig. 9.1), the movement of the cell is transmitted to the gear sector lever by a push rod which has a flattened hinge section to allow for change in alinement. The gear sector lever is**

mounted on flexure pivots. The teeth of * * * during air transportation.

* * * * * * *

b. Magnification. Magnification of the * * * in three stages:

* * * * * * *

(4) (Added) In Barometer ML-102-G, serial numbers higher than 2033 (fig. 9.1), the first stage is a simple lever magnification which is the ratio of the distance between the axis of the flexure pivot and the line of action of the push rod to the distance between the axis of the flexure pivot and the teeth of the gear sector.

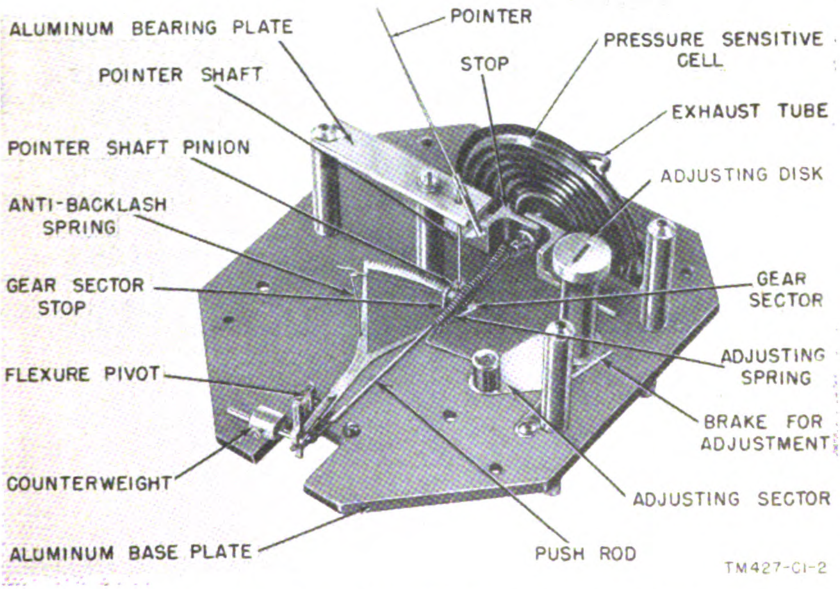

Figure 9.1 (Added). *Barometer ML-102-G, serial numbers higher than 2033, aneroid mechanism.*

[AG 300.7 (23 May 52)]

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WAR DEPARTMENT TECHNICAL MANUAL
TM 11-427

BAROMETERS ML-102-B, ML-102-D, ML-102-E, ML-102-F, AND ML-316/TM

WAR DEPARTMENT • NOVEMBER 1944

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WASHINGTON : 1944

WAR DEPARTMENT,
WASHINGTON 25, D. C., 13 November 1944.

TM 11-427, Barometers ML-102-B, ML-102-D, ML-102-E, ML-102-F, and ML-316/TM, is published for the information and guidance of all concerned.

[AG 300.7 (19 Oct 44).]

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IC 11: T/O 11-107; 11-127; 11-237; 11-287; 11-587; 11-592; 11-597.

For explanation of symbols, see FM 21-6.

DESTRUCTION NOTICE

WHY —To prevent the enemy from using or salvaging this equipment for his benefit.

WHEN —When ordered by your commander.

HOW —1. Smash—Use sledges, axes, handaxes, pickaxes, hammers, crowbars, heavy tools.
2. Cut—Use axes, handaxes, machetes.
3. Burn—Use gasoline, kerosene, oil, flame throwers, incendiary grenades.
4. Explosives—Use firearms, grenades, TNT.
5. Disposal—Bury in slit trenches, fox holes, other holes. Throw in streams. Scatter.

USE ANYTHING IMMEDIATELY AVAILABLE FOR DESTRUCTION OF THIS EQUIPMENT

WHAT —1. Smash—case, mechanism, and carrying case.
2. Burn—wooden cases; technical manuals; records.
3. Bury or scatter—any or all of the above.

DESTROY EVERYTHING

CONTENTS

Figure 1. Barometers ML-102-(*) and ML-316/TM with carrying cases.

SECTION I

DESCRIPTION

1. GENERAL. a. Use. (1) The barometers described in this manual are aneroid-type barometers used to measure the pressure of the atmosphere. Aneroid, from the Greek *a* (no) + *neros* (wet) means "containing no liquid." The greatest advantage of the aneroid is its portability. It is widely used where the use of the mercury barometer would be inconvenient or impractical. It is also valuable in giving relative indications and in measuring pressure changes over a few hours.

(2) Apart from the measurement of pressure, there is a broad field for the use of the aneroid barometer in determining height above sea level or above the ground, and in determining differences in elevation between two points. When used to measure height, the aneroid is called an *altimeter.* Altimeters are widely used in aircraft and in surveying.

(3) The barometers covered in this book are designed for use in fixed or mobile stations and for transport by hand or in vehicles.

(4) Each barometer is an integral unit requiring no additional equipment to accomplish the purpose for which it is intended.

b. Reliability. The aneroid barometer is less accurate than the mercury barometer. It should not be depended upon for measurement of *absolute* values of pressure unless it is compared at intervals of 90 days or less with a mercurial barometer for which errors are known.

Note. The aneroid barometers covered by this technical manual are much more accurate than former types of aneroid.

c. Nomenclature. (1) Throughout this manual Barometer ML–102–(*) refers to Barometers ML–102–B, ML–102–D, ML–102–E, and ML–102–F, or any one of them.

(2) Any reference to "the barometer" includes Barometer ML–102–(*) or ML–316/TM. If Barometer ML–316/TM only is indicated, the complete nomenclature is used.

2. COMPONENTS. a. Barometers ML–102–B, ML–102–E, ML–102–F. (1) *Pressure measuring and indicating system.* (*a*) Pressure sensitive cells (five in Barometer ML–102–B; two in Barometers ML–102–E and ML–102–F).

(*b*) Lever system.

(*c*) Indicating pointer.

(2) *Metal case.* (*a*) Metal base.

(*b*) Dial.

(*c*) Plastic window and snap ring.

(3) Mounting frame assembly. (*a*) Metal frame in two sections.

(*b*) Screws, lockwashers, and nuts.

(*c*) Temperature correction chart and nomograph supplied for Barometer ML–102–E only.

(4) *Carrying case with strap.*

b. Barometers ML-102-D and ML-316/TM. (*a*) Pressure sensitive cell.

(*b*) Lever systei

(*c*) Pointer.

(2) *Case.* (*a*) Wooden base and lid.

(*b*) Dial.

(*c*) Dial cover.

(*d*) Temperature correction and conversion chart.

(3) *Carrying case with strap.*

3. DIFFERENCES IN BAROMETERS. a. Barometer ML-102-B (fig. 1). Externally, Barometer ML-102-B is identical to Barometer ML-102-F. Both are contained in black metal cases and leather carrying cases. The internal mechanism of Barometer ML-102-B, however, differs from all other models, for it has five pressure cells and a more complicated lever system (par. 16).

b. Barometer ML-102-E (fig. 1). The case of Barometer ML-102-E is of metal, painted dark green, with a crackle finish. It has a solid back provided with a metal rim which holds a nomograph and temperature correction chart, calibrated specifically for each instrument. This model has two pressure sensitive cells (for complete description see par. 17).

c. Barometer ML-102-F (fig. 1). The exterior of this model is identical to that of Barometer ML-102-B. The interior is identical to that of Barometer ML-102-E.

d. Barometer ML-102-D. This barometer differs both in appearance and construction from other Barometers ML-102-(*). Externally it is housed in a square wooden case; the internal mechanism contains only one pressure cell. It is of much lighter construction than Barometers ML-102-B, ML-102-E, and ML-102-F.

e. Barometer ML-316/TM. This model is identical to Barometer ML-102-D in appearance and construction, differing only in the range of pressure (par. 4b).

4. CHARACTERISTICS. a. Essential components of aneroid barometer. The aneroid barometers covered in this manual consist of the following parts:

(1) An almost completely evacuated metal cell (or cells) sensitive to changes in the atmospheric pressure.

(2) A system of levers and gears by which the motion of the cell is magnified and transmitted to a pointer. The cell and lever system is hereafter referred to as the aneroid mechanism.

(3) A dial on which the pointer indicates the changes or pressure.

b. Pressure range. (1) *Barometers ML-102-B, ML-102-E, and ML-102-F.* The range of pressure of these instruments is 1085 to 745 millibars and 31.5 to 22 inches. The dials are graduated in both millibars and inches.

(2) *Barometer ML-102-D.* The range of pressure of this barometer is 1065 to 745 millibars. The dial is graduated in millibars only.

(3) *Barometer ML-316/TM.* The range of pressure of this barometer is 1065 to 610 millibars. The dial is graduated in millibars only.

c. Dimensions and weight. The following tables gives the dimensions and weight of the barometers covered in this manual:

Barometer	Dimensions (in.)			Approx. weight (lb.)	Approx. weight including carrying case (lb.)
	Length	Width	Depth		
ML–102–B and ML–102–F	6¾	6¾	4	6	7½
ML–102–E	6¾	6¾	4	6	10½
ML–102–D and ML–316/TM ...	6¼	6¼	4	2½	4¼

5. BAROMETERS ML–102–B, ML–102–E, and ML–102–F (fig. 1). **a. Frame and case.** These three barometers are shock-mounted in metal frames. The case is secured to the schockmounts in the frame at the four corners with screws, washers, and nuts (fig. 10). The barometer case consists of a kettle-shaped brass housing over which is fitted a circular casting with four ears for mounting it to the frame. A plastic window in this casting, held in place by a snap ring, protects the dial. A slotted screw on the bottom side of the case enables the instrument to be adjusted without opening the case. A metal ring is provided at the top of the frame for hanging the barometer. The back of the case of Barometer ML–102–E has a metal rim which holds in place a nomograph and temperature correction chart.

b. Dial (fig. 2). The dials on the three instruments are identical. Each is 5¼ inches in diameter and has three scales. The outer scale is graduated in fiftieths (0.02) inches, with numerical designations for whole inches from 26 to 31, and smaller numbers for tenths of inches. The center scale is graduated in whole millibars from 1085 to 895 millibars. The innermost scale is graduated from 895 to 745 millibars. Every five millibars bears a numerical designation. In the center of the dial is a shaft bearing an aluminum pointer which is flattened vertically at the indicating end. Concentric with the scales and between the inch and millibar scales is a mirror ring, the purpose of which is to reflect the pointer and facilitate the reading of the scales (par. 10).

c. Aneroid mechanism (figs. 7 and 8). The aneroid mechanism of these barometers is built upon a casting which is mounted to a gear plate, held in place by brackets and screws. The principle of operation is the same in the three barometers, but the internal mechanism of Barometer ML–102–B differs considerably from that of Barometers ML–102–E and ML–102–F. For a complete description of functioning of parts of Barometer ML–102–B, see paragraph 16. For Barometers ML–102–E and ML–102–F, see paragraph 17.

6. BAROMETERS ML–102–D AND ML–316/TM (fig. 1). **a. Case.** These instruments have identical wooden cases, painted olive drab, with metal reinforcements at the outside corners. Means for hanging the barometer temporarily is provided by a sliding metal hanger set flush with the back of the case. (For preferred position of this barometer, see paragraph 8c (2).) The lid is fastened to the case by separable hinges and

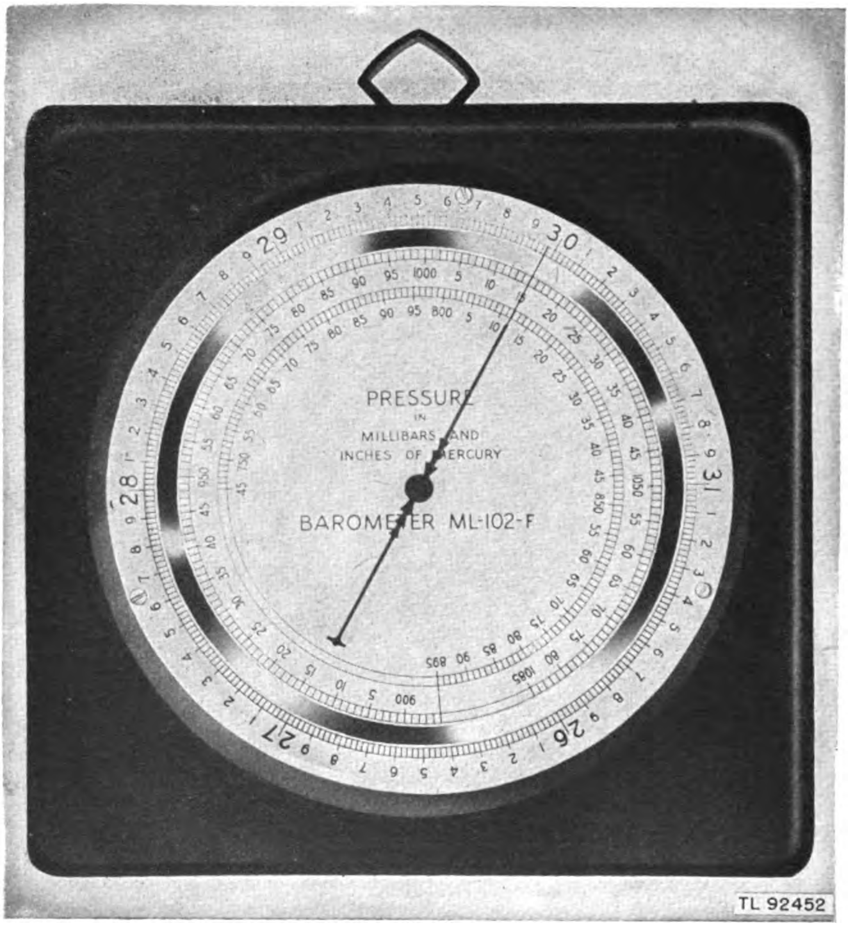

Figure 2. Barometer ML–102–F (or ML–102–B, or ML–102–E), close-up of dial.

is provided with a spring stop to prevent accidental removal. A temperature correction and conversion chart is mounted inside the lid of the case. A plastic window protects the dial. The pointer of the instrument is adjusted through a plugged opening in the window which permits access to a slot in the dial.

b. Dial (fig. 3). (1) The dial of these barometers is approximately 5¼ inches in diameter. It is graduated in half-millibar intervals and is calibrated for approximately two revolutions of the pointer. Since the graduations are not strictly linear, there is a separate scale for each revolution of the pointer. The two scales are concentric, one inside the other. A mirror ring, concentric with, and inside the two scales, reflects the pointer and eliminates parallax error when reading the scales (par. 9b).

(2) The dial of Barometer ML–102–D covers a pressure range of 1065 to 745 millibars.

Figure 3. Barometer ML–102–D (or ML–316/TM), close-up of dial.

(3) The dial of Barometer ML–316/TM covers a pressure range of 1065 to 610 millibars.

(4) The pointer, made of three sections of fine aluminum tubing, flattened vertically at the indicating end, is clamped to the pointer shaft with a small setscrew. The barometer mechanism is mounted to the under side of the flat plate on which the dial graduations are marked. This plate has rubber mounts at each of the four corners to minimize vibration. Screws and washers, screwed into small corner blocks, hold the dial and the window in place.

c. Aneroid mechanism. The mechanism of the two barometers is identical, except for the magnification of the lever and gear system, and is described in paragraph 18.

7. CARRYING CASES (fig. 1). **a. Barometers ML–102–B and ML–102–F.** These barometers are provided with identical carrying cases made of heavy cowhide, lined with velveteen, and fastened with four snap fasteners. A strap with shoulder pad is provided for use when carrying the barometer. The barometer reading may be taken without removing the instrument from the leather case.

b. Barometer ML–102–E. This barometer utilizes a strongly constructed carrying case, covered outside with canvas and lined with velveteen. The outside corners are leather-reinforced. The lid has metal fasteners and a handle for carrying. The carrying case is provided with a strap and shoulder pad. It is necessary to remove the instrument from the case to take a reading.

c. Barometers ML–102–D and ML–316/TM. These barometers are transported in lightweight, padded cases, made of waterproof canvas, and are provided with a webbing strap for carrying. One case closes with a slide fastener, protected by a flap; another model is fastened with snap fasteners.

d. The carrying cases for Barometers ML–102–E, ML–102–D and ML–316/TM are padded with shock-insulating material which provides additional protection against damage to the barometer if the case is dropped. Cases for Barometers ML–102–B and ML–102–F are unpadded.

SECTION II

INSTALLATION AND OPERATION

8. INSTALLATION OF BAROMETER. a. Location. The usual installation of Barometer ML–102–(*) or ML–316/TM is indoors. If the instrument is used outdoors, do not place it in the sun.

b. Temperature. For accurate readings:

(1) Install the barometer where the temperature will be as constant as possible. An inside wall is preferable.

(2) Do not allow the sun to shine on the instrument.

(3) Do not place the instrument near a source of heat such as a radiator or stove.

(4) Do not place it where it will be in a draft from an outside door or window.

c. Position. (1) *Barometers ML–102–B, ML–102–E, and ML–102– F.* These models are calibrated for vertical mounting and for most accurate results must be used in that position. Hang the instrument by the hanger provided and be sure it is in a vertical position.

(2) *Barometers ML–102–D and ML–316/TM.* These barometers are calibrated for use in a horizontal position, and more accurate readings will be obtained if the instrument is used in this position. If desired, the cover may be removed by pressing in on the spring stop at the left side of the right-hand hinge (with a screw driver blade), and sliding the cover to the right.

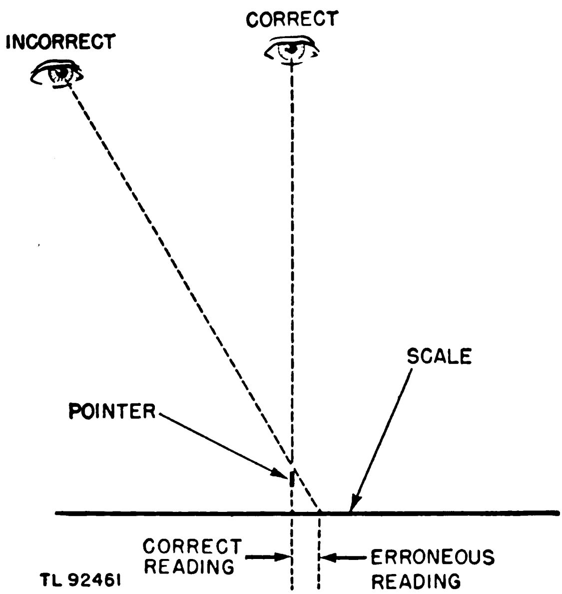

Figure 4. Illustration of parallax.

9. ALIGNING POINTER. a. Tap the instrument lightly to see that the pointer is free and in equilibrium. Have the dial lighted so that the image of the pointer is clearly visible in the mirror ring between the scales.

b. For a correct reading of the aneroid, when it is vertical, the eye must be on a level with the pointer. Never stand on tiptoe or look down at the dial of a barometer that is hanging on the wall. When the instrument is read with the dial in a horizontal position, have the eye directly above the pointer. To read the instrument correctly, have the eye in a direct line so that the image of the pointer in the mirror ring is obscured by the pointer itself (fig. 4). This is important in reading the aneroid since the pointer is approximately 3/32 inch above the dial and unless it is aligned so that it completely covers the image, parallax occurs and an erroneous reading results. In reading an aneroid barometer, parallax is the apparent displacement of the pointer with reference to the dial graduations when the pointer is viewed from the side rather than from directly above. This effect can readily be seen by moving the head to either side of the correct position and noticing the difference in the apparent indication of the pointer.

10. READING BAROMETERS ML–102–B, ML–102–E, AND ML–102–F.

Note. 1. If the barometer is transported by air, or there is a *rapid* change of pressure of 100 millibars or more, wait at least 24 hours before taking a reading in order to reduce hysteresis errors (par. 15a).

2. If the temperature of the instrument is changed suddenly by an amount exceeding 10° F., wait 1½ hours before taking a reading.

3. These barometers may be read in inches or millibars.

4. Tap the instrument lightly with the fingers before reading, to reduce residual friction in the linkage system.

a. Inch scale. (1) The outside scale is the inch scale. The inch scale may be used over a pressure range corresponding to 31.5 to 22 inches of mercury. The pointer makes more than one revolution of the dial in covering this range. A pressure of 25 inches and less is not marked on the dial. After the pointer has made one complete revolution, pressure values are obtained by subtracting six inches from the indicated value. Thus, on the second revolution 31 inches represents 25 inches of pressure, 30 inches represents 24 inches, 29 inches represents 23 inches, and 28 inches represents 22 inches of pressure. The observer must know the approximate elevation of the station in order to know which inch reading to use.

(2) The inch scale is graduated in 0.02 inch intervals. Integral inches and tenth inches are numbered. With practice, it is possible to make an estimated reading of the barometer to the nearest thousandth of an inch. Even with care, however, this estimated reading probably will be in error by as much as 0.003 inch.

(3) In figure 2 the inch reading is 29.9, plus 0.06 (since the pointer is beyond three graduations, each of which represents 0.02); the pointer is also past the center of the next division which increases the reading by an additional 0.01. Since it is slightly past the center, the reading is increased by an additional 0.002 or 0.003. Thus the approximated reading is 29.972 or 29.973 inches.

(4) Assuming that the pointer has made one revolution and is registering on the inner scale, the reading is 23.972 or 23.973 inches.

b. Millibar scale. (1) The center and inner scales measure the pressure in whole millibars. While the range of the millibar scale is from 1085 to 745 millibars, these barometers are calibrated only to 1066.7 millibars (or 31.5 inches). This does not mean that higher pressure readings will be inaccurate, but only that the accuracy has not been checked above 1066.7 millibars.

(2) In covering the range of the millibar scale, the pointer makes almost two revolutions of the dial. Unlike the inch scale, the same scale is not used on the second revolution of the pointer. Pressures between 1085 and 895 millibars are read on the center scale, while pressures between 895 and 745 millibars are read on the inside scale.

(3) The millibar scales are graduated in whole millibars and estimated readings may be made to a tenth of a millibar.

(4) In figure 2 the reading on the outer scale is 1015.0 millibars. The reading on the inner scale is 811.8 millibars.

c. Station pressure. (1) The pressure, as read on the dial of Barometer ML–102–B or ML–102–F is the *station pressure.*

(2) The pressure, as read on the dial of Barometer ML-102-E must be corrected for temperature (see par. 11 below) before the station pressure is obtained.

11. CORRECTING READING OF BAROMETER ML–102–E FOR TEMPERATURE.

Note. Barometer ML–102–E must have a temperature correction applied to each reading. Barometers ML–102–B and ML–102–F are equally affected by temperature but temperature correction charts were not required, hence pressure data obtained from these two barometers generally will not be as accurate as that obtained from Barometers ML–102–E, ML–102–D and ML–316/TM.

a. Chart. The effect of temperature upon the indicated reading of Barometer ML–102–E has been determined by actual test for each instrument and the corrections are shown in the form of curves on the temperature calibration chart fastened to the back of each instrument (fig. 5). These curves also include a small residual error for each instrument (par. 15c (2)).

b. Method. (1) Three temperature curves are given on the graph: one for a temperature of 80° F., another for 40° F., and a third for 0° F. These curves are plotted on a grid on which the pressure is shown on the horizontal scale and the corrections on the vertical scale.

(2) To compute the temperature correction, determine the temperature to which the barometer has been exposed and locate the temperature curve nearest to that temperature.

(3) Find the indicated pressure on the horizontal scale. Move vertically until the pressure value meets the correction curve. From the point on the correction curve move horizontally to the left until the correction scale is encountered. If the pressure reading does not meet the temperature correction curve on a horizontal line, it will be necessary to estimate between the two tabulated correction values. Determine the correction at that point, noting whether it is plus or minus.

(4) Add or subtract this sum to the observed pressure reading.

Caution: If the temperature is changed very suddenly, wait at least 1½ hours before making a reading.

c. Interpolated correction. (1) When the temperature falls between the values for which correction curves are given, the corrections must be determined for both curves and the true correction by interpolation.

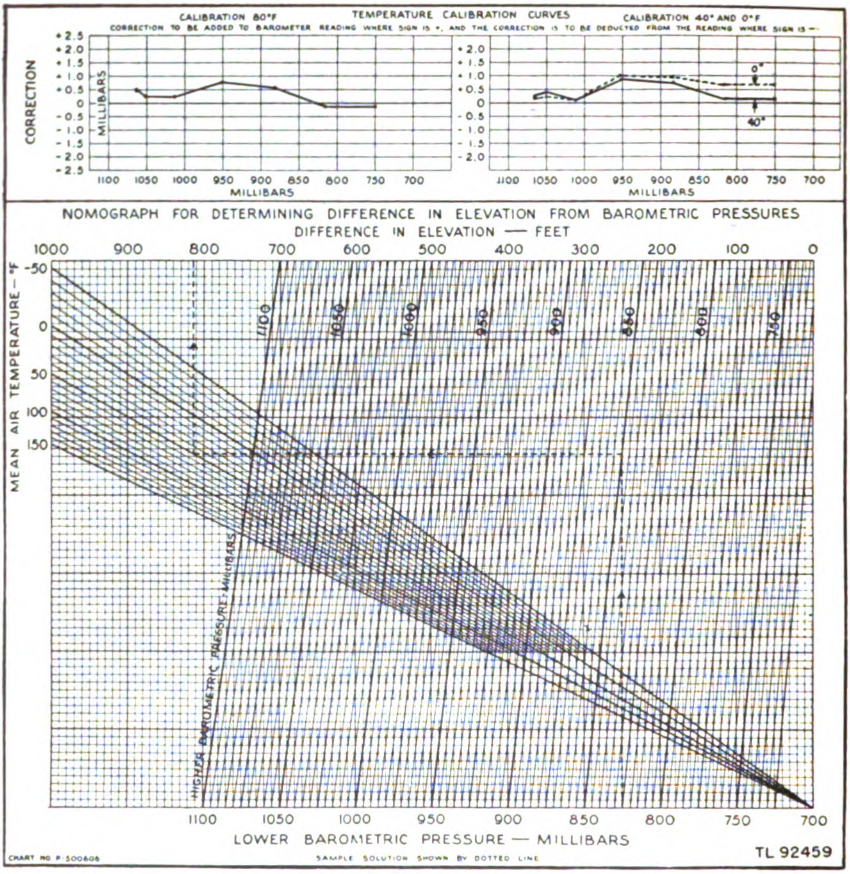

Figure 5. Barometer ML–102–E, temperature correction curves and nomograph.

(2) Example: Assume that the indicated pressure is 810 millibars and the temperature 20° F. The temperature correction at 40° F. is 0.2 mb. The temperature correction at 0° F. is 0.7 mb. Interpolating between these two values, the true correction would be 0.45 mb. Since the barometer is read to the nearest tenth of a millibar, the correction to be used is 0.4 mb, making the corrected pressure 810.4 mb.

d. Correction in inches. Temperature corrections are given only in millibars. Corrections apply to both scales, however. In order to obtain the corresponding corrections in inches, multiply the millibar correction by 0.02954.

12. USE OF BAROMETER ML–102–E IN DETERMINING APPROXIMATE DIFFERENCES IN ELEVATION. a. Method. Barometer ML–102–E may be used either alone or with another precision barometer to determine the difference in elevation between two points by comparing the difference in pressure. Since humidity is a factor to be considered, the use of a thermometer or a psychrometer is required. This method also requires the use of a nomograph which is attached to the back of the barometer case, or Smithsonian Meteorological Tables 51 and 52, Fifth Revised Edition. The procedure given in b and c below illustrates the use of two barometers. The procedure given in paragraph 13d illustrates the method when one barometer is employed. Either method may be used with satisfactory results.

b. Procedure. (1) Leave one barometer at a given location. Read the barometer and the thermometer at regular intervals and record the time, pressure, and temperature.

(2) Take the second barometer to the other location. Read it and record the time of the readings, pressure and temperature.

(3) Determine the average temperature between the two locations.

(4) If readings were not taken at both stations at the same time, interpolate to find the pressure value at each station at the same time as follows:

	9:00 AM	9:05 AM	9:15 AM
Fixed Barometer	849 mb	(850 mb)	852 mb
Mobile Barometer		825 mb	

(The interpolated pressure value, 850 millibars (mb), is shown in parenthesis. Assume that the mean air temperature between the two locations is 50° F.)

(5) With simultaneous pressure readings of 825 and 850 millibars at two different points and a mean temperature of 50° F., it is possible to obtain the difference in elevation by the use of the nomograph.

c. Use of nomograph (fig. 5). The nomograph of Barometer ML–102–E is marked on graph paper. Pressure values, in millibars, are represented by slanting vertical lines. Mean air temperature is represented by diagonal lines running from the lower right-hand corner to the top left side of the graph. To read the sample solution marked by dotted lines on the graph, proceed as follows:

(1) Locate the lower pressure value (825 mb) on the bottom scale.

(2) Move vertically upward until you intersect the slanting vertical line which corresponds to the higher pressure (850 mb).

Note. The use of a straightedge will help in using the nomograph.

(3) At the point of intersection, move horizontally until you intersect the diagonal line which corresponds to the mean air temperature (50° F.).

(4) At the point of intersection, move vertically upward to the top scale, and on this read the approximate difference in elevation between the two points. This is about 813 feet.

(5) Thus there is a difference of 813 feet between the two elevations. This corresponds to a difference of 25 millibars in pressure at 50° F., mean air temperature, *under these particular pressure conditions.*

13. READING BAROMETERS ML–102–D AND ML–316/TM.

Note. 1. If the barometer is transported by air, or if there is a rapid change of pressure of 100 millibars or more, wait at least 24 hours before taking a reading in order to reduce hysteresis errors (par. 15a).

2. If the temperature of the instrument is changed suddenly by an amount exceeding 10° F., wait 1½ hours before taking a reading.

a. General. (1) The dial of these barometers is graduated in half-millibar intervals and is calibrated for approximately two revolutions of the pointer.

(2) Barometer ML–102–D covers a range from 1065 to 745 millibars on two scales. Since each dial is individually calibrated to its respective pressure sensitive cell, the crossover point from the outer to the inner scale is between 880 and 920 millibars.

(3) Barometer ML–316/TM covers a range from 1065 to 610 millibars on two scales. The crossover point from outer to the inner scale occurs between 825 and 855 millibars.

(4) In reading the scales, estimate the reading to the nearest tenth millibar.

(5) In figure 3 the reading of the barometer is 1004.8 millibars on the outer scale. Assuming that the pointer has made one revolution of the dial, the reading is 839.4 millibars.

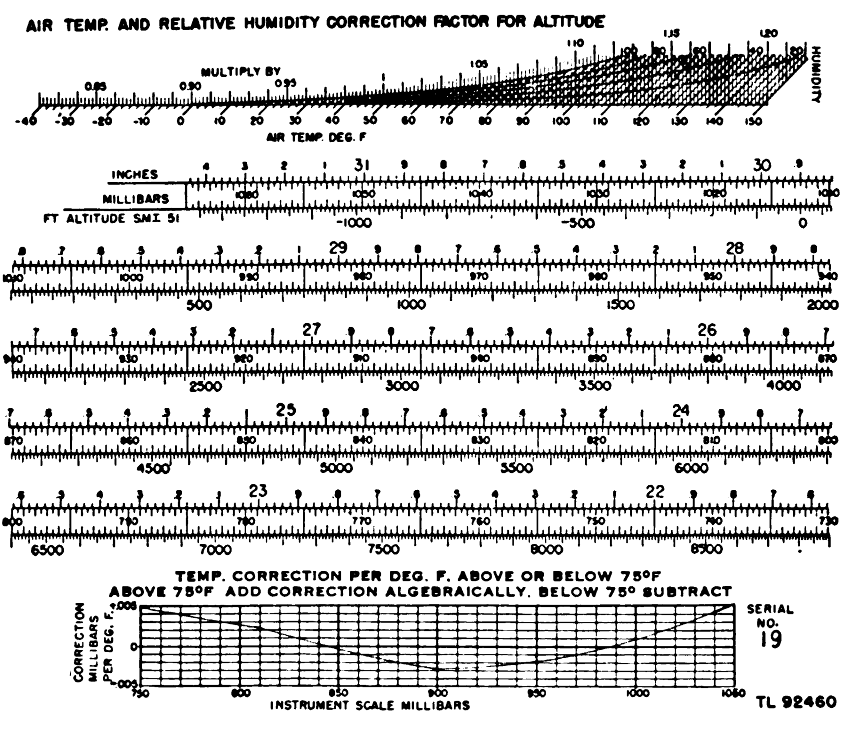

Figure 6. Barometer ML–102–D (or ML–316/TM), temperature correction curve and conversion chart.

b. Temperature correction. (1) Barometers ML–102–D and ML–316/TM are designed so that the temperature correction at 75° F. is zero. At temperatures above and below this value the indications of the barometer are slightly affected by temperature. However, this correction need not be applied unless it exceeds one-tenth (0.1) millibar, since the scale of these barometers cannot be read with greater accuracy than that. Ordinarily, for temperatures within 20° of 75° F., the correction will not exceed one-tenth millibar.

(2) A temperature correction curve showing the difference in calibration due to temperature is determined for each instrument individually and is plotted on a graph inside the lid of the case. Figure 6 is an example of such a correction curve.

(3) To correct the observed reading for temperature:

(*a*) Locate the indicated pressure on the horizontal scale of this graph. Note the point on the red correction curve which is vertically above or below this pressure value.

(*b*) Read the value of the correction to be applied per degree Fahrenheit (above or below 75° F.,) from the point on the vertical scale of the graph, corresponding to the point on the red curve.

(*c*) Determine the difference between the existing temperature and 75° F.

(*d*) Multiply the correction (found in b above) by this difference.

(*e*) Add or subtract this value from the observed reading as directed on the calibration chart.

(4) *Example:* Assume that the indicated pressure is 904.3 mb and the temperature is 10° F.

(*a*) Using the reproduction of the chart in figure 6, find the indicated pressure on the horizontal scale. Move up vertically until the pressure line intersects the temperature curve.

(*b*) The correction for this pressure is −0.003 mb per degree F. (The correction is estimated to the nearest 0.001 mb.)

(*c*) A temperature of 10° F. is 65° below 75° F. Therefore, the correction, −0.003, is multiplied by 65, giving a correction of −0.195 mb.

(*d*) Since the reading is taken only to the nearest tenth millibar, the correction becomes −0.2 mb. Therefore, the corrected pressure is

$$\begin{array}{r} 904.3 \text{ mb} \\ -.2 \text{ mb} \\ \hline 904.1 \text{ mb} \end{array}$$

(5) This pressure, as read on the dial of the barometer, when corrected for temperature, is the *station pressure*.

c. Conversion to inches. (1) To convert a reading in millibars to inches of mercury, use the conversion chart inside the lid of the case.

(2) Locate the pressure reading (which has been corrected for temperature) on the conversion chart and simply read off the corresponding value in inches of mercury.

(3) *Example:* For a corrected pressure reading of 904.1 mb, the corresponding pressure in inches of mercury is 26.700 in.

d. Determining approximate differences in elevation. Barometers ML–102–D and ML–316/TM may be used for determining approximate differences in elevation in a manner similar to that used with Barometer ML–102–E. In the following method only one barometer is used. The use of a psychrometer is also necessary, since humidity is a factor to be considered.

(1) Take the pressure reading at the station of lower elevation.

Record the reading, also the time, the temperature, and the humidity.

(2) Take the barometer to the higher elevation. Record the pressure, the time, the temperature and the humidity.

(3) Return the barometer to the original position and take the pressure reading, the time, the temperature and the humidity.

(4) Interpolate between the two sets of readings made at the lower elevation to find the pressure, temperature and humidity values at the lower elevation which corresponds *in time* to the pressure, temperature and humidity values at the higher elevation.

(5) The following is an example of such interpolation:

(*a*) Assume that the pressure reading is taken at the station of lower elevation at 10:30. The pressure is 1015.0 mb; temperature is 100° F.; relative humidity, 62 per cent.

(*b*) Take the barometer to the station of higher elevation. At 11:15 the pressure, corrected for temperature, is 891.3 mb; temperature is 97° F.; relative humidity, 57 per cent.

(*c*) Return the barometer to the original station at 11:45. Pressure, corrected for temperature is 1015.3 mb; temperature is 101° F.; relative humidity, 60 per cent.

(*d*) Tabulating the pressure values:

	10:30	11:15	11:45
Lower station	1015.0 mb	(1015.18 mb)	1015.3 mb
Higher station		981.3 mb	

By interpolation, the pressure at the lower station at 11:15 is 1015.18 mb. Since the reading is taken only to the nearest tenth millibar, this is 1015.2 mb.

(*e*) The influence of temperature and humidity on the values of the correction is sufficiently small that these values need not be known closer than the nearest 2° F. and 10 per cent relative humidity. Thus the average temperature of the two stations is 98° F. and the relative humidity 60 per cent.

(*f*) Using the conversion table, the altitude corresponding to 1015.2 mb is −70 feet. The altitude corresponding to 981.3 mb is 855 feet. Subtracting the values, the approximate difference in elevation is 855 − (−70) = 925 feet.

(6) It is now necessary to correct the approximate difference in elevation for temperature and humidity. (As noted in (*e*) above, the average temperature is 98° F., the relative humidity 60 per cent.)

(*a*) Locate 98° F. on the horizontal scale along the bottom of the curves for Air Temp. and Relative Humidity Correction Factor for Altitude (fig. 6). Follow the 98° F. line diagonally upward until it intersects the 60 per cent relative humidity curve. The correction factors are given in the horizontal scale at the top of the curves.

(*b*) Follow the intersection of the 98° F. diagonal and the 60 per cent relative humidity curve vertically upward to this correction factor scale and read the correction indicated by that scale. This correction is 1.109.

(*c*) Multiplying the approximate difference in elevation by this correction factor ($925 \times 1.109 = 1{,}026$), the true difference in elevation is found to be 1,026 feet (fractions of a foot are not considered).

SECTION III

FUNCTIONING OF PARTS

14. PRINCIPLES OF ANEROID BAROMETER. a. General. (1) The aneroid is a form of "elastic" barometer, that is, one in which the elastic deformation of some solid system is used as an indicator of atmospheric pressure.

(2) The aneroid type of barometer can be made extremely sensitive and is convenient to use because of its portability. A further advantage is that its readings are not affected by variation in the force of gravity.

(3) The aneroid barometer is subject to errors due to irregularities in the elasticity of the metal (par. 15) and for this reason it should not be relied upon as an instrument for routine meteorological observations unless compared frequently (at least every 90 days) with a mercury barometer.

b. The Vidie barometer. The type of aneroid most generally used is one invented in 1843 by Lucien Vidie, which uses a wafer-like cell, (sometimes called diaphragm or capsule) of thin, flexible metal, usually brass or German silver, which is very nearly exhausted of air. The opposite sides of the cell are kept apart by a strong internal metal spring; some models use a stiff external spring for this purpose. Usually the elastic properties of the spring determine those of the whole instrument. The residual air in the cell can be adjusted to give a partial correction for temperature. The movement of the cell, caused by variations in pressure, is greatly magnified, and is indicated on a dial by a train of gears and levers.

c. Principle of operation. (1) The barometers treated in this manual differ from the Vidie type in that the material of the cell itself serves as a spring, making the use of an internal or external spring unnecessary. The aneroid element of these barometers consists of one or more cells of beryllium copper which have been almost completely exhausted of air, only enough being left inside to help compensate for changes in the spring properties of the cell as a result of changes in temperature. Corrugations in the cell increase the flexibility of the metal so that there is a greater movement with changes in pressure. Changes in the atmospheric pressure cause the cells to expand and contract. This movement is magnified and transmitted by a lever system connected to a pointer which indicates the pressure values on a dial graduated in inches of mercury or the equivalent pressure value in millibars.

(2) A detailed description of the different models of the barometer covered by this manual, with the functioning of the aneroid mechanisms, is given in paragraphs 16, 17, and 18.

15. ERRORS OF ANEROID BAROMETER. Factors which introduce errors into the readings of the aneroid barometer are *hysteresis, temperature, scale errors,* and *drift.*

a. Hysteresis. (1) One of the chief causes of error in an aneroid barometer is hysteresis. All elastic materials tend to change shape when placed under stress. As soon as the stress is removed, they return *almost* to their original shape. The retardation or failure of the material to assume *completely* its original form is known as hysteresis. All aneroid barometers are subject to the effects of hysteresis although an attempt is made to keep these effects to a minimum by the proper selection and treatment of materials. Over a long period of time hysteresis effects gradually tend to disappear.

(2) Hysteresis occurs in the pressure sensitive cell of the aneroid barometer and for that reason appreciable errors may be noticeable immediately after a large and rapid pressure change. These errors can be greatly reduced by waiting a sufficient length of time before taking a reading. It is difficult to make a specific recommendation as to the interval of time necessary to reduce hysteresis errors to a minimum since hysteresis varies with the amount of change in pressure, with the rate of change, and with the time involved – that is, the length of time at which the barometer has been subjected to a pressure differing from current atmospheric values.

(3) For pressure changes occurring at any fixed station, hysteresis errors are small enough to be neglected. When the barometer is subjected to a comparatively large pressure change for a short time only, and then restored to its previous values, hysteresis effects are small and quickly disappear. Hysteresis errors are probably most pronounced when a barometer is transported by airplane, especially if the flight is of several hours duration and the plane flies at high altitude. Therefore, to be reasonably sure of reducing hysteresis errors to a minimum under such circumstances, it is advisable to wait at least 24 hours before taking a reading.

b. Temperature. A second and exceedingly important error which affects the aneroid is temperature changes. Without compensation for changes in temperature the errors of an aneroid would be quite large. Several methods of temperature compensation are used in the barometers covered by this manual.

(1) *Aneroid cell.* If a barometer is maintained at a constant pressure, a change in temperature, if not compensated, will cause a movement of the pointer on the dial. This indicated change in pressure is due to a physical change in the dimensions of the instrument and also to variations in the stiffness of the pressure sensitive cell. This latter condition may be compensated, for the most part, by leaving a small amount of air in the cell. Thus when a change in temperature occurs, the change in pressure of the air inside the cell partially balances the change in strength of the metal. This does not entirely compensate for changes in temperature. Therefore, temperature correction curves are provided for some models of Barometer ML–102–(*) and ML–316/TM. These corrections, however, are small, indicating that the greater part of the error has been compensated.

(2) *Bimetal temperature compensation shaft.* Barometers ML–102–B, ML–102–E, and ML–102–F use an additional temperature compensation in the form of a bimetal pivot shaft made of a strip of invar and a strip of brass welded together lengthwise. Since invar and brass have different coefficients of expansion, changes in temperature cause the bimetal shaft to bow slightly, thus changing the indication of the pointer.

(3) *Temperature correction chart.* Barometers ML–102–D, ML–102–E, and ML–316/TM have a temperature correction plotted for each instrument individually. Specific instructions for the application of temperature corrections to Barometer ML–102–E are given in paragraph 11. Specific instructions for the use of the temperature curve for Barometer ML–102–D or ML–316/TM are given in paragraph 13b.

c. Scale errors. (1) The dials of Barometers ML–102–B, ML–102–E, and ML–102–F have linear graduations; that is, the spacing between each of the 0.02 inch graduation lines is the same. The aneroid cells used in these barometers do not expand and contract linearly with changes in pressure, but by selection of cells and individual adjustment of the lever system the movement of the *indicating pointer* may be made approximately linear with changes in pressure. There is always some residual scale error, however, which varies slightly at different parts of the scale. Small differences in the characteristics of individual aneroid cells cause variations in the value of this scale error among different barometers. It is necessary, therefore, to calibrate barometers individually to eliminate scale error.

(2) Barometer ML–102–E has been calibrated for scale error and the corrections are included in the temperature correction curves fastened to the back of each barometer (fig. 5). Thus no separate correction can be applied for scale error; it is automatically included when temperature corrections are made.

(3) Barometers ML–102–B and ML–102–F do not have either temperature or scale error correction curves, hence pressure measurements made with either of these instruments probably are less accurate than those made with Barometer ML–102–E, ML–102–D, or ML–316/TM. The error in indication introduced by neglecting scale and temperature corrections will vary among instruments and at different pressures. On the average, this error probably does not exceed 0.7 millibar.

(4) The dials of Barometers ML–102–D and ML–316/TM are individually calibrated for each instrument. This reduces scale error to an amount which need not be considered in making pressure measurements.

d. Drift. (1) Another error to which the barometer is subject is drift (often called *creep*), which is due to changes in the aneroid cell occurring slowly over a long period of time. Drift is caused by molecular changes in the metals of which the cell is made, and by alterations in the shape of the cell, due to the tendency of all materials to assume a new permanent shape when placed under steady stress. In meteorological textbooks, drift is sometimes referred to as "secular change," for it is an error taking place over a long period of time.

(2) Drift is manifest by a gradual increase in the difference between the indications of the aneroid barometer and a mercurial barometer with which it may be compared. Errors of drift can be largely eliminated by setting the barometer to indicate the pressure shown by an accurate mercury barometer.

(3) Some barometers drift because of very minute leaks in the evacuated cell. Usually a leaking cell is detected before the instrument leaves the manufacturer's plant, but occasionally a leak can develop in a barometer that has been in use some time. The indications of a leak are progressively lower readings than are normal for

the station. There is no way to remedy the defect. Return the barometer to the depot and requisition a new one.

(4) For the first few months after the aneroid is built, the drift effects are more pronounced, but after this time they usually become negligible. In general, the longer the barometer is in use, the more consistent the performance is likely to be.

(5) Occasionally a barometer will show a persistent drift. To detect this condition, keep a record of the amount of *resetting* necessary to eliminate drift. If, over a period of time, this *total* exceeds 12 millibars, requisition a new barometer and return the defective instrument to the depot.

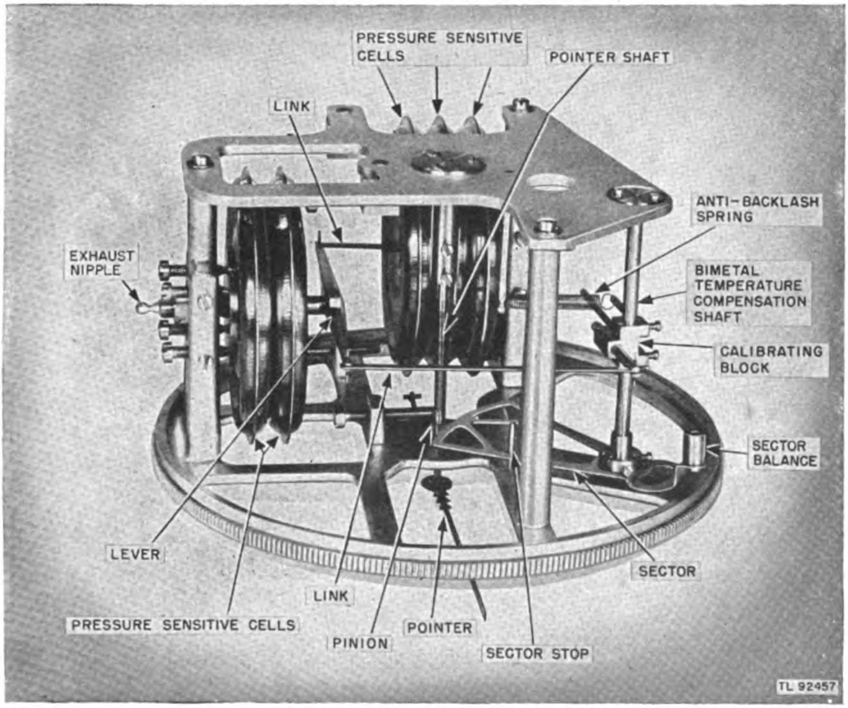

Figure 7. Barometer ML–102–B, aneroid mechanism.

16. BAROMETER ML–102–B (fig. 7). **a.** The mechanism of Barometer ML–102–B is built within a brass frame. While differing considerably in internal appearance, this barometer functions practically the same as Barometers ML–102–E and ML–102–F, except for an additional step in magnification.

b. In Barometer ML–102–B the atmospheric pressure acts upon *two* sets of cells. The movement of one group (of two cells) is transmitted to the *center* of the main lever. The movement of the other group (of three cells) is transmitted to one *end* of the main lever. Thus the initial magnification is performed by a simple lever in which one end and the center are moved oppositely by the two sets of cells. This causes a greatly magnified movement of the free end of the lever. The combined motion resulting from the movement of both sets of cells is transmitted to the bimetal shaft from the free end of the main lever by means of an adjustable link. From this point, the functioning of the parts is identical to that of Barometers ML–102–E and ML–102–F.

c. This model utilizes a coil spring concentric with the pointer shaft to take up backlash in the gear teeth instead of the flat hairspring used in the other models.

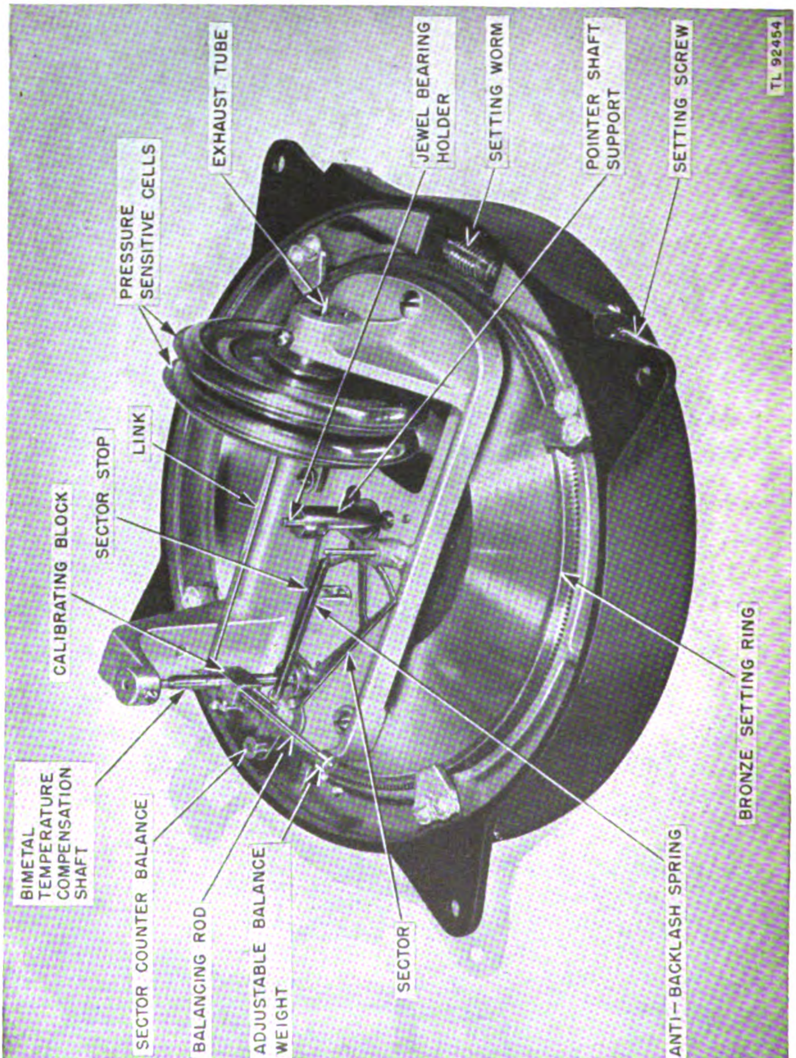

Figure 8. Barometer ML–102–E (or ML–102–F), aneroid mechanism.

17. BAROMETERS ML–102–E and ML–102–F (fig. 8). **a. Mechanism.** (1) The mechanism of Barometers ML–102–E and ML–102–F is mounted below the dial and is built upon a brass casting which is screwed to a bronze gear plate. The gear plate is fastened inside the top of the barometer case by brackets and screws.

(2) The aneroid element consists of two pressure sensitive cells approximately 2¼ inches in diameter. The cells have been almost completely evacuated (about 95 per cent) through a tube which is pinched off and soldered at the end.

(3) Changes in the atmospheric pressure cause the cells to expand and contract, and this motion is transmitted by a connecting link to an adjustable lever mounted on a bimetal temperature compensation shaft. The link is connected at one end to the aneroid cells and at the other to the adjustable lever by small pivots and is held in place by antifriction washers and locking springs. The adjustable lever converts the motion of the link into a rotation of the bimetal temperature compensation shaft. A small calibrating block near the center of the bimetal shaft serves as the mounting for the adjustable lever. A counterbalance rod with a counterbalance weight at the end also is attached to the calibrating block. The purpose of this balance weight is to balance the linkage system so that the pointer will not change in indication when the position of the barometer is changed. A fine coil spring, 1¼ inches long, is attached at one end to a rod on the calibrating block and anchored at the other to the casting. Its purpose is to prevent backlash by keeping the linkage system under tension.

Note. Both Barometers ML–102–E and ML–103–F are calibrated for a vertical position and should be used in that position for accurate readings.

(4) The bimetal temperature compensation shaft is made of a strip of brass and a strip of invar welded together lengthwise. It is set in jeweled bearings at the top and bottom. Since the coefficient of expansion of invar is much less than that of brass, changes in temperature cause the shaft to bow slightly. The bowing of the shaft displaces the adjustable lever which is mounted near the center of the shaft, and thereby changes the indication of the pointer slightly. This change in indication offsets the change resulting from slight movement of the pressure sensitive cells caused by variations in temperature.

(5) A brass sector is fastened to the bimetal shaft by a hub containing two setscrews. This sector transmits the motion of the bimetal shaft to the pointer shaft. Fine gear teeth cut into the arc of the sector mesh with a small pinion on the pointer shaft. At the opposite end of the sector is a counterweight to balance the sector on the shaft. A **U**-shaped stop is mounted on the casting to limit the movement of the sector.

(6) The pointer shaft is set in jeweled bearings. The pointer, which fits over the end of the pointer shaft, is made of aluminum, painted dull black, and has a counterweight on the non-indicating end. The indicating end, which projects over the scales on the dial, is approximately 0.011 inch wide.

(7) A hairspring is attached to the pointer shaft on the forward side of the casting, immediately below the dial. Its purpose is to take up any backlash between the sector and the pinion of the pointer shaft.

(8) A horseshoe-shaped brass stop is fastened to the brass casting to prevent expansion of the pressure element to a point below the lower pressure limit of the instrument. This could happen only when the instrument is transported by air.

(9) Teeth, cut around the periphery of the gear plate, mesh with a worm which rotates the mechanism and the pointer so that the aneroid

may be set to read current atmospheric pressure. The shaft of the worm extends outside the barometer case and may be adjusted by means of a screwdriver.

b. Magnification. (1) A movement of 0.009 inch (linear measurement) of the aneroid cells causes the pointer to move over a pressure interval of 1 inch. When it is remembered that an ordinary human hair is 0.003 inch in thickness, the sensitivity of the instrument and the extent of the magnification of the cell movement may be realized.

(2) In the first stage, the ratio of magnification is the radius of the sector as compared with the distance from the end of the adjustable lever to the bimetallic shaft.

(3) In the second stage, the ratio of magnification is the radius of the sector as compared with the radius of the pinion gear.

(4) The third stage of magnification is the ratio of the radius of the pointer from the pointer pivot shaft to the scale being used on the dial to the radius of the pinion gear. Thus the outer scale, the inch scale, givse slightly greater magnification than the inner millibar scales.

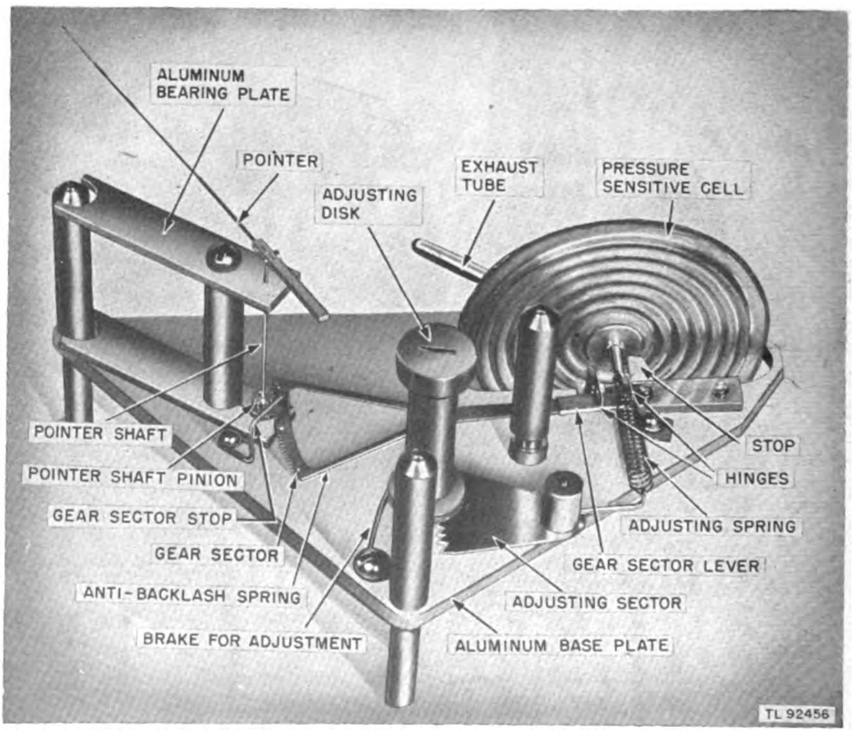

Figure 9. Barometer ML–102–D (or ML–316/TM), aneroid mechanism.

18. BAROMETERS ML–102–D and ML–316/TM (fig. 9). **a. Mechanism.** (1) The mechanism of Barometers ML–102–D and ML–316/TM is built upon a triangular-shaped aluminum base plate. The difference in range of the two instruments is achieved by changing the spring rate of the pressure sensitive cell. The aneroid element is a single corrugated cell of beryllium copper about 2 inches in diameter and

$\frac{1}{8}$ inch in thickness. The lead exhaust tube through which the cell is evacuated is pinched off and sealed at the end.

(2) The movement of the cell, caused by the varying pressure of the atmosphere, is transmitted to the gear sector lever by thin strips of beryllium copper which act as hinges. A fixed hinge serves as the fulcrum of the gear sector lever. The teeth of the gear sector engage a small pinion on the pointer shaft. A wire safety stop prevents the teeth on the gear sector from becoming disengaged from the pinion gear during severe vibrations or rough handling. A small auxiliary coil spring is attached to the gear sector lever. The tension of the spring can be varied by an adjusting disk which has a gear at its lower end which meshes with a brass adjusting sector (fig. 9). The adjusting disk is reached through a plugged opening in the plastic window. The range of adjustment is approximately 10 millibars. Backlash in the gears is removed by means of a small wire spring attached to the lower side of the gear sector. The tension of this spring is transmitted to the pointer shaft by a nylon thread looped once around a small lucite drum at the base of the pointer shaft. A stop is provided to prevent expansion of the cell below its lower limit during air transportation.

(3) The pinion is fastened to the pointer shaft which revolves in a jeweled bearing at the bottom and extends through a hole in the top bearing plate. The pointer, fastened to the end of the shaft, is made of three sections of fine aluminum tubing and is clamped to the shaft by a small setscrew.

b. Magnification. Magnification of the cell movement is accomplished in three stages:

(1) The first stage is a simple lever magnification, being the ratio of the distance between the fixed hinge (which acts as the fulcrum of the lever) and the teeth of the gear sector to the distance between the two hinges.

(2) The second stage is the ratio of the diameter of the gear sector to the diameter of the pinion.

(3) The third stage is the ratio of the distance between the pointer shaft and the scale being read to the radius of the pinion.

SECTION IV

MAINTENANCE

Note. Failure or unsatisfactory performance of equipment will be reported on WD, AGO Form 468. If this form is not available, see TM 38-250.

19. CARE OF BAROMETER. a. General. (1) Protect the aneroid against violent and sudden jolts.

(2) Use care in handling and transporting.

(3) Do not move the instrument unnecessarily.

b. Plastic window. (1) Clean the plastic window that protects the dial by wiping with a damp cloth and polishing with a soft clean cloth. Do not use soiled or gritty cloths. An occasional thin coat of wax well rubbed with a soft clean cloth will help remove any existing scratches and at the same time provide a protective film to prevent further scratching.

(2) If the plastic window becomes wavy when exposed to a combination of high temperature and high humidity, requisition a new one.

20. FIELD INSPECTION AND MAINTENANCE. a. Accuracy tolerances. Barometers ML–102–(*) are precision instruments whose readings are generally dependable to 0.7 millibar (0.02 inch of pressure) or better. Barometer ML–316T/M is usually dependable to one millibar (0.03 inch of pressure) or better. The readings made with these instruments ordinarily will be considerably more accurate than these tolerances, provided the barometers are compared periodically with a mercury barometer (see b below), checked for free, unimpeded action of the linkage system (see c below), and reset to agree with a mercury barometer (par. 21).

b. Comparison with mercury barometer. (1) To check the accuracy of the aneroid, compare it with a mercury barometer of known accuracy at least once every three months, or at any time the instrument is dropped, mishandled, or subjected to severe vibrations in transportation. The indications of the aneroid will be more reliable if this check is made at or near the average pressure of the station where the aneroid is used.

(2) Hang or set the aneroid barometer at the same level as the cistern of the mercury barometer.

(*a*) Barometer ML–102–B, ML–102–E, or ML–102–F, must be hung alongside the mercurial barometer with the dial in a vertical position.

(*b*) Barometer ML–102–D or ML–316/TM should always be placed with the dial in a horizontal position.

(3) Read the mercury barometer and apply temperature, gravity, and instrumental corrections to determine the true station pressure.

Note. In comparing an aneroid instrument supplied with a millibar scale only against a standard mercury barometer which is graduated in inches only, convert the readings of the aneroid into inches of mercury rather than convert the readings of the mercury barometer into millibars. (One millibar equals 0.02954 inches.)

(4) The difference between the true station pressure and the indication of the aneroid is the error of the aneroid barometer. If this error exceeds 3 millibars, it is probable that the mechanism has sustained

some permanent damage and a new barometer should be requisitioned.

c. Testing linkage. The linkage system of an aneroid barometer must be as friction-free as possible if the barometer is to respond to small changes in pressure. Anything which increases this friction decreases the sensitivity of the instrument very rapidly. In regions of prevailing high humidity the tests given in (1), (2), and (3) below, should be made at least twice a month. In other regions, monthly tests should be sufficient.

(1) *Tests for all models.* The simplest test for the proper functioning of the linkage system is to note the change in indication of the aneroid when its elevation is changed approximately 15 feet.

(*a*) Read the barometer very carefully at the lower elevation.

(*b*) Holding the barometer steadily in both hands and being careful not to jar or move it suddenly, walk upstairs, or otherwise change its elevation approximately 15 feet. The pointer should indicate the changed elevation by a decrease in pressure as the elevation is increased.

(*c*) Now return the barometer to the original elevation and again take the reading. The pointer should have returned to its original position.

(2) *Amount of change.* Generally, there will be a change of approximately one-tenth millibar for every 3 feet of change in elevation. Any barometer that does not respond to a change of 15 feet in elevation is probably defective and should be returned to the depot.

(3) *Barometers ML–102–D and ML–316/TM.* (*a*) These models are more sensitive than other types to slight changes of pressure. A change in elevation of as little as 3 feet should cause a slightly different indication of the pointer. This is sometimes hard to discern and the least vibration will destroy the value of this test.

(*b*) Another and easier test for these models consists of the following: Pick up the barometer case in both hands. With the thumbs in the center of the plastic window, suddenly press inward a slight amount. If the barometer is functioning properly, the pointer will quickly move a small amount to indicate a higher pressure, then as quickly return to its original position. Remove the thumbs suddenly. The pointer should move slightly in the opposite direction to indicate a decrease in pressure and then quickly return to its original position.

Warning: *Never open the case of Barometers ML–102–B, ML–102–E, or ML–102–F. Any adjustment that can be made in the field can be made without opening the case. Barometer ML–102–D and ML–316/TM may be opened to place the mechanism in a new case or to make adjustments in an emergency, as outlined in paragraph 23. Except for these adjustments, the case must not be opened. These barometers are precision instruments. Tampering with the internal mechanism or attempting to adjust the linkage or magnification system will make it necessary to recalibrate the instrument. This CANNOT be done by Signal Corps repair facilities. Recalibration involves the use of specialized auxiliary precision equipment and highly skilled personnel available only at the manufacturer's plant. The adjustments and replacements which are allowed on these barometers are given in the following paragraphs. Using personnel are instructed to confine themselves to these operations.*

21. ADJUSTING BAROMETER. a. Comparative readings. (1) Before adjusting the aneroid barometer, make at least six comparative readings with an accurate mercury barometer. These readings should be made at intervals during a period of 1½ to 2 hours. If time permits, even more readings should be made since the greater the number of such comparative readings, the higher the degree of accuracy in the final results. Take the average of the readings of each barometer.

(2) Subtract the *average* of the aneroid readings from the *average* of the mercury readings. If the average reading of the aneroid exceeds that of the mercury barometer, the difference should have a negative sign.

(3) If the difference exceeds 0.3 millibar (0.01 inch) adjust the aneroid by the amount of the difference (see b below).

(*a*) If the difference has a positive value, the reading of the aneroid should be increased.

(*b*) If the difference is negative, the aneroid reading should be decreased.

Note. It is doubtful whether improved accuracy can be obtained by making an adjustment of less than 0.3 millibar since the random error of the instrument is probably as much as 0.3 millibar.

b. Adjusting Barometers ML–102–B, ML–102–E, and ML–102–F. (1) Insert a screw driver in the slot which turns the worm of the gear plate (fig. 10). Rotate the gear plate by means of this worm until the pressure indicated by the aneroid has been changed by the amount of the average difference as determined in a above.

(2) Turn the screw clockwise to decrease, and counterclockwise to increase the indicated pressure.

c. Adjusting Barometers ML–102–D and ML–316/TM. (1) Remove the plastic screw-plug from the plastic dial cover.

(2) Insert a small-bladed screw driver in the slot of the adjusting disk. A clockwise rotation of this disk causes a like movement of the pointer. This adjustment is limited to one-half revolution of the disk either side of the index line marked on the face of the dial (fig. 3) or

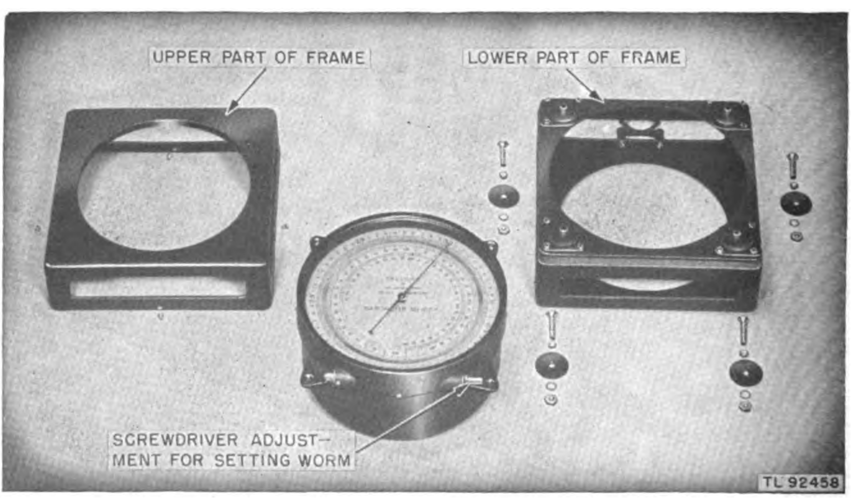

Figure 10. Barometer ML–102–F (ML–102–B or ML–102–E), disassembly of frame.

approximately 10 millibars. The barometers can readily be adjusted by the use of this disk.

22. REPAIRS TO BAROMETERS ML–102–B, ML–102–E, and ML–102–F. **a. Replacing hanger.** (1) It is necessary to remove the barometer case from the metal frame to attach a new hanger (fig. 10). First remove the four small screws in the sides of the frame and remove the upper part of the frame.

(2) Remove the nuts, star lockwasher, sleeves, and large round washers securing the barometer to the shockmounts at each of the four corners of the frame. Remove the case from the frame.

(3) With a short screw driver, remove the two screws that hold the hanger posts to the frame.

(4) Insert one new post and tighten the screw.

(5) Insert the hanger in the two posts and tighten the screw of the other post.

Note. On Barometer ML–102–E the posts of the hanger are attached to the frame by means of nuts and washers instead of screws. In this case, use a pair of fine-nose pliers to remove the posts.

(6) Reassemble the frame (fig. 10 shows the order in which these parts are assembled).

b. Replacing plastic window. It is necessary to remove the upper half of the frame to replace the plastic cover which protects the dial.

(1) Follow directions in a (1) above to disassemble the frame.

(2) Start at one end and gently pry up the snap ring with a screw driver. Remove the ring and the plastic window.

(3) Make certain the new window is washed, polished, and free from fingerprints. Insert the new window and replace the snap ring.

(4) Reassemble the frame (fig. 10).

c. Replacing pointer. The pointer of these barometers may be loosened on its shaft by severe vibration. When this occurs, proceed as follows:

(1) Follow the direction given in a and b above for removing the upper half of the barometer frame and the plastic window.

(2) Place the pointer on its shaft lightly and set it to read the station pressure. Place the thumb nails on the pointer on opposite sides of the pointer shaft, but as close to the shaft as possible. Press directly downward on the pointer until it is firmly set on the shaft. *Be very careful not to bend the shaft.*

(3) Reassemble the dial cover and frame.

23. REPAIRS TO BAROMETERS ML–102–D and ML–316/TM. **a. Replacing plastic window.** (1) Open the cover, press the spring stop by the right-hand hinge, and remove the cover.

(2) Remove the four screws and washers that hold the plastic panel in place.

(3) Gently pry up the plastic dial cover with a pen knife or a screw driver and lift out the panel.

(4) Insert the new window, being sure it is polished and free from fingerprints. The plastic screw in the cover must be directly above the adjusting disk (fig. 3).

(5) Replace and tighten the screws and washers.

b. Replacing pointer.

Caution: *This is a very delicate operation. It must be attempted in the field only when absolutely necessary and only by competent personnel.*

(1) Remove the cover and plastic window as described in a (1) to (3) above.

(2) Using a very small screw driver or the blade of a pen knife, loosen the pointer clamping screw and remove the pointer, being careful not to bend the pointer shaft.

(3) Carefully place a new pointer on the pointer shaft and rotate it around the shaft until it reads the pressure (at least within a half millibar) as determined by a mercury barometer. Gently press the pointer down flush with the end of the pointer shaft.

(4) Tighten the pointer setscrew, again being careful not to bend the pointer shaft.

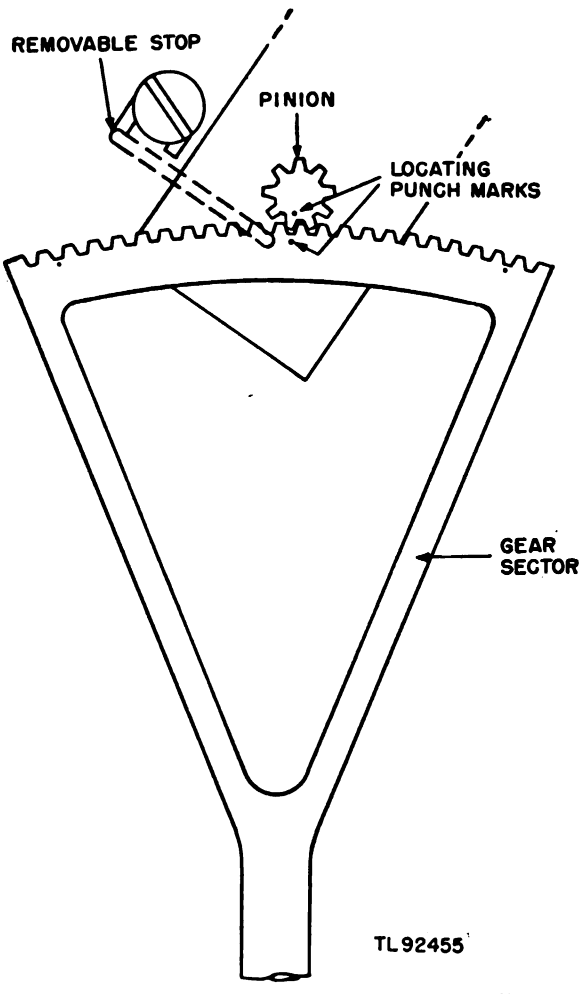

Figure 11. Barometer ML-102-D (or ML-316/TM), adjustment of gear sector and pinion.

(5) Use the adjusting disk on the dial to set the aneroid to the *exact* station pressure. This disk should not be used for large adjustments.

(6) The tip of the pointer should clear the dial by at least 1/16 inch. If it does not, *very carefully* spring the pointer upward until this clearance is obtained.

(7) Replace the plastic window, screws, washers, and cover.

c. Placing mechanism in new case.

Note. The mechanisms and dials of Barometers ML–102–D and ML–316/TM are not interchangeable, since each aneroid mechanism is hand-calibrated with its particular dial, but the complete mechanism, with dial, may be placed in a new case. Before placing in a new case, however, check the instrument against an accurate mercury barometer and apply the linkage test (par. 20c (3)), to make sure the interior mechanism is functioning properly. A barometer that is in error by 3 millibars, or more, should be replaced. Ordinarily anything that would damage the case sufficiently to require it to be replaced would also damage the mechanism. If the case is replaced in the field, it must be done only by qualified personnel.

(1) Remove the cover and plastic window according to instructions above.

(2) By means of the rubber mounts in the two rear corners, carefully lift the dial and mechanism assembly from the case. Be extremely careful not to damage the corrugated cell and the pointer during this operation.

(3) Holding the dial and mechanism assembly by the rear rubber mounts, fit the two front rubber mounts into the front corners of the new case. (Avoid striking the cell against the metal stop in the front righthand corner.) Now ease the dial to a level position, being sure the rubber mounts are resting against the stops in the four corners.

(4) Replace the plastic window, screws, washers, and cover.

d. Adjusting rack and pinion (fig. 11).

Caution: Occasionally, following a severe shock, the barometer may show an error of 10 millibars. This may indicate that the rack and pinion have jumped a tooth. In this event, send the barometer to the Signal Corps depot where it will be adjusted by qualified personnel. *Do not attempt this adjustment in the field!*

(1) The distance between teeth is equal to 10 millibars on the scale. Look closely and note that there are three prick punch marks on the rack between the teeth. There is also one prick punch mark on one of the teeth of the pinion (fig. 11).

(2) The distance between two punch marks on the rack is equal to one complete revolution of the pinion. When the teeth are properly meshed, the punch mark on the pinion should be directly opposite one of the punch marks on the rack as shown in figure 11.

(3) If the punch mark on the pinion is out of mesh with the punch mark on the rack, swing the vertical stop (fig. 11) away from the rack 90° to the right or left, with the aid of a small pair of pliers. Gently raise the rack above the pinion and rotate the pinion until the punch marks line up. Allow the rack to return to its normal position and replace the stop in its original position.

24. LUBRICATION. The mechanism of Barometer ML–102–(*) does not require oil. Oil would only interfere with the proper functioning of the instrument and thereby introduce serious errors in reading. DO NOT USE OIL ON THE MECHANISM!

SECTION V

SUPPLEMENTARY DATA

25. MAINTENANCE PARTS LIST FOR BAROMETERS ML-102-B, ML-102-E AND ML-102-F.

Ref. figure	Signal Corps stock No.	Name of part and description	Quan. per unit	Depot stock	Station stock	Region stock
1	7A470	CASE, barometer carrying: empty; Friez #V-500634; (part of Barometer ML-102-E).	1	*		*
10	7A312E/C1	CASE, barometer housing: empty; Friez #AS-500537; (part of Barometer ML-102-E).	1	*		*
10	6L20806-8.10	SCREW, machine: brass; RH; 6-32 thd; NF; Friez #A-500528; (part of Barometer ML-102-E).	1	*		*
10	7A316/H1	HANGER: brass; pentagon-shaped; 2 shoulders 5/8" long; Friez #A-500439; (part of Barometer ML-102-E).	1	*		*
1	7A471	CASE, barometer carrying: empty; Friez #S-40125; (part of Barometer ML-102-B, ML-102-F).	1	*		*
10	7A312B/C1	CASE, barometer housing: empty; Friez #P-38038; (part of Barometer ML-102-B, ML-102-F).	1	*		*
10	6L6632-6.7B	SCREW, machine: brass; FH; Friez 500235-P2; 6-32 thd; NF; (part of Barometer ML-102-B, ML-102-F).	1	*		*
10	7A316/P1	POST: hanger; brass; Friez #38041; (part of Barometer ML-102-B, ML-102-F).	1	*		*
10	7A312B/W1	WINDOW: clear lucite or equal; Friez #X-38044; (part of Barometer ML-102-B, ML-102-E, ML-102-F).	1	*		*
10	7A316/H1	HANGER: brass; pentagon-shaped; 2 shoulders 5/16" long; Friez #39492; (part of Barometer ML-102-B, ML-102-F).	1	*		*

*Indicates stock available.

26. MAINTENANCE PARTS LIST FOR BAROMETERS ML-102-D and ML-316/TM.

Ref. figure	Signal Corps stock No.	Name of part and description	Quan. per unit	Depot stock	Station stock	Region stock
1	7A312D/C2	CASE: carrying, barometer; empty; Wallace and Tiernan No. FU-1935.	1	*		*
1	7A312D/C1	CASE: housing, barometer; empty; Wallace and Tiernan No. FU-1943.	1	*		*
3	7A312D/W1	WINDOW: clear lucite; Wallace and Tiernan No. FP-4053.	1	*		*
3	7A312D/P1	POINTER: Wallace and Tiernan No. FU-1877.	1	*		*

* Indicates stock available.

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TM 11-429

WAR DEPARTMENT TECHNICAL MANUAL

WIND EQUIPMENT SCM-20-A

AND

WIND EQUIPMENT AN/GMQ-1

WAR DEPARTMENT • 10 MARCH 1943

TECHNICAL MANUAL

WIND EQUIPMENT SCM-20-A

AND

WIND EQUIPMENT AN/GMQ-1

CHANGES No. 1

WAR DEPARTMENT,
WASHINGTON 25, D. C., 25 September 1944.

TM 11-429, 10 March 1943, is changed as follows:

The date of this manual is changed to read: 10 March **1944,** wherever it occurs.

5. WIND PANELS ML-204-A AND ML-204-B (figs. 3 and 4).

* * * * * * *

b. The wind-speed meter * * * ma d-c movement. It has two external resistors that are controlled by the toggle switch mounted below it, to give the necessary calibration for the two ranges (par. 1*c*) of the instrument. Normally the switch is in the 150-mph range position.

6. CARRYING CASES ML-207A and ML-207-B.

a. Carrying Case ML-207-A contains the disassembled wind transmitter (par. 2*a*), the wind panel, and the set of running spares (par. 2*c*), of **Wind Equipment SCM-20-A.**

b. Carrying Case ML-207-B contains the disassembled wind transmitter (par. 3*a*), the wind panel, and the set of running spares (par. 3*c*), of Wind Equipment AN/GMQ-1.

* * * * * * *

8. SUPPORT ML-206-A. Support ML-206-A * * * provided with steps. It has additional accessories (par. 3*e*) for mounting on the ground as well as mounting on either roof or platform.

11. UNPACKING.

* * * * * * *

c. Carry the other * * * support when unpacking. Check the parts with those listed in paragraph 2*e* for SCM-20-A, or paragraph 3*e* for AN/GMQ-1.

15. ASSEMBLING WIND TRANSMITTER.

* * * * * * *

b. Assemble the transmitter as follows:

* * * * * * *

(8) Check the running spares (par. 2c) left in the case. Close the carrying * * * parts are needed.

* * * * * * *

20 FINAL WIRING ADJUSTMENT.

* * * * * * *

d. Finally, close the panel and lock the wing clamps (par. 14*d*(3)).

27. ANEMOMETER HEAD.

* * * * * * *

b. If a wind * * * replace the assembly.

* * * * * * *

(2) Remove the faulty * * * the new assembly.

(*a*) On Support ML-205-A, simply climb the mast, loosen the thumbscrew, and lift off the old head and rotor. Put the new * * * paragraph 15*b*(3).

* * * * * * *

36. (SUPERSEDED) MAINTENANCE PARTS LIST.

NOTE: Order maintenance parts by stock number, name, and description. Only maintenance parts can be requisitioned.

Ref. figure	Signal Corps stock No.	Name of part and description	Quan. per unit	Mfrs. part and code No.	Station stock	Region stock
		WIND TRANSMITTER ML-203-A and ML-203-B.				
Fig. 5	7A2023A/R1	RESISTOR ASSEMBLY: consists of wirewound resistor and collector ring on 4-prong base plug; special.	1	WT-334 B	(*)	(*)
Fig. 5	7A2023A/C2	CONTACT ASSEMBLY: consists of 4 contacts mounted on a phenolic plate; special.	1	WT-312 B	(*)	(*)
Fig. 2	7A2023A/V1	VANE TAIL ASSEMBLY: consists of vane tail with locknut for mounting tail to vane shell; special.	1	WT-204 B		(*)
Fig. 13	3H305-14	BEARING: radial; ¾'' bore; 1⅝'' OD, 5/16'' wide; special; (provides bearing surface for rotation of wind vane shell).	2	S8-R D		(*)
Fig. 2	7A2023A/A1	ANEMOMETER HEAD: consists of bearing assembly complete in phenolic mounting, generator unit, and associated gear train; special; Signal Corps dwg. 74-58.	1		(*)	(*)
Fig. 12	7A2023A/B1	BEARING ASSEMBLY: less shaft; complete in phenolic housing which contains small radial bearing, rotor shaft, retaining nut with coupling No. 12-28 thread; special; Signal Corps dwg. 74-58.	1			(*)
Fig. 2	7A2023A/R2	ROTOR: cup; consists of 3 plastic cups mounted on a spider; special; Signal Corps dwg. 74-58.	1		(*)	(*)

*Indicates stock available.

Ref. figure	Signal Corps stock No.	Name of part and description	Quan. per unit	Mfrs. part and code No.	Station stock	Region stock
Fig. 12	7A2023A/S1	SHAFT ASSEMBLY: 2.381″ long; threaded at both ends; one end threaded ¼″, 12–24 threaded, National Fine; other end threaded 9/16″, 10–32, National Fine; bushing ⅞″ diam at end of 9/16″ threaded portion; 2 pins on bushing 0.120″ high to fit into cup rotor spider; special; Signal Corps dwg. 74–58.	1			(*)
	7A2023A/N1	NUT: cap; phenolic; No. 10–32 tap. N. F. (holds cup rotor to anemometer head).	1	Dayton Insulating Molding Co. No. 116¾.	(*)	(*)
	7A2023A/W1	WASHER: flat; rubber and steel, zinc-plated; 0.281″ ID, 1.1879″ OD, 0.0641″ thick (seals locking pin holes).	1	70344 A	(*)	(*)
	7A2023A/S5	SPRING: retainer; steel, nickel-plated (provides tension between washer and nut).	1	70276 A	(*)	(*)
		WIND PANEL ML–204–A and ML–204–B				
	3Z9692-3	SWITCH: toggle, SPST	2	20992 K or Bud Radio SW–1003.		(*)
Fig. 4	3F891–41	AMMETER: 0- to 1-milliampere; calibrated in double-range mph scale, 0–25 mph, 0–150 mph; supplied with 2-fixed noninductive calibrating resistors of 44,300 ohms and 9,700 ohms, respectively; special.	1	301 F		(*)
Fig. 4	7A2009–204A/W1	INDICATOR: wind direction; d-c self-synchronous repeater; special scale showing direction of wind through 360° of rotation; special.	1	807 H		(*)

Ref. figure	Signal Corps stock No.	Name of part and description	Quan. per unit	Mfrs. part and code No.	Station stock	Region stock
		SUPPORT ML-205-A and ML-206-A				
Fig. 10	7A1743-206A/S1	STAKES: ground; steel; bonderized; channel; special; parts of Support ML-206-A only.	4	M		(*)
Fig. 10	7A1743-206A/C1	CAP: driving; malleable iron; certified; weight for No. 3 or No. 3½ post; weighs 2¼ lbs; part of Support ML-206-A only.	1	O	(*)	(*)
Fig. 7	5B3553	CLAMP: cable guy; drop-forge finish; cadmium-plated; for $\frac{3}{16}$" diam. wire rope.	4	3 N	(*)	(*)

*Indicates stock available.

[A. G. 300.7 (10 Aug 44).]

By order of the Secretary of War:

G. C. MARSHALL,
Chief of Staff.

Official:

J. A. ULIO,
Major General,
The Adjutant General.

Distribution:

As prescribed in paragraph 9a, FM 21-6: Armies (2); Corps (2); Sv C (1); Dept (1); Def C (1); D (2); IBn 1 (5); IC 3 (2).

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For explanation of symbols, see FM 21-6.

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WAR DEPARTMENT TECHNICAL MANUAL

TM 11-429

WIND EQUIPMENT
SCM-20-A

AND

WIND EQUIPMENT
AN/GMQ-1

WAR DEPARTMENT • 10 MARCH 1943

WAR DEPARTMENT,
WASHINGTON 25, D. C., 15 MAY, 1943

TM 11-429, War Department Technical Manual, Wind Equipment SCM-20-A and Wind Equipment AN/GMQ-1 is published for the information and guidance of all concerned.

[A.G. 062.11 (27 Feb 43).]

BY ORDER OF THE SECRETARY OF WAR:

G. C. MARSHALL,
Chief of Staff.

OFFICIAL:

J. A. ULIO,
Major General,
The Adjutant General.

DISTRIBUTION:
X

(For explanation of symbols see FM 21-6.)

TABLE OF CONTENTS

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DESTRUCTION NOTICE

WHY —To prevent the enemy from using or salvaging this equipment for his benefit.

WHEN—When ordered by your commander.

HOW —1. Smash—Use sledges, axes, handaxes, pickaxes, hammers, crowbars, heavy tools, etc.

2. Cut —Use axes, handaxes, machete, etc.

3. Burn —Use gasoline, kerosene, oil, flame throwers, incendiary grenades, etc.

4. Explosives—Use fire arms, grenades, TNT, etc.

5. Disposal —Bury in slit trenches, fox holes, other holes. Throw in streams. Scatter.

Use Anything Immediately Available For Destruction of This Equipment.

WHAT—1. Smash—Wind panel, anemometer heads, cup rotors, spare resistor, and contact assemblies.

2. Cut —Guy cables, wires, etc.

3. Burn —Wooden cases and other combustible material.

4. Bend —Mast sections, vane tail, and counterbalance.

5. Bury or scatter—Any or all of the above pieces left after burning.

DESTROY EVERYTHING

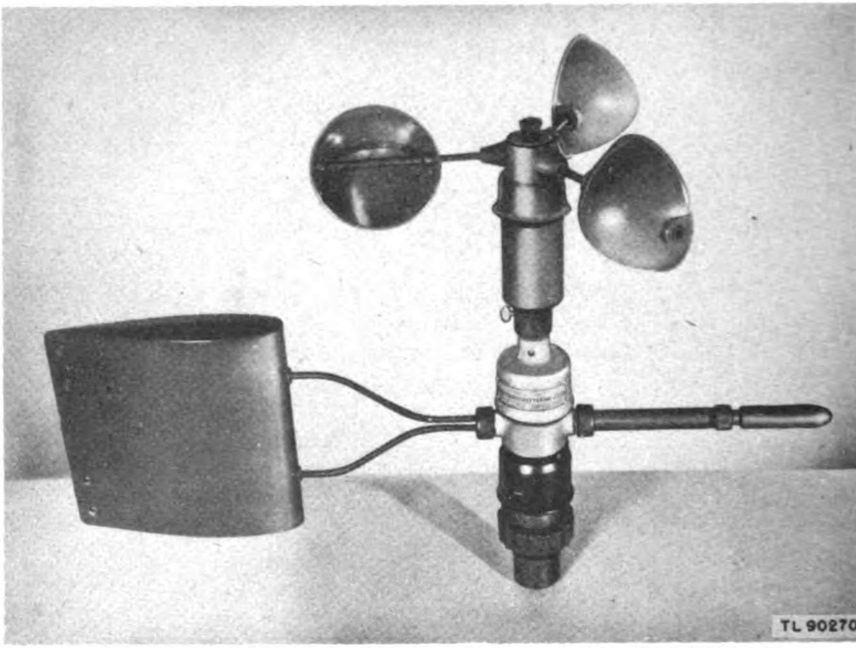

Figure 1. Wind Transmitter ML-203-A or ML-203-B, assembled.

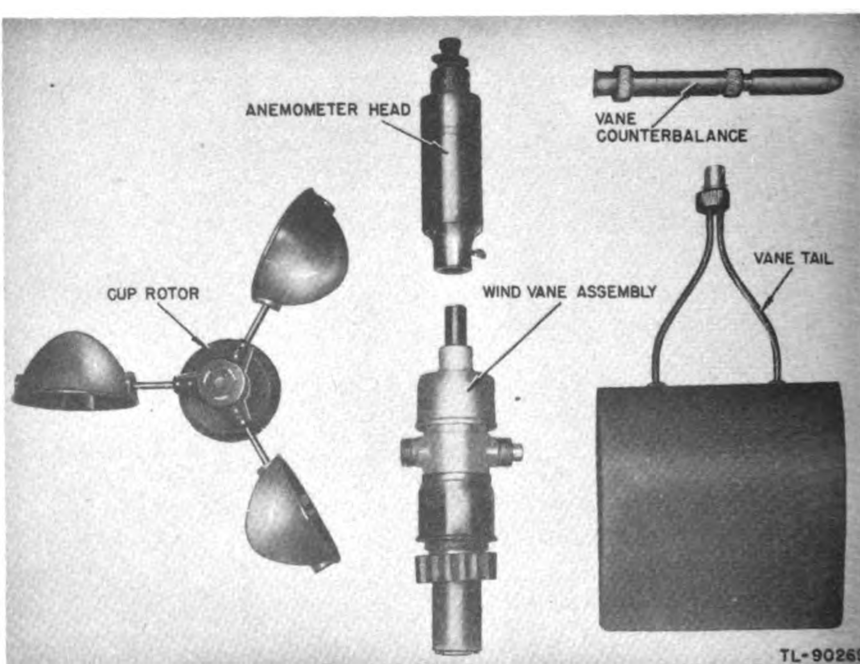

Figure 2. Wind Transmitter ML-203-A or ML-203-B, disassembled.

SECTION I

DESCRIPTION

1. GENERAL.

a. Wind Equipment SCM-20-A and Wind Equipment AN/GMQ-1 are sets of equipment for measuring and remotely indicating the speed and direction of surface winds. Wind Equipment SCM-20-A is intended primarily for permanent attachment to airdrome control towers. Wind Equipment AN/GMQ-1 is intended primarily for semi-permanent installations at weather stations.

b. Wind Equipment SCM-20-A and Wind Equipment AN/GMQ-1 differ only in the type of support used. The wind transmitter and wind panel units used by each equipment are identical in construction and appearance, and the parts of each are completely interchangeable.

c. The wind speed indicator of both sets of equipment is a meter calibrated in two scales: one from the starting speed of approximately 2 miles per hour (mph) to 30 mph; the other from the starting speed to 150 mph.

d. The wind direction indicator of both sets of equipment is a meter calibrated in degrees for every 10° position of the compass, and the cardinal and inter-cardinal letters are included on the dial.

e. The wind speed transmitter of both sets of equipment has an over-all speed accuracy of $\pm 1\frac{1}{2}$ mph from the starting speed to 30 mph, ± 3 mph from 30 mph to 75 mph, and the accuracy from 75 mph to 150 mph is 4 percent of the scale reading.

2. COMPONENTS OF WIND EQUIPMENT SCM-20-A.

a. Wind Transmitter ML-203-A (fig. 1), which consists of (fig. 2):

1 cup rotor
1 anemometer head
1 wind vane assembly
1 vane tail
1 vane counterbalance

b. Wind Panel ML-204-A (figs. 3 and 4).

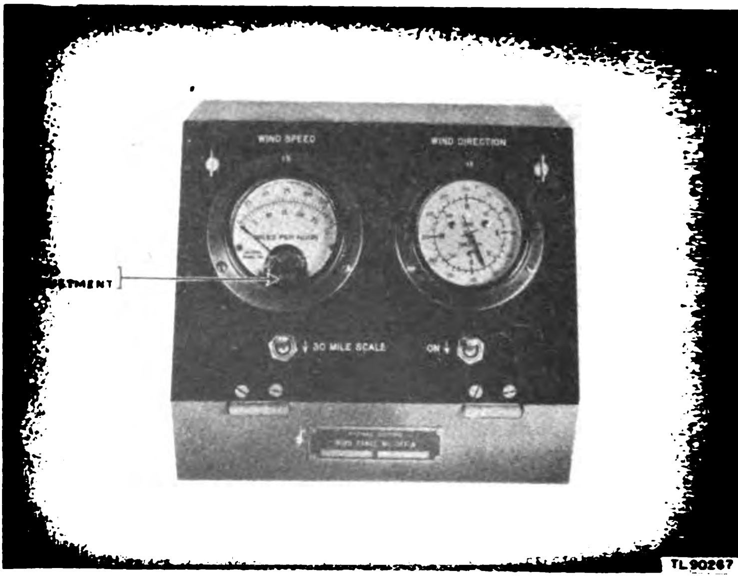

Figure 3. Wind Panel ML-204-A or ML-204-B.

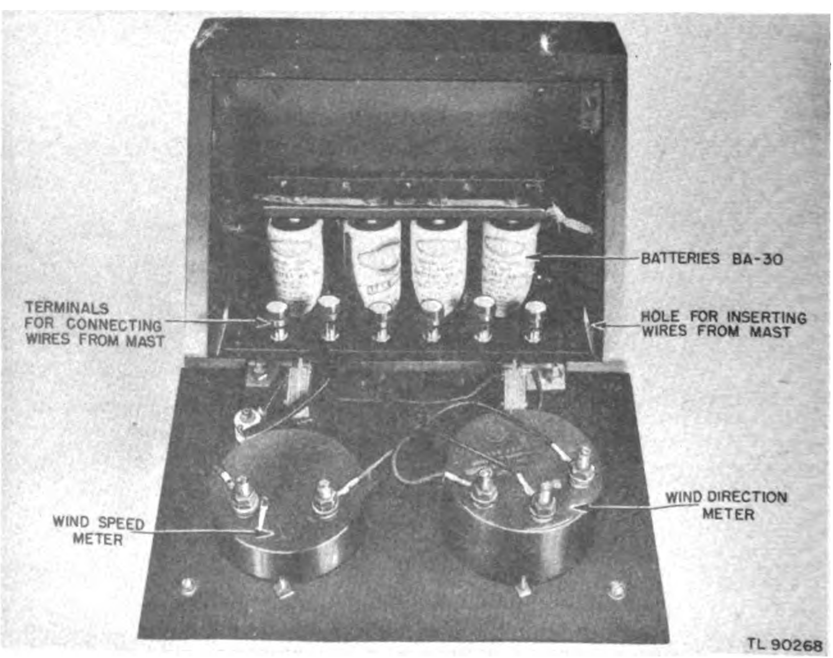

Figure 4. Wind Panel ML-204-A or ML-204-B, opened.

c. A set of running spares, which consists of:

1 cup rotor
1 anemometer head
2 wind vane resistor assemblies
1 wind vane contact assembly

d. Carrying Case ML-207-A for transporting Wind Transmitter ML-203-A, Wind Panel ML-204-A, and the set of running spares.

e. Support ML-205-A, which consists of:

1 top mast section
1 bottom mast section
1 mast base
4 roof brackets
4 guy wire assemblies
4 wire clamps
4 eyebolts with handnuts and swivel rods
10 lag screws

f. Wire W-110-B (600 feet).

3. COMPONENTS OF WIND EQUIPMENT AN/GMQ-1.

a. Wind Transmitter ML-203-B (fig. 1), which consists of (fig. 2):

1 cup rotor
1 anemometer head
1 wind vane assembly
1 vane tail
1 vane counterbalance

b. Wind Panel ML-204-B (figs. 3 and 4).

c. A set of running spares, which consists of:

1 cup rotor
1 anemometer head
2 wind vane resistor assemblies
1 wind vane contact assembly

d. Carrying Case ML-207-B for transporting Wind Transmitter ML-203-B, Wind Panel ML-204-B, and the set of running spares.

e. Support ML-206-A, which consists of:

1 top mast section
1 middle mast section
1 bottom mast section
1 mast base
4 roof brackets
4 ground stakes

4 guy wire assemblies
4 wire clamps
4 eyebolts with handnuts and swivel rods
10 lag screws
2 stakes GP-2

f. Wire W-110-B (600 feet).

g. Carrying Case ML-208-A for transporting Support ML-206-A and Wire W-110-B.

4. WIND TRANSMITTERS ML-203-A and ML-203-B (figs. 1 and 2).

a. Wind Transmitter ML-203-A is the measuring and transmitting unit for Wind Equipment SCM-20-A. Wind Transmitter ML-203-B is the similar unit for Wind Equipment AN/GMQ-1. They are identical in every respect. Each consists of an anemometer (an instrument that rotates with the wind to measure its speed) and a wind vane (an instrument that positions itself in the direction from which the wind is blowing). The anemometer and the wind vane are mounted in separate housings that are assembled together on the same central shaft, with the wind vane assembly below the anemometer.

b. The anemometer consists of a 3-cup rotor and an anemometer head. The cup rotor is mounted and held on the anemometer head by a cap nut. The anemometer head is essentially an a-c generator driven through suitable gearing by the cup rotor. The lower end of the anemometer head fits on, and has generator terminals that plug into, the top end of the central shaft of the transmitter.

c. The wind vane assembly consists of a vane tail and a counterbalance attached to a rheostat unit (fig. 5) mounted on the central shaft of the transmitter, with the shaft and the base of the transmitter as part of the assembly. The rheostat unit is essentially a low-voltage d-c telemeter.

d. The central shaft of the transmitter is screwed into the transmitter base. The base is provided with a loctal socket to which the rheostat unit of the wind vane assembly and the generator of the anemometer head are connected.

5. WIND PANELS ML-204-A AND ML-204-B (figs. 3 and 4).

a. Wind Panel ML-204-A is the indicating unit of Wind Equipment SCM-20-A. Wind Panel ML-204-B is the similar unit for Wind Equip-

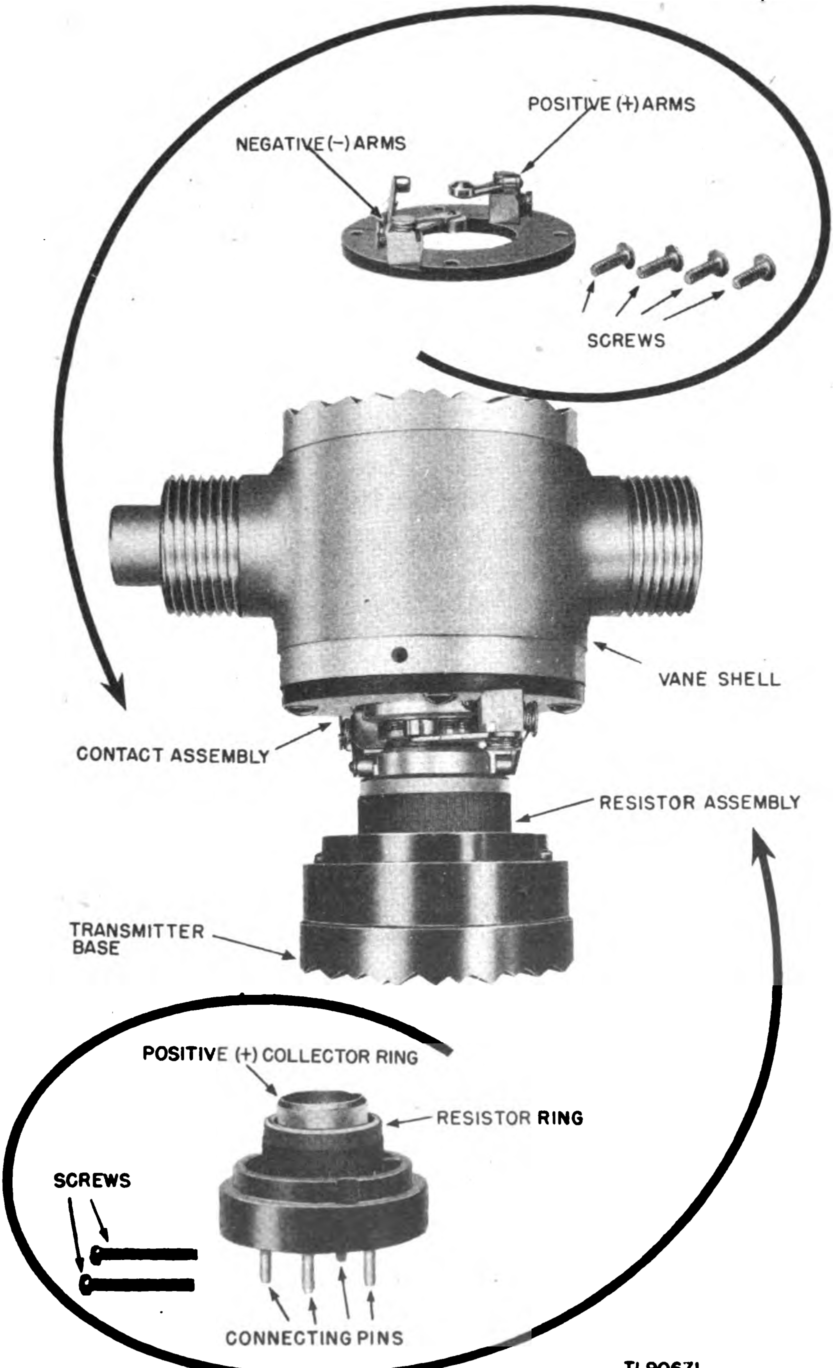

Figure 5. Wind vane rheostat assembly.

ment AN/GMQ-1. They are identical in every respect. Each consists of a small wooden box containing a rack for mounting dry batteries, and binding posts for connection of wires from the mast supporting the wind transmitter. The box has a hinged inclined panel on which is mounted a wind-speed meter, a wind-direction meter, and two single-pole toggle switches.

b. The wind-speed meter is a rectifier-type a-c milliammeter having a 1 ma d-c movement. It has two external resistors that are controlled by the toggle switch mounted below it, to give the necessary calibration for the two ranges (par. 1*b*) of the instrument. Normally the switch is in the 150-mph range position.

c. The wind-direction meter is a specially designed (par. 23) low-voltage d-c self-synchronous repeater. It is similar to the standard d-c aircraft self-synchronous repeater used for indications of aircraft control flap positions. (In an emergency, the standard 12- or 24-volt aircraft self-synchronous indicator can be substituted.)

d. The battery supply consists of four Batteries BA-30 connected in series-parallel to provide 3-volt output. The battery circuit is controlled by the panel toggle switch mounted below the wind direction meter. Normally the switch is in the off position.

6. CARRYING CASES ML-207-A and ML-207-B.

a. Carrying Case ML-207-A contains the disassembled wind transmitter (par. 2*a* (1)), the wind panel, and the set of running spares (par. 2*a* (3)).

b. Carrying Case ML-207-B contains the disassembled wind transmitter (par. 2*b* (1)), the wind panel, and the set of running spares (par. 2*b* (3)), of Wind Equipment AN/GMQ-1.

c. The cases are made of wood, and are identical in construction. Each has a hinged cover fastened by a catch, and is provided with handles for carrying. The inside is provided with felt-lined compartments for safe storage of the contents.

7. SUPPORT ML-205-A. Support ML-205-A is the mast support of Wind Equipment SCM-20-A. It consists of a hinged mast base, two 5-foot sections of pipe, and a set of accessories (par. 2*a* (5)) for mounting on a roof or wooden platform. The base and pipe sections are provided with means for assembling and clamping them together. The upper end of the top section is fitted with a plug wired to a connection box on the side of the pipe. The bottom section is provided with handles for orienting the equipment. Steps are provided on both sections to permit climbing the mast when it is raised. *Support ML-205-A is not intended for ground installation.*

8. SUPPORT ML-206-A. Support ML-206-A is the mast support of Wind Equipment AN/GMQ-1, and is provided with a special Carrying Case ML-208-A (par. 9). It consists of the same items that make up Support ML-205-A (par. 7), excepting that it has a third section of pipe for insertion between the bottom and top sections and none of the sections are provided with steps. It has additional accessories (par. 2*b* (5)) for mounting on the ground as well as mounting on either roof or platform.

9. CARRYING CASE ML-208-A. Carrying Case ML-208-A is a special case in which Support ML-206-A (par. 8) and Wire W-110-B of Wind Equipment AN/GMQ-1 are packed. It is a wooden case with a hinged cover fastened by catches, and has handles for carrying. The inside is arranged for the proper storage of the disassembled support and the wire. Note that Support ML-205-A of Wind Equipment SCM-20-A has no special carrying case.

SECTION II

INSTALLATION

10. LOCATION.

a. Select a location for the wind transmitter that is not shielded by buildings or trees and which is easily accessible for maintenance of the instrument.

b. Locate the wind panel inside a building or shelter of some sort where the initial wiring and subsequent routine observations can be made with ease. *Never expose the wind panel to outdoor conditions.*

11. UNPACKING.

a. Either set of wind equipment ordinarily is packed in two crates.

(1) One of the two crates of Wind Equipment SCM-20-A contains Carrying Case ML-207-A, and the other contains Support ML-205-A and 600 feet of Wire W-110-B.

(2) One of the two crates of Wind Equipment AN/GMQ-1 contains Carrying Case ML-207-B, and the other contains Carrying Case ML-208-A (par. 9).

b. Carry the crate containing either Carrying Case ML-207-A or ML-207-B to the shelter in which the wind panel will be installed. Do not unpack this crate until ready to wire the wind panel (par. 14*d*).

c. Carry the other crate to the site selected for the support, and unpack it. (If Wind Equipment SCM-20-A is being handled, the support and wire will be packed directly in this crate; if Wind Equipment AN/GMQ-1 is being handled, this crate will contain Carrying Case ML-208-A in which the support and wire are packed). Take care not to overlook or lose small parts of the support when unpacking. Check the parts with those listed in paragraph 2*c* for SCM-20-A, or paragraph 3*c* for AN/GMQ-1.

12. INSTALLING SUPPORT ML-205-A (fig. 6).

a. Place the mast base in the center of the platform or roof. Put the hinged socket in a horizontal position. If the roof or platform is smaller than 20 feet square, turn the base so the open end of the socket points toward a corner of the roof or platform. If the roof or platform is larger than 20 feet square, install the base in any position in the center of the area. Fasten the base with two of the lag screws provided with the support, using the two *small* holes in the base.

b. Fasten the roof brackets, which can be used either horizontally on the roof surface or vertically on the side of the building, as shown in the enlarged views in figure 6.

(1) If the roof or platform is smaller than 20 feet square, locate the brackets in the corners.

(2) If the space is larger, locate the brackets about 10 feet from the mast base and equally spaced around it, as shown at A, B, C and D in figure 6. Fasten the roof brackets with lag screws.

c. Insert an eyebolt through one of the holes in the curve of each bracket, and then slip on a swivel rod and screw on the handnut. Use the bracket hole nearest the end of the curve if the bracket is fastened on the roof; use the other hole if the bracket is fastened to the sidewall.

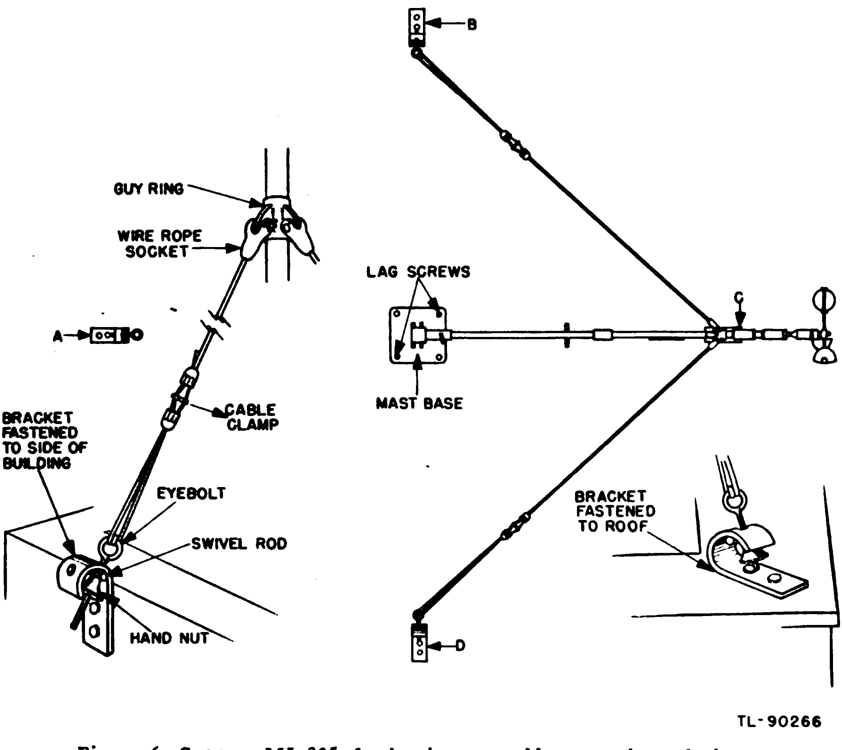

Figure 6. Support ML-205-A, showing assembly on roof or platform.

d. Assemble the mast horizontally as follows:

(1) Insert the unslotted end of the bottom mast section (the one with the opposite slot and small hole located about one foot from the top end) into the hinged socket of the mast base. Make sure the clamp on the socket is loose enough for the section to be inserted easily, otherwise the socket may be damaged. Tighten the clamp on the socket.

(2) Loosen the clamp of the top mast section, and place the collar end over the bottom section, making certain that the pin inside the collar fits the slot in the end of the bottom section. Push the section down as far as it will go. Tighten the clamp. *Do not remove the cap from the end of the top section until ready to install the wind transmitter* (par. 15*c*).

e. Straighten out the four guy cables, and fasten them to the guy ring near the top of the mast. (The ring should turn freely on the mast. If it does not, lightly tap one of its lugs. Do not hit too hard or the lug may bend or snap off).

(1) Remove the cotter pin from the wire rope socket at one end of a guy cable and remove the connecting pin.

(2) Place the yoke of the socket over one of the lugs of the guy ring on the mast.

(3) Replace the connecting pin in the socket and through the hole in the guy ring lug. Replace the cotter pin and bend its ends so it cannot slip out.

(4) Repeat the steps in subparagraphs (1), (2), and (3) above, to fasten a guy cable to each of the three remaining lugs of the guy ring.

f. Connect the loose ends of three of the guy cables to eyebolts.

(1) Slip a cable clamp on the cable attached to the guy ring lug toward bracket B, figure 6.

(*a*) Unscrew the two nuts of the cable clamp, which is split lengthwise and divides into two halves when the nuts are unscrewed.

(*b*) Slip the cable end first through the nut with the larger hole, and then through the nut with the smaller hole.

(2) Insert the end of the cable into the eyebolt, and take a double turn through the eye, as shown in the enlarged view that is part of figure 6.

(3) Put the cable end back through the cable clamp nut that has the smaller hole, and then through the nut that has the larger hole.

(4) Place the split clamp sections over the wires between the nuts. Screw on the nuts. Pull up the slack in the cable and hand-tighten the nuts so the clamp prevents the wires from slipping.

(5) Repeat the steps in subparagraphs (1), (2), (3), and (4) above, to fasten the cable attached to the lug toward bracket D (fig. 6) to the eyebolt in that bracket.

(6) Repeat the steps in subparagraphs (1), (2), (3), and (4) above, to fasten the cable attached to the bracket on which the mast is resting, to the eyebolt in that bracket. Leave enough slack so the length of cable between the guy ring and the eyebolt is approximately the same as the lengths fastened to brackets B and D.

NOTE: The remaining guy cable is not fastened to bracket A until the mast is raised.

13. INSTALLING SUPPORT ML-206-A (fig. 7).

a. To mount Support ML-206-A on a roof or platform:

(1) The procedure is identical with that given in paragraph 12 for Support ML-205-A, except that a middle mast section is used between the bottom and top mast sections.

(2) Mount the middle section on the bottom section, and then the top section on the middle section. Proceed as instructed in paragraph 12*d* (2).

b. To mount Support ML-206-A on the ground:

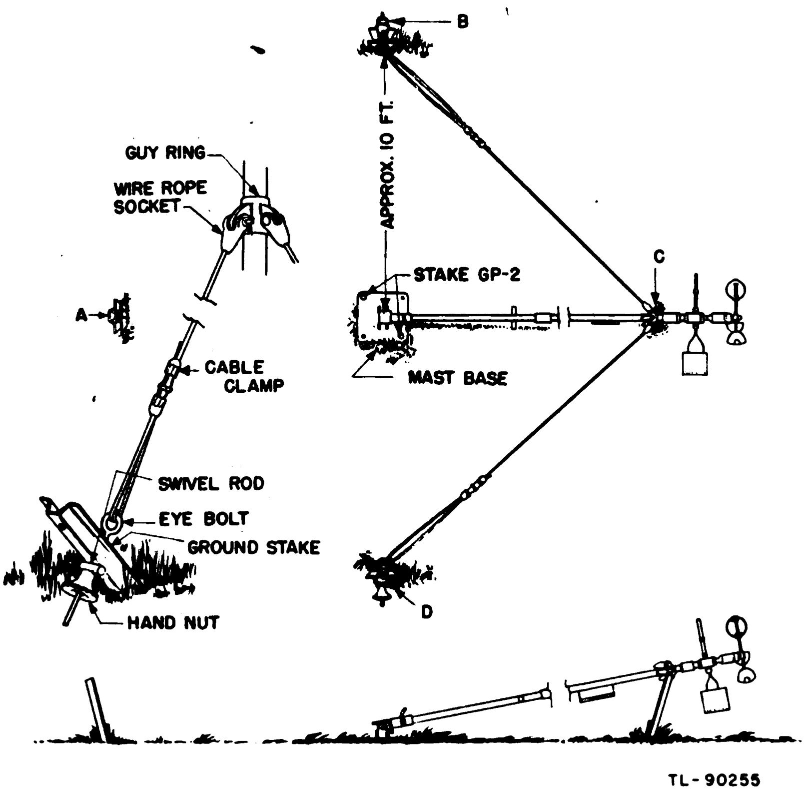

Figure 7. Support ML-206-A showing assembly on ground.

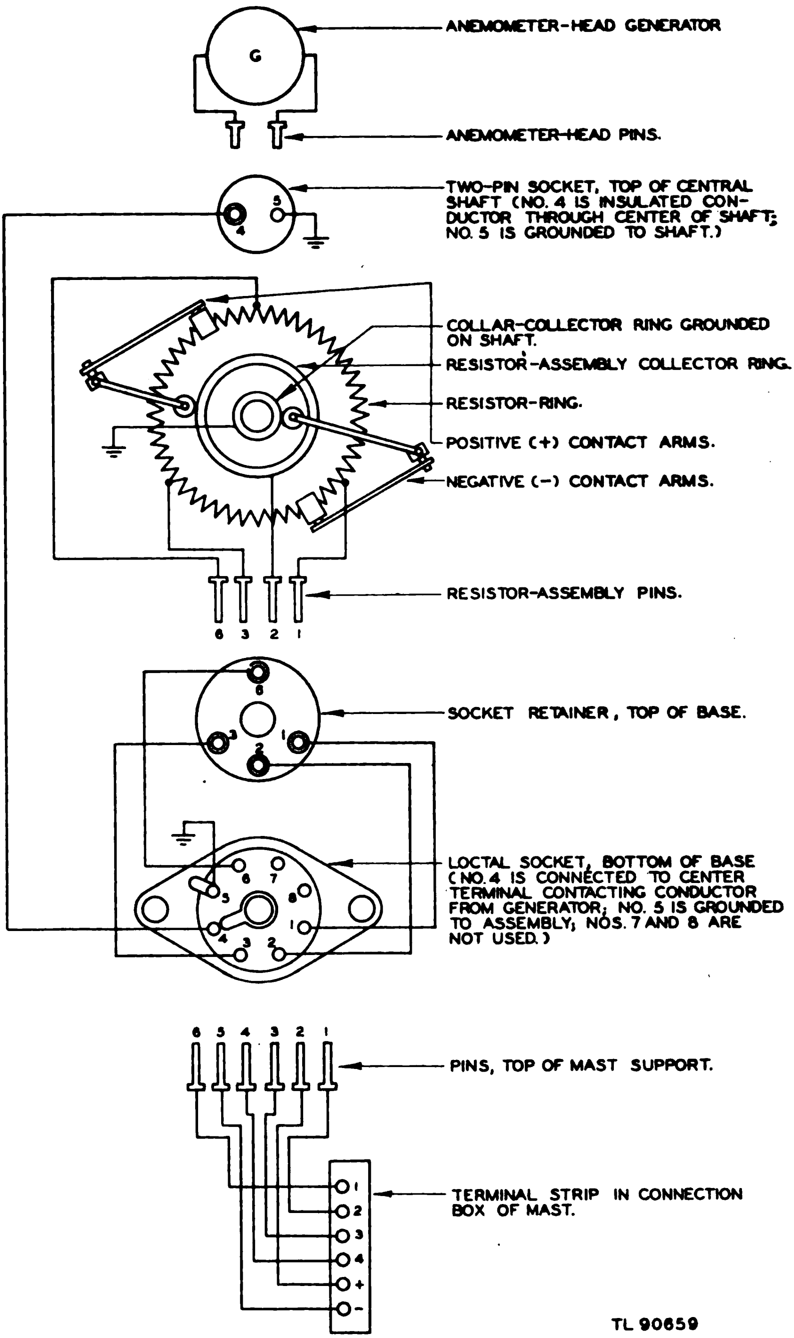

Figure 8. Wind Transmitter ML-203-A or ML-203-B and Support ML-205-A or ML-206-A, wiring diagram.

(1) Locate the mast base and drive two Stakes GP-2 into the ground through the two *large* holes in the base.

(2) Locate the four large ground stakes about 10 feet away from the mast base and equally spaced around it (A, B, C, and D in fig. 7). Drive each stake firmly into the ground at about a 45° angle, with the top of the stake extending *away* from the direction of the mast base.

(*a*) Put the driving cap on top of each stake as it is being driven, to prevent damage to the stake, and be careful not to strike the spade portion of the stake. Never strike the stake a direct blow with the sledge hammer. If a driving cap is not available, use a piece of wood or some other flat solid object to protect the end of the stake.

(*b*) In soft ground, drive the stake in far enough to cover the spade; in hard ground, drive the stake in as far as possible. (On rocky ground where it is impossible to drive a stake, secure the guy wires to an imbedded rock or any other firmly rooted object.)

(4) Put eyebolts in the stakes, assemble the mast sections, and fasten the guy wires, the same way as instructed in paragraph 12 for Support ML-205-A, but remember to use the third mast section as instructed in subparagraph 13*a* (2) above.

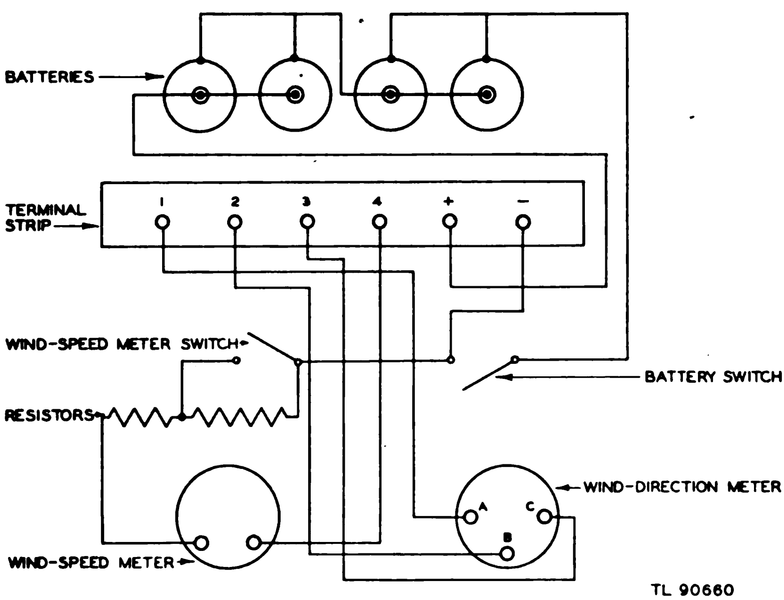

Figure 9. Wind Panel ML-204-A or ML-204-B, wiring diagram.

14. WIRING.

a. Three equal lengths of paired wires are required for wiring either Support ML-205-A or ML-206-A to either Wind Panel ML-204-A or ML-204-B.

(1) The 600 feet of Wire W-110-B that is provided is sufficient if the mast and wind panel are located within 185 feet (for SCM-20-A), or 190 feet (for AN/GMQ-1), of each other.

(2) The support and wind panel can be separated as far as 1000 feet from each other if sufficient wire is available.

b. Unwind the field wire from the spool and cut it into three equal lengths as follows:

(1) Place the spool on the ground so that it can roll, and anchor the end of the wire at the mast.

(2) Unwind the wire by rolling the reel along the ground in the direction of the location of the wind panel.

(3) Loop the wire around a stake or some other stationary object, and unwind more wire by rolling the spool back to the mast.

(4) Loop the wire around the mast, and unwind the remainder of the wire by rolling the spool in the opposite direction again.

(5) Cut the wire at the loops to obtain three approximately equal lengths of paired wires, with one end of each length at the mast and the other in the vicinity of the wind panel.

(6) Tie a knot at each end of one pair of wires, tie two knots at each end of another pair, and leave one pair unknotted. This will help identify the pairs after making connections at the mast.

c. Open the hinged cover of the connection box on the side of the top section of the mast, and insert the ends of the wires at the mast through the hole in the bottom of the box. Connect the wires to the terminals (fig. 8).

(1) Connect one wire (of the pair that has one knot at each end) to terminal No. 1, and connect the other to terminal No. 2.

(2) Connect one wire (of the pair that has two knots at each end) to terminal No. 3, and connect the other to terminal No. 4.

(3) Connect one wire of the remaining pair (unknotted at the ends) to the terminal marked plus (+), and connect the other to the terminal marked minus (—).

(4) Close and fasten the cover of the connection box on the mast. Gather the wires running from the box and twist them into the spiral hooks provided on the mast, so they will be fastened to the mast when it is raised (fig. 10).

d. Remove Carrying Case ML-207-A or ML-207-B from the crate at the site intended to install the wind panel. Remove the wind panel from the case. *Handle it with care.* Set the wind panel on its base on a table or shelf, or use the holes in the back of the box and screw or bolt it on a wall. Then connect the wires from the mast.

(1) Open the hinged front panel by twisting ¼-turn (counterclockwise) the small wing clamp in each upper corner. Do not let the panel drop down. Lower it gently.

(2) Insert the three pairs of wires from the mast into the box through either of the side holes (fig. 4). Connect the wires to the terminals (fig. 9).

(*a*) Connect one wire (of the pair that has one knot) to terminal No. 1, and connect the other to terminal No. 2.

(*b*) Connect one wire (of the pair that has two knots) to terminal No. 3, and connect the other to terminal No. 4.

(*c*) Connect one wire (of the unknotted pair) to the terminal marked plus (+), and connect the other to the terminal marked minus (—), in the box.

(3) Close the front panel and push and turn each wing clamp until its end is felt to engage the wire, then lock by twisting ¼-turn clockwise.

15. ASSEMBLING WIND TRANSMITTER.

a. Wind Transmitters ML-203-A and ML-203-B are stored in their respective Carrying Cases ML-207-A and ML-207-B in a disassembled condition. The parts required for one complete wind transmitter assembly are shown in figure 2.

b. Assemble the transmitter as follows:

(1) Remove the wind vane assembly from the carrying case and spin the vane shell to see that it turns easily. (The vane shell is that part of the assembly which has two threaded hub projections. If the shell does not turn easily, *do not force it.* Send it to the nearest mobile or fixed repair depot where the necessary tools are available.)

(2) Remove the anemometer head from the carrying case, and loosen but do not remove the thumbscrew from the socket at the lower end.

(3) Place the lower end of the anemometer head over the slotted shaft at the top of the wind vane assembly. Do not force the head on the shaft. Rotate the head until the pin in the lower end fits the slot in the shaft, and the head will slip on easily. Tighten the thumbscrew. Make it hand-tight only. *Do not use a tool.*

(4) Remove the vane tail from the carrying case and insert its small-cylinder end into the hollow hub on the side of the wind vane assembly.

Take care that the two pins on the cylinder are lined up with the slots in the end of the hub. Screw on the union nut. Make it hand-tight only.

(5) Remove the counterbalance from the carrying case and slip its open end over the hub on the opposite side of the wind vane assembly. Screw on the union nut. Make it hand-tight only.

(6) Grasp the top and bottom ends of the wind transmitter, and hold the transmitter horizontally. The counterbalance must balance the vane tail. Loosen the union nut in the center of the counterbalance and move the weighted end of the counterbalance in or out a ways in the tube until correct balance is obtained. Tighten the union nut. Make it hand-tight only.

(7) Remove one cup rotor from the carrying case and lay it aside.

(8) Check the running spares (par. 2*a* (3)) left in the case. *Immediately requisition any parts that are missing.* Close the carrying case and put it away where it will be convenient when spare parts are needed.

c. Take the assembled transmitter (minus the cup rotor) to the mast, and attach it.

(1) Remove the screw cap from the end of the mast and screw in cap lug-on side of support for future use. (Fig. 10.)

(2) Insert the lower end of the transmitter assembly into the end of the mast, taking care that the key on the side of the transmitter base fits into the slot provided in the end of the mast. Tighten the union nut. Make it hand-tight only. *Do not use a wrench.*

16. PRELIMINARY WIRING ADJUSTMENT.

a. Open the wind panel and install four Batteries BA-30 in the rack that is provided.

(1) Hold a battery by the top and place the bottom against one of the base springs in the rack.

(2) Press down to compress the spring enough to slip the top of the battery under the top of the rack. Release the battery and the spring will hold it in place.

(3) Repeat the steps in subparagraphs (1) and (2) above to install a battery in each of the remaining three stalls of the rack.

(4) Close the panel but do not lock the wing clamps.

b. Hold the battery switch (the one below the wind-direction meter) down to ON. If the wind-speed meter shows a reading, it indicates that the wires are incorrectly connected to the panel terminals.

(1) Open the panel and transpose the wires connected to terminals 3 and 4. Close the panel.

(2) If the meter still shows a reading when the battery switch is ON, open the panel again and transpose the wires connected to the plus (+) and minus (—) terminals. Close the panel.

(3) If the meter still shows a reading when the switch is ON, open the panel and again transpose the wires connected to terminals 3 and 4. Close the panel.

(4) If the meter still reads, repeat steps (1), (2) and (3) above; if that fails, recheck the wiring to the mast.

17. ATTACHING CUP ROTOR.

a. Take the cup rotor to the mast and attach it to the wind transmitter.

(1) Remove the cap nut from the top of the anemometer head, and remove the spider spring and washer located under it.

(2) Fit the hub of the cup rotor over the threaded shaft of the anemometer head, taking care to line up the two pins there with the two holes in the hub. The shield on the rotor should extend down over the anemometer head (fig. 1).

(3) Replace the washer and then the spider spring.

(4) Replace the cap nut and tighten it. Make it hand-tight only. It is likely to break if tightened with a tool.

18. RAISING MAST.

a. Lift the top end of the mast high enough to stand directly beneath it, and face the mast base. Walk forward and raise the mast hand over hand until it is upright. (Another man can aid by pulling on the loose guy cable.)

b. Fasten the loose guy cable to its bracket or stake.

(1) Slip the remaining cable clamp on the cable.

(2) Insert the end of the cable into the eyebolt fastened to bracket or stake A (figs. 6 and 7) and take a double turn through the eye, as shown in the enlarged views.

(3) Put the cable end back through the clamp, pull up the slack, and tighten the nuts on the ends of the clamp to hold the cable.

c. Adjust each guy cable until the mast is as nearly vertical as can be judged by the eye. Figure 10 shows the mast raised on the ground.

(1) Loosen the cable clamp, pull up the slack or pay out more cable, as the case may be, and then tighten the clamp. (For permanent installa-

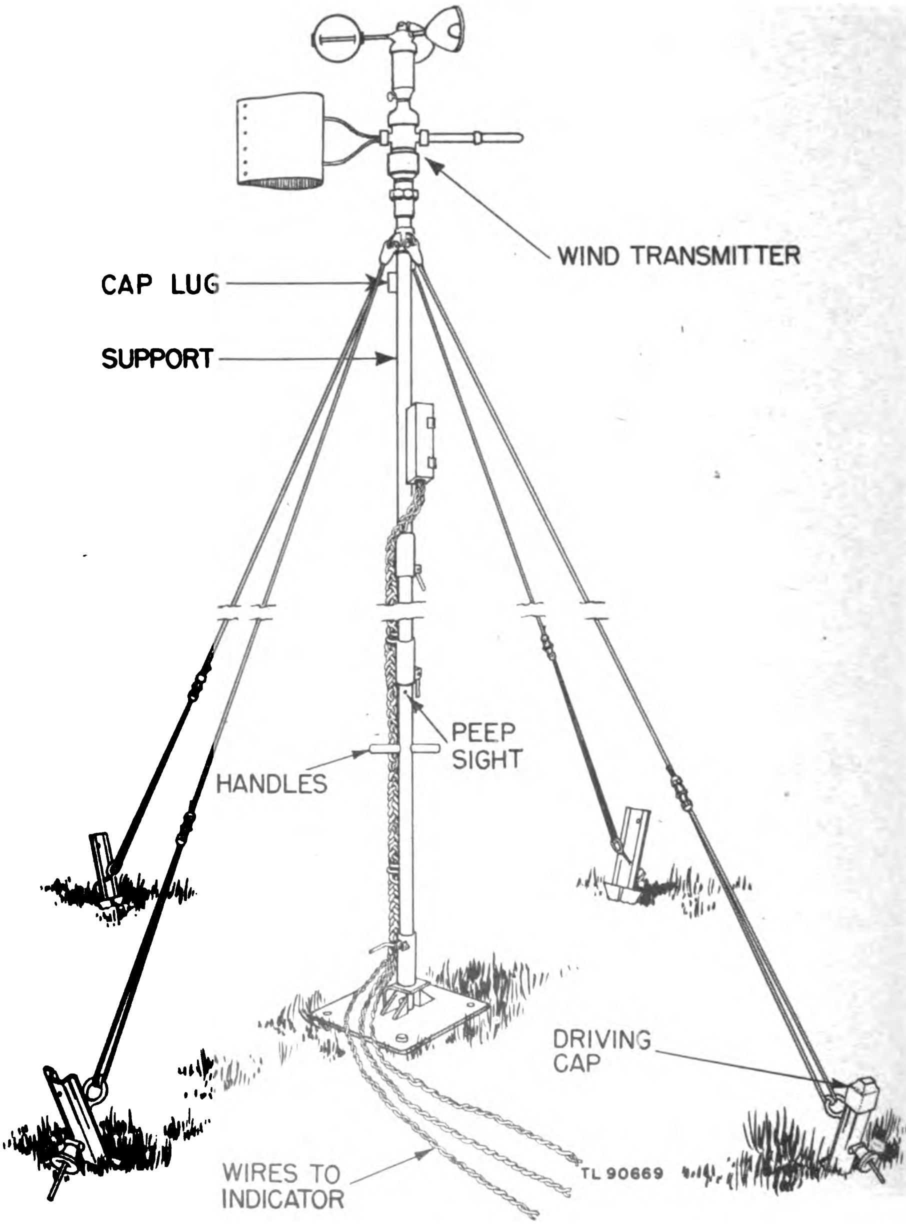

Figure. 10. Support ML-206-A, showing assembly in raised position on ground. On a roof or platform, brackets instead of stakes are used to fasten guy cables, and screws instead of stakes are used to fasten mast base.

tions where wind is extremely severe, use a pair of wrenches or two pairs of pliers to tighten the clamp.)
(2) Finally, make the cable taut by adjusting the eyebolt hand nut.

19. ORIENTING.

a. It is necessary to orient the raised mast so the wind vane assembly can indicate true direction.
(1) Determine the ***true*** north direction from the mast, using a compass if necessary and allowing for the magnetic declination of the locality.
(2) About 100 feet away from the mast and on a line ***due north*** from it, locate a natural landmark or drive a stake into the ground.

b. Loosen the clamp on the mast base (fig. 10) so the mast can be turned in the socket, and sight the mast on the due north object.
(1) Stand at the mast and sight through the small hole located near the top of the bottom mast section. (The eye must be at the hole, not at the slot on the opposite side.)
(2) Grasp the handles on the bottom mast section and turn the mast until the object located on the ***due north*** line is sighted through the hole and slot.
(3) Tighten the mast base clamp to hold the mast in the oriented position.

20. FINAL WIRING ADJUSTMENT.

a. Hold the battery switch on the wind panel in the ON position. Note the reading of the wind direction meter.

b. If the meter indicates the direction in which the wind vane of the transmitter is pointing, the wiring is correct and needs no further adjustment.

c. If the meter indicates a different direction, open the wind panel and transpose the wires connected to terminals 1 and 2.

d. Finally, close the panel and lock the wing clamps (par. 14*d* (6)).

SECTION III

OPERATION

21. WIND PANEL.

a. General. Leave the wind panel closed (fig. 3) when the equipment is in operation. Do not keep the equipment in operation if either meter appears to be erratic. See Section V.

b. Reading Wind-Direction Meter. The dial of the wind direction meter is marked with the cardinal and inter-cardinal points of the compass, and is divided into thirty-six 10° graduations with numeral designations every 30°.

(1) To obtain a direction reading, hold the battery switch down to ON and note the direction indicated by the meter pointer.

(2) After taking the reading, release the switch and it will return to the off position.

c. Reading Wind-Speed Meter. The dial of the wind speed meter is calibrated directly in miles per hour. It has two scales, one above the other. The upper scale is calibrated from 0 to 150 mph; the lower scale from 0 to 30 mph. In case wind-speed meter does not read zero when not connected or with no wind, rotate zero adjustment (fig. 3) clockwise or counter-clockwise until zero reading is obtained.

(1) To take a wind speed reading, note the position of the meter pointer on the upper scale (150-mph range).

(*a*) If it indicates a speed above 30 mph, take the reading directly from the 150-mph scale.

(*b*) If it indicates a speed below 30 mph, throw the switch (located directly below the meter) and hold it down. Take the desired reading from the position of the meter pointer on the lower scale (30-mph range). After noting the reading, release the switch and it will return to the normal position on the 150-mph scale.

(2) Never use the switch when the meter pointer indicates more than 30 mph on the upper scale. To do so will damage the meter. The purpose of the switch is to use the lower scale's wider calibration for the slower wind speeds. Upper scale readings, even of wind speeds less than 30 mph, will be satisfactory for most purposes. The real value of switching over to the lower scale is in reading wind speeds less than 15 mph.

SECTION IV

FUNCTIONING OF PARTS

22. WIND SPEED SYSTEM.

a. The wind speed portion of the equipment utilizes an a-c generator at the wind transmitter and a rectifier-type a-c milliammeter at the wind panel.

b. At the transmitter, the generator shaft is coupled through a gear train to a three-cup rotor exposed to the wind. The cup rotor turns because of the wind force on it, and its rotational speed is proportional to the wind speed. The generator driven by the cup rotor develops a voltage which is proportional to the cup rotor speed. Thus the output of the generator is proportional to wind speed. The current is conducted by wires from the wind transmitter (fig. 10) to the wind panel.

c. At the wind panel, the current is fed through an arrangement of two resistors and a single-pole switch to the milliammeter which measures the strength of the current (fig. 9).

(1) One resistor is 44,300 ohms, the other is 9,700 ohms. The wind speed meter switch normally is open and both resistors (totaling 54,000 ohms) are in series with the milliammeter. This permits the milliammeter to handle safely the output of the generator when the cup rotor is driven by the maximum wind (150 mph) for which the equipment is designed. The upper scale of the milliammeter dial is calibrated for this range.

(2) When the switch is closed, the 44,300-ohm resistor, is shunted out of the circuit, and only the 9,700-ohm resistor remains in series with the milliammeter. This permits the milliammeter to be more sensitive to the smaller currents generated by low wind speeds, but limits the maximum current it can handle safely to that produced by the transmitter generator when driven by no more than a 30-mph wind. The lower scale of the milliammeter dial is calibrated for this range.

23. WIND DIRECTION SYSTEM.

a. The wind direction system of the equipment is essentially a d-c self-synchronous repeater system, with the transmitting portion at the wind transmitter, and the repeater at the wind panel.

b. The transmitting portion is a rheostat (fig. 5) consisting of a stationary resistor assembly and a movable contacting assembly actuated by the wind vane.

(1) The resistor assembly consists of a resistor and a metal collector ring mounted together on a plastic base.

(*a*) The resistor is a continuously wound torroidal resistor ring divided into three equal electrical sections by three taps spaced 120 degrees apart. Each tap is wired to a pin in the plastic base (fig. 8).

(*b*) The collector ring is mounted in the center of, and extends above the resistor ring. It is insulated from the resistor and is wired to the fourth pin in the bottom of the base.

(*c*) The complete resistor assembly plugs into a socket in the wind transmitter base, and is connected through the wiring of the wind transmitter and the support to the wind panel. At the panel the three resistor contacts are connected to the three terminals of the wind-direction meter, and the collector ring is connected through a single pole switch to the positive terminal of the battery supply, consisting of four dry cells connected in series parallel to furnish 3 volts (fig. 9).

(2) The contact assembly (fig. 5) consists of two metal mounting blocks fixed on a plastic base. Each block bears two pivoted contact arms.

(*a*) One arm of each block is pivoted so it can move in the vertical plane and the other is pivoted to move in the horizontal plane. Each arm is provided with a spring to maintain tension in one direction, and each has a contact button at its free end.

(*b*) The mounting blocks are spaced on the plastic base so the contact arms which move vertically have their contact buttons spaced 180° apart while making contact with the resistor ring when the rheostat is assembled.

(*c*) One of the contact arms that move horizontally is mounted so its button makes contact (fig. 8) with the collector ring of the resistor assembly.

(*d*) The other contact arm that moves horizontally is mounted so its button makes contact (fig. 8) with a collector ring that is part of the collar holding the wind vane assembly on the central shaft of the wind transmitter. The collar and shaft constitute the negative side for both the wind direction and wind speed circuits.

c. The repeater at the wind panel is a meter movement consisting essentially of a rotor and a stator.

(1) The rotor consists of a small bar-type permanent magnet with a shaft mounted through a hole in the center of the magnet. The shaft is supported by jewel bearings and has an indicating needle mounted on one end.

(2) The stator consists of three identical form-wound coils spaced 120° apart and mounted on a copper cylinder surrounding the rotor. The coils are interconnected in a delta connection, and are encased in a special shell that shields them from terrestrial magnetism. The three terminals of the coil assembly are connected to the three terminals of the transmitter resistor.

d. The single pole switch in the positive side of the battery supply normally is open and no current flows through the wind direction system (figs. 8 and 9).

(1) When the switch is closed, current flows to the collector ring of the resistor assembly at the wind transmitter.

(2) Current is taken from the collector ring and fed to the resistor ring by one pair of contact arms, and the circuit is completed by the other pair of arms.

(3) The current is distributed among the three sections of the resistor and the three delta-connected coils of the meter movement at the wind panel, so the needle attached to the rotor shaft of the meter movement maintains a fixed angular relationship to the position of the contact arms on the resistor. In other words, the magnet of the repeater follows in synchronism the positions of the contact arms moved by the wind vane.

SECTION V

PREVENTIVE MAINTENANCE

24. ROUTINE INSPECTION.

a. Maintaining Wind Equipments SCM-20-A or AN/GMQ-1 in good operating condition depends on regular inspection to detect broken, worn or dirty parts.

b. Thoroughly examine the equipment at least once every two months if it is installed where conditions are normal. Inspect more often if rain or dust are severe.

c. Periodically replace the resistor and contact assemblies as instructed in paragraph 28.

25. CALIBRATION. The equipment is calibrated before it is sent to the field. Further adjustment is not required, *so do not attempt it.* Any change in the calibration will be due to damage of one of the component parts of the wind transmitter or of the wind panel. The damaged part must be replaced. The mast support does not affect the calibration in any way.

26. CUP ROTOR.

a. The cup rotor is a complete and permanent assembly. Damage to any part of it requires replacement of the entire cup rotor.

b. Inspect the cup rotor for loose, cracked or broken cups, or bent cup arms, which will cause the rotor to be unbalanced and result in serious vibration of the equipment at high speeds. If any of these faults are detected, immediately replace the cup rotor with the one from the spare parts.

c. Do not attempt to repair a damaged rotor. Send it to a depot. The correct calibration of the equipment is dependent upon the position and shape of the cups.

27. ANEMOMETER HEAD.

a. The anemometer head of the wind transmitter is the heart of the wind speed system, and is adjusted for maximum sensitivity before being sent out to the field. In use, however, its bearings may become dirty or corroded and reduce the sensitivity.

b. If a wind speed of more than 3 mph is required to make the cup rotor on the anemometer head turn, replace the assembly.

(1) Assemble a new anemometer head and a cup rotor (par. 17) from the spare parts in the carrying case.

(2) Remove the faulty head and attached cup rotor from the support and replace it with the new assembly.

(*a*) On Support ML-205-A, simply climb the mast, loosen the thumbscrew, and life off the old head and rotor. Put the new assembly on as instructed in paragraph 15*b* (3).

(*b*) On Support ML-206-A, first lower the mast (par. 28*b* (2)), then replace the head as instructed in (*a*) above, and raise the mast (par. 18).

(3) Immediately requisition a new anemometer head to maintain a full complement of spare parts.

c. Remove the cup rotor from the faulty head.

(1) Examine the rotor for faults (par. 26). If it is in satisfactory condition, store it with the spare parts.

(2) Replace the washer, spider spring and cap nut on the faulty head, and send the head to a depot for repair. *Do not attempt to repair it in the field.*

28. WIND VANE ASSEMBLY.

a. Routine. (1) Inspect the wind vane assembly frequently to determine that the vane turns freely and that the resistor and contact assemblies are not broken or dirty.

(2) Obtain a whole new wind vane assembly from a depot whenever the assembly is sluggish in operation and loses sensitivity, that is, if more than a 3-mph wind is required to move the wind vane when it is 10° off the wind stream. Send the old assembly to the depot.

(3) Replace a resistor assembly (fig. 5) with a new one from the spare parts after *every four months of service,* regardless of whether or not it is broken or dirty.

(4) Replace a contact assembly (fig. 5) with the new one from the spare parts after *every six months of service,* regardless of whether or not it is broken or dirty.

b. Removing Wind Transmitter from Mast. Whenever a fault is detected in the operation of the wind vane assembly, or when it is time to replace the resistor or contact assemblies as instructed in subparagraphs

(2) and (3) above, remove the entire transmitter (fig. 1) from the mast support.

(1) REMOVING WIND TRANSMITTER FROM SUPPORT ML-205-A. (*a*) Climb mast and take cap from cap lug near top of mast (fig. 10).

(*b*) Unscrew the union nut holding the wind transmitter, and lift the transmitter out of the pipe.

(*c*) Screw the cap on the open end of the mast pipe. Make it hand-tight only.

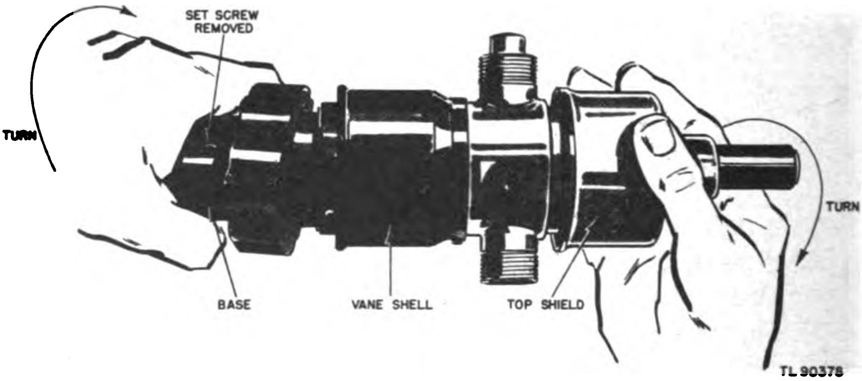

Figure 11. Unscrewing wind vane assembly.

(*d*) Hold the wind transmitter carefully while descending the mast.

(2) REMOVING WIND TRANSMITTER FROM SUPPORT ML-206-A. Support ML-206-A does not have steps for climbing. It has to be lowered to remove the wind transmitter.

(*a*) Loosen but do not remove the hand nuts on the eyebolts on brackets or stakes B and D (figs. 6 and 7).

(*b*) Remove the hand nut and swivel rod from the eyebolt in bracket or stake A, and, while holding on to the guy cable to keep the mast erect, remove the eyebolt from that bracket or stake.

(*c*) While one man holds on to the loose guy cable, another should stand on the opposite side of the mast and carefully pull it over and lower it hand over hand while walking backward. Take care not to disturb the wires held to the mast by the spiral hooks. Rest the top of the mast on bracket or stake C.

(*d*) Unscrew the union nut holding the wind transmitter to the mast and slide the transmitter from the pipe.

(*e*) Screw a cap on the open end of the mast pipe. Make it hand-tight only.

c. Disassembling Wind Transmitter. (1) Take the wind transmitter to a sheltered place, preferably inside a building.
(2) Loosen the thumbscrew and lift off the anemometer head and attached cup rotor from the wind vane assembly. Lay them aside where they will be safe.
(3) Unscrew the union nut and remove the vane tail from the vane shell.

NOTE: If the vane tail is damaged, obtain a replacement as soon as possible. It controls the accuracy of the wind direction system. Except in an emergency, do not attempt to repair a damaged vane tail.

(4) Unscrew the union nut and remove the counterbalance from the vane shell.
(5) Separate the two main sections of the wind vane assembly (fig. 11).
(*a*) Remove the set screw from the base of the assembly.
(*b*) Grasp the base with one hand and the top shield with the other and unscrew and remove the base from the vane shell.

d. Replacing Resistor Assembly. (1) Remove the three screws on the base that hold the two shields (one within the other) around the resistor assembly, and remove the shields.
(2) Remove the two screws that hold the resistor assembly in place (fig. 5). Remove the resistor assembly by pulling it up from the socket in which its four connecting pins are inserted.
(3) Plug a new resistor assembly in the socket, taking care to position its pins properly, and fasten it with the two screws.
(4) Replace the two shields, one inside the other, to enclose the resistor assembly, and fasten them to the base with the three screws.

e. Replacing Contact Assembly. (1) Remove the three screws on the vane shell that hold the two shields (one within the other) around the contact assembly, and remove the shields.
(2) Remove the four screws that hold the contact assembly in place (fig. 5). Remove the contact assembly by slipping it off the central shaft.
(3) Slide a new contact assembly over the shaft, and fit it in place on the vane shell. Take care that the contact arms do not jam against the end of the collector ring on the shaft, and see that the screw holes in the contact mounting plate are lined up with the threaded holes in the vane shell. Fasten the new assembly with the four screws.
(4) Replace the two shields, one inside the other, to enclose the contact assembly, and fasten them to the vane shell with the three screws.

f. Reassembling Wind Transmitter. (1) Insert the lower end of the central shaft to which the vane shell is attached, into the base and screw them together, turning in the opposite directions from those indicated in figure 11.

(2) Insert the set screw in the side of the base, and screw it all the way in.

(3) Attach the vane tail and the counterbalance to the vane shell (par. 15*b* (4) and (5)).

(4) Attach the anemometer head and cup rotor to the wind vane assembly (par. 15*b* (3)).

g. Replacing Wind Transmitter on Mast. (1) Replacing on Support ML-205-A.

(*a*) Carefully carry the transmitter and climb the mast support to within reach of the top.

(*b*) Unscrew the cap from the top of the mast, and insert the base of the transmitter into the pipe, taking care that the key on the side of the base fits into the slot provided in the end of the mast. Tighten the union nut. Make it hand-tight only.

(2) Replacing Wind Transmitter on Support ML-206-A. (*a*) Take the transmitter to the horizontal mast and attach it (par. 15*c*).

(*b*) Raise the mast (par. 18).

(*c*) Insert the eyebolt into bracket or stake A (figs. 6 and 7), slip the swivel rod on the eyebolt, then screw on the hand nut and tighten it.

(*d*) Tighten the eyebolt hand nuts on stakes B and D, and adjust all eyebolt handnuts to make the mast as nearly vertical as can be judged by the eye.

h. Disposal of Used Resistor and Contact Assemblies. (1) Keep the old resistor and contact assemblies that have been replaced because they were in service four and six months, respectively. These old assemblies can be used in an emergency, when a replacement is required and there are no new ones in the spare parts. Upon receipt of new assemblies, however, immediately replace the old ones that are being reused.

(2) Do not keep the old broken or dirty resistor and contact assemblies that are replaced because they are inoperative. Send them to the depot when requisitioning replacements.

29. MAST SUPPORT. *a.* Inspect the mast support at least once a month.

b. Check the guy cables to see that they are sufficiently tight.

c. Check the brackets or stakes to see that they have not loosened.

d. If a guy cable fails, salvage all the fittings, and obtain a replacement cable from a depot.

30. WIND PANEL.

a. General Care. (1) Keep the wind panel dry and located where it is not exposed to excessive dirt or dust.

(2) Requisition a replacement wind panel whenever the indicating meters of the one in use fail or are erratic (except that a lag of the wind-direction meter pointer behind the actual position of the wind vane may indicate weak batteries). Send the old wind panel to the depot for repair. Do not attempt repairs in the field.

b. Battery Care. (1) Keep the battery contacts dry, clean and free from corrosion.

(*a*) Dry the batteries, the springs, and the holders, with a clean cloth.

(*b*) Clean the bottom of each battery (where it makes contact with the spring) by scraping the zinc surface with a knife. Be careful to remove the dull white zinc oxide without gouging into the metal itself. Polish the scraped surface with sandpaper until it is bright.

(2) With normal use of the battery switch (which must not be used any oftener nor held closed any longer than actually is necessary to take a wind direction reading), the batteries in the wind panel should last at least six months.

(3) Replace the batteries whenever they show the slightest indication of weakening.

(*a*) Open the wind panel (par. 14*d* (1)).

(*b*) Press downward on each old battery, and pull its top end from under the top of the rack.

(*c*) Insert new batteries (par. 16*a*) after preparing the contacts as instructed in (1) above.

(*d*) Be careful not to disturb the calibrating resistors of the wind speed meter, nor the wires connected to the terminal strip, when replacing batteries.

SECTION VI

CORRECTIVE MAINTENANCE

31. CUP ROTOR. Do not attempt any repairs on a damaged cup rotor. Send it to the main depot for salvage.

32. ANEMOMETER HEAD. *a.* Determine whether the fault is in the upper bearing assembly or in the generator unit.

(1) Remove the three long screws (located on the ledge near the top of the head) that hold the two sections together.

(2) Separate the sections by twisting slightly and pulling them apart. Lay the generator unit aside.

(3) Spin the shaft in the upper bearing assembly. If it spins freely, the fault with the anemometer head lies in the generator unit. *Do not attempt to repair it.* Replace the upper bearing assembly on the generator unit and fasten them together with the three screws. Send the anemometer head to the main depot for salvage.

b. If the shaft of the upper bearing assembly does not spin freely, disassemble it for examination (fig. 12).

(1) Unscrew the coupling nut at the lower end of the shaft.

(2) Pull the shaft up and remove it from the housing.

(3) Remove the screws from the upper and lower bearing retainers, and remove the retainers.

(4) Remove the two bearings and the felt-lined spacer (on some models the spacer is not lined) from the housing. Take care not to lose the washers separating the bearings from each end of the spacer.

c. Examine the removed parts.

(1) If the shaft is worn or broken, replace with a new one.

(2) If any part of the bearing assembly is worn or broken, replace the whole assembly, which consists of the housing, the two bearings, the two retainers, the spacer, and the two washers. (The shaft is separately replaceable).

(3) If the bearings are dirty, clean them (par. 35), and reassemble the parts, taking care that the raised center portions of the washers (placed at each end of the spacer between the bearings) extend toward the spacer.

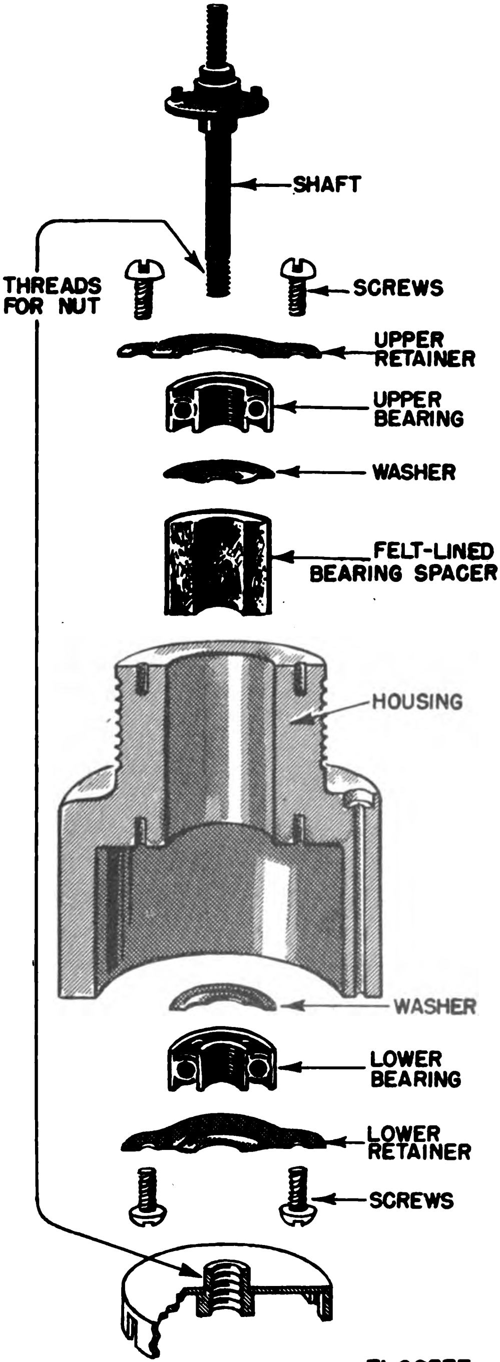

Figure 12. Anemometer head upper bearing assembly, extended cross-section view.

Do not tighten the retainer screws too much or the threads in the plastic housing will strip.

(4) Fit the upper bearing assembly on the generator unit, taking care that the coupling pan engages the pin extending from the generator shaft, and that the screw holes of the two sections are lined up. Fasten with the three long screws, but do not tighten the screws too much and strip the threads in the plastic housing.

33. WIND VANE ASSEMBLY. *a.* Worn or dirty bearings will be the usual trouble with wind vane assemblies returned to a depot for repair.

b. The bearings are located within the vane shell section of the assembly.

(1) Separate the vane shell from the base section (par. 28*c* (5)), and lay the base aside.

(2) Remove the shields and the contact assembly from the vane shell (par. 28*e* (1) and (2)).

c. Disassemble the vane shell (fig. 13).

(1) Loosen the two set screws in the collar, and slide the collar off the shaft.

(2) Pull the shaft and attached top shield up and remove it from the vane shell.

(3) Remove the lower bearing, the lower washer, the spacer cylinder, the upper washer, and then the upper bearing, through the bottom opening of the vane shell.

d. Examine the bearings. Clean the ones that are dirty (par. 35). Replace the ones that are worn.

e. Reassemble the bearings in the vane shell, taking care that the raised center portions of the washers (placed at each end of the spacer inserted between the bearings) extend toward the spacer.

f. Replace the collar (thick-end first) on the shaft and up against the lower bearing in the vane shell. Tighten the two set screws, taking care to see that the end of each enters the depression provided for it on the shaft.

g. Replace the contact assembly and shields (par. 28*e* (3) and (4)), and screw the vane shell section into the base (par. 28*f* (1) and (2)).

34. WIND PANEL. *a.* Do not attempt any repairs to damaged meters on wind panels. Replace with new meter assemblies, and send the old ones to the main depot for salvage.

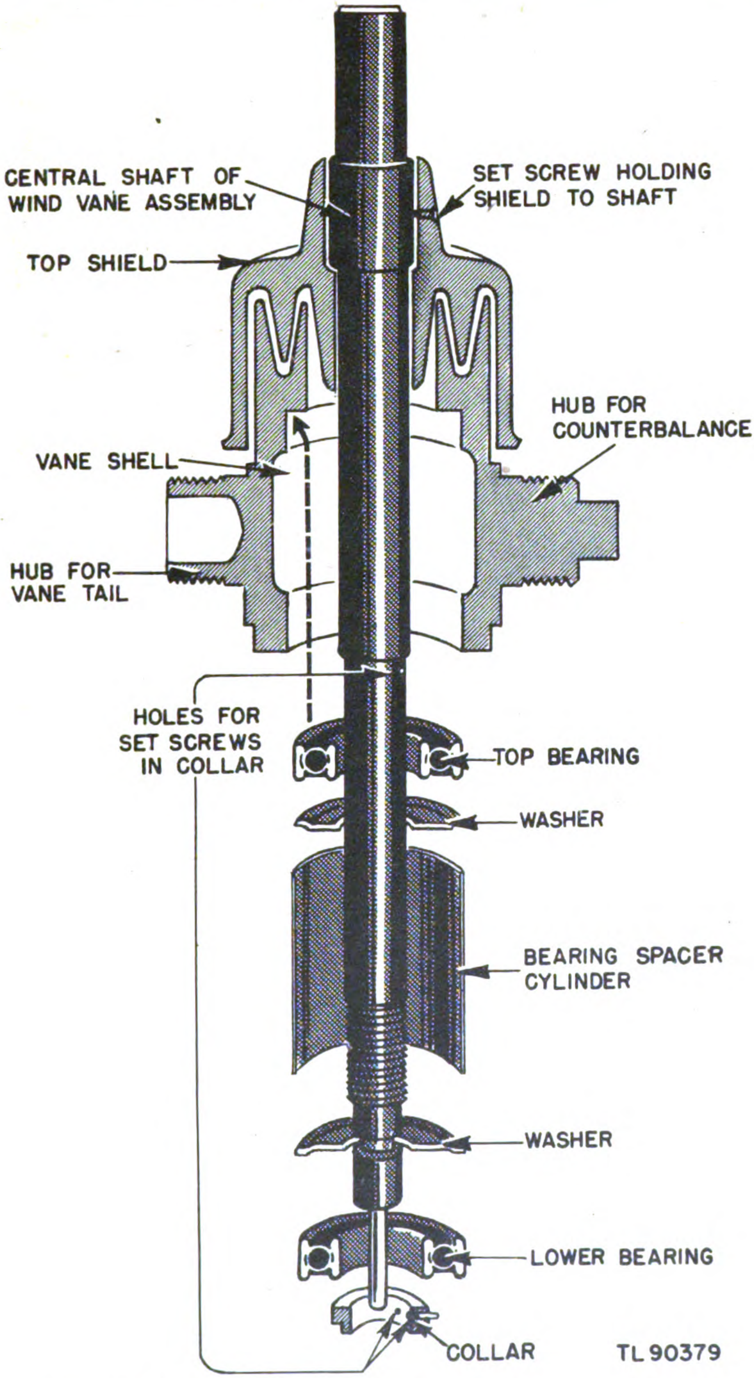

Figure 13. Vane shell bearing assembly, extended cross-section view.

b. A wind speed meter replacement includes new calibrating resistors. *Carefully follow the wiring diagram (fig. 9) when replacing the meter and resistors.*

35. CLEANING BEARINGS. *a.* Only the bearings removed from the upper bearing assembly of the anemometer head (par. 32*b*) and those removed from the vane shell of the wind vane assembly (par. 33*c*), are to be cleaned. *Do not attempt to remove and clean the bearings in the generator unit of the anemometer head.*

(1) Wash the removed bearings thoroughly in kerosene or gasoline.

(2) Spread Cities Service M-51A compound entirely over the clean bearings, and work the grease into the raceways.

(3) *Under no circumstances should ordinary motor oil or grease be used on the bearings.* If the compound specified in (2) above is not available, simply wash the dirty bearings in kerosene.

SECTION VII
SUPPLEMENTARY DATA

36. TABLE OF REPLACEABLE PARTS.

NOTE: Order parts by Signal Corps Stock No., name, and description.

a. Wind Equipment SCM-20-A.

Quantity in Equip.	*Signal Corps Stock No.*	*Name of Part and Description*	*Function*	*Mfr. Code*	*Drawing No.*
1	7A2023A	Wind Transmitter ML-203-A	Transmit wind speed and direction to wind panel	A & B	
1	7A2009-204-A	Wind Panel ML-204-A	Indicate wind speed and direction	A & B	
1		Set of spare parts, including: 1 cup rotor 1 anemometer head 2 resistor assemblies 1 contact assembly	Replacement parts for operational maintenance of wind transmitter	A & B	
1		Carrying Case ML-207-A	Packing case for wind transmitter, wind panel, and spare parts	B	
1	7A1743-205-A	Support ML-205-A	Mast support for Wind Transmitter ML-203-A	A & B	
1	1B110B	Wire W-110-B, 600 ft.	Electrical connection between support and wind panel		

b. Wind Equipment AN/GMQ-1

Quantity in Equip.	*Signal Corps Stock No.*	*Name of Part and Description*	*Function*	*Mfr. Code*	*Drawing No.*
1	7A2023B	Wind Transmitter ML-203-B	Transmit wind speed and direction	A & B	
1	7A2009-204-B	Wind Panel ML-204-B	Indicate wind speed and direction	A & B	
1		Set of spare parts, including: 1 cup rotor 1 anemometer head 2 resistor assemblies 1 contact assembly	Replacement parts for operational maintenance of wind transmitter	A & B	
1		Carrying Case ML-207-B	Packing case for wind transmitter, wind panel, and spare parts	B	
1	7A1743-206-A	Support ML-206-A	Mast support for Wind Transmitter ML-203-B	A & B	
1	1B110B	Wire W-110-B, 600 ft.	Electrical connection between support and wind panel		
1		Carrying Case ML-208-A	Packing case for Support ML-206-A and Wire W-110-B	B	

c. Wind Transmitters ML-203-A and ML-203-B.

1		Cap nut, plastic	Secure cup rotor to anemometer head.	A & B	74-58[a]
1		Cup rotor, consisting of 3 plastic cups mounted on a spider.	Rotate with the wind.	A & B	74-58[a]
1		Spider spring, steel, 3-arm type	Hold cup rotor down.	A	70276[c]
1		Spider gasket, rubber	Seal locking pin holes against rain, etc.	A	70344[c]
1		Anemometer head, consisting of: 1 bearing assembly, complete in phenolic housing which contains small radial bearings, rotor shaft, retaining nut with coupling No. 12-28 thread, special.	Transfer cup rotor motion to generator unit.	A & B	74-58[a]
		1 thumb screw, full-dog, stainless steel, No. 10-32 x ½" screw, length, Type "P".	Secure anemometer head to center shaft of wind vane assembly.	C	
		1 generator unit housing phenolic, with head-locating pin.	House generator unit.	A	70176[c]

c. *Wind Transmitters ML-203-A and ML-203-B.*

Quantity in Equip.	*Signal Corps Stock No.*	*Name of Part and Description*	*Function*	*Mfr. Code*	*Drawing No.*
		1 generator unit, consisting of generator and associated gear train, mounted on an aluminum mounting plate.	Generate a voltage proportional to wind velocity.	A & B	74-58[a]
		3 screws, machine, fillister head, steel, No. 6-32 x 1⅝".	Position and secure bearing housing and generator mounting plate to generator unit housing.		
1		Central shaft assembly, including silver plated brass base contant, and insulator.	Central support for transmitter; base contact provides connection between generator and socket in transmitter base.	A & B	WT-290[b]
1		Vane shell, aluminum.	Mounting for vane bearings, vane tail and counterbalance.	A & B	WT-308[b]
1		Spacer, bearing, lower.	Spacer for vane shell bearings.	A & B	WT-305[b]
2		Shield, bearing, large.	Separator between vane shell spacer and bearings.	A & B	WT-304[b]
1		Collector ring, upper, brass, silver plated.	Hold vane shell assembly on central shaft, and serve as contact.	A & B	WT-310[b]
1		Rain shield, molded bakelite with nameplate.	Prevent moisture entering wind vane bearing assembly.	A & B	70294[c]

1		Screw machine oval head, brass, zinc plate, black oxidized; No. 6-32 x ¼".	Fasten rain shield to center shaft of wind vane assembly.	A & B	WT-301[b]
1		Contact assembly, consisting of 4 contacts mounted on a phenolic plate.	Translate wind vane movement to resistor assembly.	A & B	WT-312[b]
4		Screw, machine, binding head, stainless steel; No. 4-40 x ⅜".	Fasten contact assembly to vane shield.	A & B	WT-327[b]
1		Resistor assembly, consists of wire wound resistor and collector ring on 4-prong base plug.	Variable resistance element for wind direction circuit.	A & B	WT-334[b]
2		Screw, machine, fillister head, brass; No. 4-40 x ⅞".	Fasten resistor assembly to base.	A & B	70336[c]
1		Outer shield, with cover, steel, mounted on vane shell.	Protect rheostat element from weather.	A & B	WT-330[b] (shield) WT-336[b] (cover)
1		Inner shield, with cover, steel, mounted on transmitter base.	Protect rheostat element from weather.	A & B	WT-332[b] (shield) WT-365[b] (cover)
6		Screw, machine, binding head, stainless steel (black); No. 4-40 x ¼".	Secure inner and outer shields and covers.	A & B	WT-328[b]
2		Bearing, radial; No. S8-R, ¾" bore, 1⅝" OD, by 5/16" wide.	Provide bearing surface for rotation of wind vane shell.	D	S8-R

c. Wind Transmitters ML-203-A and ML-203-B.

Quantity in Equip.	Signal Corps Stock No.	Name of Part and Description	Function	Mfr. Code	Drawing No.
2		Set screw headless, cone point, stainless steel; No. 6-32 x 7/32".	Position collar-collector ring securely to central shaft.	A & B	WT-311[b]
1		Vane tail assembly consisting of vane tail with locknut for mounting tail to vane shell.	Respond to change in wind direction.	A & B	WT-204[b]
1		Counterbalance assembly, with adjustable weight and lock nut for mounting to vane shell.	Nose of wind vane and counterbalance of vane tail.	A & B	WT-205[b]
1		Clamp nut, special, brass, black oxidized.	Secure wind transmitter to mast support.	A & B	WT-347[b]
1		Transmitter base contact, brass, silver plated.	Electrical contact between generator and socket in transmitter base.	A & B	WT-298[b]
1		Insulator, lower, phenolic.	Insulate transmitter base contact from center shaft.	A & B	WT-297[b]
1		Setscrew, headless, full-dog, steel; No. 10-32 x 9/16".	Lock transmitter base, after screwing, to center shaft.	A & B	WT-323[b]
1		Socket, loctal type; No. 88-8X, with 1 5/16" mounting centers.	Electrical contact between wind transmitter and mast support.	E	Cat. No. 65
2		Screw, special, fillister head, brass; No. 6-32 x 3/8".	Mount loctal socket to transmitter base.	A & B	WT-358[b]

d. Wind Panels ML-204-A and ML-204-B.

1		Wind speed instrument, model No. 301 milliammeter, rectifier type, 1-ma range, calibrated with double-range mph scale.	Measure current from wind transmitter generator.	F	No. 301 with mod. scale 74-58[a]
1		Resistor, calibrating, non-inductive, fixed resistance; value, 44,300 ohms.	Resistance for wind speed instrument.	G	WEP-131[b]
1		Resistor, calibrating, non-inductive, fixed resistance; value, 9,700 ohms.	Resistance for wind speed instrument.	G	WEP-130[b]
1		Screw assembly; No. 4-40 x 1¼", steel, pentrated.	Mount calibrating resistors on panel.		
1		Wind direction instrument, 3", d-c self-synchronous repeater, with special scale.	Indicate position of wind vane.	H	Special scale 74-58[a]
6		Screw assembly, No. 4-40 x ½", steel, pentrated.	Mount wind speed and wind direction instruments to panel.		
2		Fastener with spring and grommet.	Closures for panel.	I	AJW3-35 S3-150 GA3-175
2		Spring bracket, special.	For panel fasteners.	A & B	WEP-122[b]

d. Wind Panels ML-204-A and ML-204-B.

Quantity in Equip.	*Signal Corps Stock No.*	*Name of Part and Description*	*Function*	*Mfr. Code*	*Drawing No.*
2		Hinge, narrow butt, modified, wrought steel; 1¼" x 1⅜" x 1/16".	For attaching phenolic panel to wooden case.	J	Cat. No. 800 mod. WEP-33[b] 33[b]
2		Switch, toggle, spring return; 3 amp, 250 volt, with solder lugs, and 2 hex locknuts 1/16" thick.	One to make circuit at wind direction instrument; one to control 44,300-ohm calibrating resistor of wind speed instrument.	K	Cat. No. 20992
1		Wire harness, with terminal lugs.	Connect binding posts and batteries to wind speed and direction instruments.	A & B	No. D-8412 WEP-60[b]
5		Terminal lug, Burndy, Hylug "Yavia" 14-T2.	3 for connecting wire harness to wind direction instrument; 1 from wire harness to wind speed instrument; 1 from wire connecting calibrating resistors to wind speed instrument.	L	Cat. No. 10 WEP-132[b]
6		Terminal lug No. 1, with hole for No. 8 screw, brass, tinned, cord type, ⅝".	Attach to binding posts on terminal board, connects wires to instruments.	L	No. 1
1		Terminal board assembly.	Receive leads from mast support.	A & B	
6		Binding post, complete.			

1		Battery block assembly, thermosetting plastic.	Rack for batteries.	A & B	WEP-21[b]
4		Contact, complete, brass.	Provide contact from battery to binding post.	A & B	
4	3A30	Battery BA-30.	Furnish current for wind direction circuit.		

e. Support ML-205-A.

1		Mast base assembly, steel, consisting of a base plate, a swivel bracket and clamp screw device.		M	74-58[a]
4		Roof bracket, steel.		M	74-58[a]
10		Lag screw, steel bonderized; ½" diam. x 1½" long, gimlet point.	Fastening mast base and roof brackets to wood.	M	74-58[a]
1		Mast section, lower 1½" standard steel pipe, with handles and steps.		M	74-58[a]
1		Mast section, upper, 1½" standard steel pipe, with steps, steel terminal box, and 4-lug guy ring.		M	74-58[a]

e. Support ML-205-A.

Quantity in Equip.	*Signal Corps Stock No.*	*Name of Part and Description*	*Function*	*Mfr. Code*	*Drawing No.*
1		Plug, black phenolic, special 6-prong, brass, located in top of upper mast section.	Provide connection to loctal socket of transmitter.	A & B	WEM-76[b]
1		Terminal board assembly.	For terminal box on upper mast section.	A & B	
6		Binding post, "Sergeant".	For terminal box.	A & B	
1		Wire harness, consisting of 6 wires with terminal lugs at one end, tinned at the other.	Connect 6-prong plug to terminal box.	A & B	WEM-75[b]
6		Terminal lug; No. 1, with No. 8 hole, tinned, brass, cord type, 5/8".	For wire harness.	L	
4	6L6832-6.18	Screw, machine, round head, steel, bonderized No. 8-32 x 3/8".	For mounting terminal board in terminal box.		
1		Pipe cap, for upper mast section.	Protect 6-prong plug.	M	
4		Guy wire assembly, consisting of wire rope complete with socket.	Lateral bracing for mast support.	M	
4		Eyebolt, galvanized steel; 1/2" diam. 13 thd x 6" of threaded length, standard.	Attach wire rope to bracket or ground stake.	M	74-58[a]

4		Hand nut, cast iron, ½" ID 13 thd.	For eyebolt.	M	
4		Swivel rod, steel.	For eyebolt, to prevent hand nut loosening.	M	
4		Guy clamp, "Safe-Line", drop forge finish, cadmium plated, for 3/16" diam. wire rope.	Clamp wire rope fastened to eyebolt.	N	

f. Support ML-206-A. Same parts as in *e* above, with the exception of the mast section, and in addition, the following:

1		Mast section, lower; 1½" standard steel pipe, with handles. (No steps.)		M	74-58[a]
1		Mast section, middle; 1½" standard steel pipe. (No steps.)		M	74-58[a]
1		Mast section, upper, 1½" standard steel pipe, with steel terminal box and 4-lug guy ring. (No steps.)		M	74-58[a]
4		Ground stakes, steel, bonderized, special.		M	

f. Support ML-206-A. Same parts as in *e* above, with the exception of the mast section, and in addition, the following:

Quantity in Equip.	*Signal Corps Stock No.*	*Name of Part and Description*	*Function*	*Mfr. Code*	*Drawing No.*
1		Driving cap, malleable iron, certified; weight for post No. 3 or 3½, 2¼ lb.	Used for protection of ground stake while being driven.	O	
2	2A3302	Stake GP-2.	Fasten mast base to ground.		

[a] Signal Corps specification.
[b] Lionel Corp. drawing.
[c] Sangamo Elec. Co. drawing.

37. LIST OF MANUFACTURERS.

Code	Manufacturer	Address
A	Sangamo Electric Co.	Springfield, Ill.
B	Lionel Corp.	Irvington, N. J.
C	Parker-Kalon Corp.	New York, N. Y.
D	Federal Bearing Co., Inc.	Poughkeepsie, N. Y.
E	American Phenolic Corp.	Chicago, Ill.
F	Weston Instrument Co.	Newark, N. J.
G	Instrument Resistors Co.	Little Falls, N. J.
H	The Rubicon Co.	Philadelphia, Pa.
I	Dzus Fastener Co., Inc.	Brooklyn, N. Y.
J	The Stanley Works	New Britain, Conn.
K	Arrow-Hart & Hegeman	Hartford, Conn.
L	American Radio Hardware Co., Inc.	New York, N. Y.
M	Kerby Saunders, Inc.	New York, N. Y.
N	National Products Co.	Detroit, Mich.
O	Sweets Steel Co.	Williamsport, Pa.

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WAR DEPARTMENT

TECHNICAL MANUAL

STORAGE BATTERIES FOR SIGNAL COMMUNICATION EXCEPT THOSE PERTAINING TO AIRCRAFT

January 16, 1942

TECHNICAL MANUAL No. 11-430

WAR DEPARTMENT
WASHINGTON, January 16, 1942.

STORAGE BATTERIES FOR SIGNAL COMMUNICATION EXCEPT THOSE PERTAINING TO AIRCRAFT

Prepared under direction of the
Chief Signal Officer

*This manual supersedes TR 1190-5, May 16, 1931, including Changes No. 1, January 2, 1932.

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SECTION I

FUNCTION AND DESCRIPTION

1. Use.—Storage batteries are used by the Signal Corps both in fixed locations, such as common battery telephone exchanges, and as portable sources of moderate amounts of power for the operation of electrical signal communication equipment. Since the voltage delivered by the usual type of storage battery is low, storage-battery-driven dynamotors are extensively used to obtain the high voltages required for the operation of radio transmitters and receivers. In many motor vehicle radio installations the storage battery used is the same one used in operation of the vehicle. In these cases the battery is supplied and maintained by the arm or service responsible for procurement and maintenance of the vehicle. (See par. 3, AR 850-15.) In addition to the Signal Corps portable batteries described in section V, commercial type motor vehicle batteries are used in some field signal communication equipment. These batteries are described in TM 10-580.

2. Description and definitions.—A storage battery consists of one or more storage cells which are a special form of voltaic cell. A voltaic cell is a device in which chemical energy is converted into electrical energy when the terminals are connected to a closed electrical circuit. Such cells are classified as primary cells or secondary cells. The primary cell, of which the most common type is the "dry cell," is characterized by the fact that the materials of which it is composed are consumed in the production of electrical energy and must be replaced in part or entirely as the process continues. The secondary cell is the type to which the storage cell belongs, and is characterized by the fact that the conversion of chemical to electrical energy is a reversible process. Before describing the storage cell further, it is desirable to define a number of terms which will be used with reference to it.

a. Electrodes.—Metals or metallic compounds which are placed in the cell and connected to its two terminals. The materials of which the electrodes are composed must be different. They are usually constructed in the form of plates or groups of plates.

b. Electrolyte.—Solution which conducts electric current. It is placed in a cell so that it covers both electrodes. Depending upon the nature of the cell, the electrolyte may or may not take part in the chemical action which occurs at the electrodes.

c. Under load.—Term used to describe the condition when a storage cell or battery is delivering current to an external circuit. This condition is also expressed by the term "closed-circuit."

d. Open-circuit.—Term which means that the battery is disconnected from an external electrical circuit and is delivering no current.

e. Terminal voltage.—Voltage or difference of potential as measured by voltmeters connected between the terminals of a storage cell or battery. This is called closed-circuit or load voltage when the battery is delivering current and open-circuit voltage when the battery is not delivering current to an external circuit. The minute current drawn by the voltmeter itself is neglected. The voltage which is obtained from a cell depends upon the materials of which its electrodes and electrolyte are made and upon the concentration of the electrolyte.

3. Chemical action.—There are two varieties of storage cells which may be encountered in connection with signal communication: the lead-lead-acid cell, sometimes called the lead accumulator; and the nickle-iron-alkali cell or Edison cell. The two-cell portable battery BB–29 (fig. 1) is an example of the lead type.

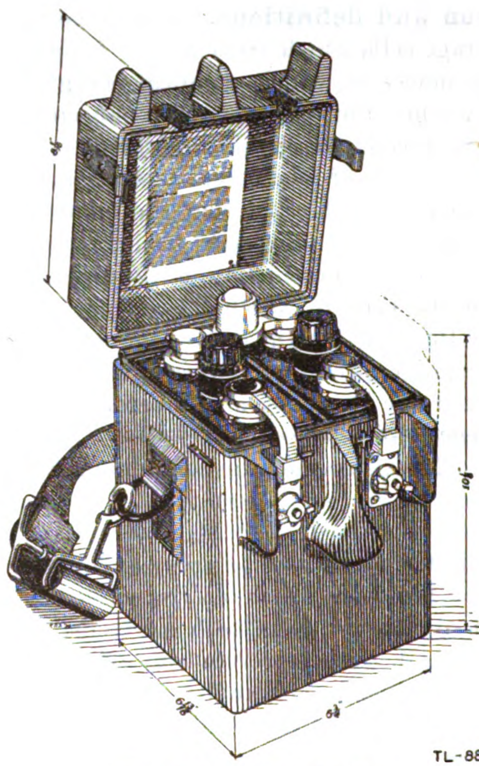

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FIGURE 1.—Battery BB–29.

a. Lead-lead-acid cell.—In the lead-lead-acid cell the materials are as follows: The positive electrode is made of a chocolate-brown-colored lead peroxide. The negative electrode is made of gray metallic lead in finely divided form commonly called spongy lead. The electrolyte is a solution of sulphuric acid in water. The open-circuit terminal voltage of this cell when fully charged is approximately 2.2 volts and when discharged is about 1.75 volts. When the cell is delivering current to an external circuit, that is, when it is discharging electrical energy, the chemical actions may be summarized as follows:

$$\left.\begin{matrix}PbO_2\\ \text{Lead peroxide}\end{matrix}\text{ (positive plate)}\right\}\text{plus}\left\{\begin{matrix}Pb\\ \text{spongy lead}\end{matrix}\text{ (negative plate)}\right\}\text{plus}\left\{\begin{matrix}2H_2SO_4\\ \text{sulphuric acid}\end{matrix}\right.\text{ (electrolyte)}$$

is converted to:

$$\left.\begin{matrix}PbSO_4\\ \text{Lead sulphate}\end{matrix}\text{ (positive plate)}\right\}\text{plus}\left\{\begin{matrix}PbSO_4\\ \text{lead sulphate}\end{matrix}\text{ (negative plate)}\right\}\text{plus}\left\{\begin{matrix}2H_2O\\ \text{water}\end{matrix}\right.\text{ (electrolyte)}$$

Note this action removes acid from the electrolyte, lowering its specific gravity (see par. 6) and that both plates become converted in part to the same substance, lead sulphate, thus reducing the voltage delivered by the cell. The process may be reversed by connecting to the cell through suitable resistance an external source of d-c electrical power of higher voltage than that of the cell, connecting the positive terminal of the external source to the positive terminal of the battery or cell and the negative terminal of the external source to the negative terminal of the battery or cell. This causes an electric current to flow through the cell in the opposite direction to that in which current flows when the cell is discharging (see par. 16). This process is called charging and results in converting electrical energy into chemical energy. The chemical processes on charging may be summarized as follows:

$$\left.\begin{matrix}PbSO_4\\ \text{Lead sulphate}\end{matrix}\text{ (positive plate)}\right\}\text{plus}\left\{\begin{matrix}PbSO_4\\ \text{lead sulphate}\end{matrix}\text{ (negative plate)}\right\}\text{plus}\left\{\begin{matrix}2H_2O\\ \text{water}\end{matrix}\right.\text{ (fiom electrolyte)}$$

is converted to:

$$\left.\begin{matrix}PbO_2\\ \text{Lead peroxide}\end{matrix}\text{ (positive plate)}\right\}\text{plus}\left\{\begin{matrix}Pb\\ \text{spongy lead}\end{matrix}\text{ (negative plate)}\right\}\text{plus}\left\{\begin{matrix}2H_2SO_4\\ \text{sulphuric acid}\end{matrix}\right.\text{ (electrolyte)}$$

Note that this action restores acid to the electroylte, thus increasing its specific gravity, and that the plates are reconverted to the original materials. Upon completion of charging, the battery or cell is again ready to deliver current to an external circuit by conversion of chemical energy into electrical energy. During both the discharging and the charging processes some of the water in the electroylte is decomposed into its elements, hydrogen and oxygen, both of which are gases. These gases bubble from the solution. This bubbling is much greater in quantity during charging than during discharging. *A mixture of hydrogen and oxygen gases is highly explosive.* For this reason a *battery charging room must always be well ventilated and all flames must be kept out of it.* Distilled water must be added occasionally to replace that lost by decomposition.

b. Edison cell.—The Edison cell has its electrodes made of nickel oxide and finely divided metallic iron with an electrolyte of potassium hydroxide (an alkali commonly called caustic potash) dissolved in water. This cell was developed to provide a very rugged type of storage battery which could stand physical shocks and much abuse. Its voltage is about 1.2 when fully charged and about 0.9 volt when discharged. Its state of charge can be tested by measurement of its terminal voltage. The methods of charging Edison cells are the same

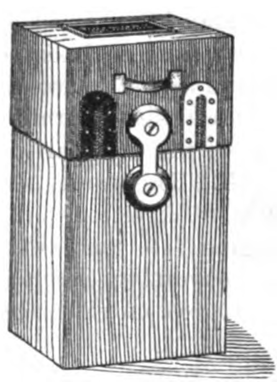

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FIGURE 2.—Battery BB-41.

as those of charging lead acid cells, but the chemical actions upon charge and discharge are different. The potassium hydroxide does not enter into the chemical action as does sulphuric acid in the lead cell, hence concentration of the electrolyte does not change. Subsequent to the development of this cell, methods of construction of the lead cell have so improved the ruggedness of that type of cell that its advantages as compared to those of the Edison cell have greatly increased. Only the lead type is now being procured for signal communication purposes. Some Edison cells are, however, still found in service.

4. Plate structure.—The active materials of the electrodes of storage batteries are soft, porous, and flaky. They have inadequate mechanical strength to support themselves, especially in the portable types of batteries. It is therefore necessary to provide support for these materials by means of a rigid framework of some inactive substance which is also an electric conductor. There are various different ways of preparing the plates of a lead cell, but in the final form each consists of a framework containing the active material in a porous form which exposes a considerable amount of surface of its particles to the electrolyte. The material of which the supporting framework is usually made is a hard lead-antimony alloy. Especially in the portable types of batteries, this framework usually takes the form of a grid structure of horizontal and vertical wires (see fig. 3). The single plates are assembled into positive and negative groups (see fig. 6).

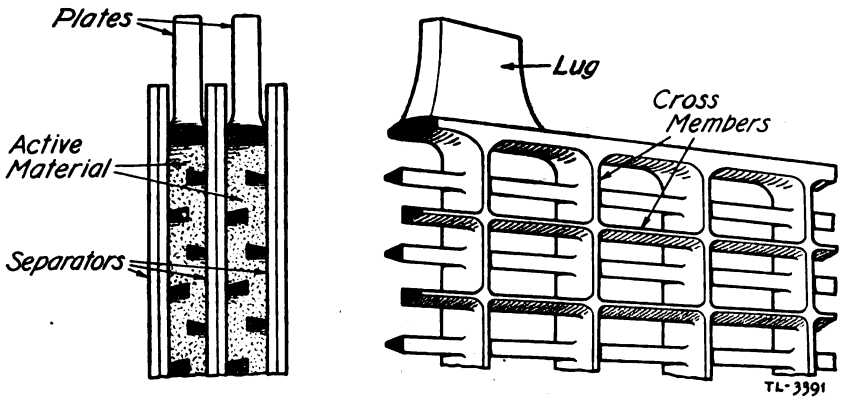

FIGURE 3.—Section of battery plate grid with cross section showing active material in place.

Each negative group always has one more plate than the positive group with which it is to be used. The plates of each group are permanently joined to a connecting post strap by melting a portion of each plate and the strap at the point where they come together (see figs. 4 and 5). This process is known as "lead burning" and is done with a gas flame or an electric arc. An assembly consisting of a positive group and a negative group with separators is called an element. The separate plates of the positive and negative groups alternate within the element assembly.

5. Separators.—To reduce the internal resistance of the cell the plates are separated by as small a space as practicable. To prevent the plates from actually touching and causing a short circuit, sheets of insulating material called separators are inserted between them. Separators are made of various materials such as treated acid-resisting wood, perforated rubber, or a combination of the two, porous rubber, or spun glass. When wood separators alone are used they are grooved

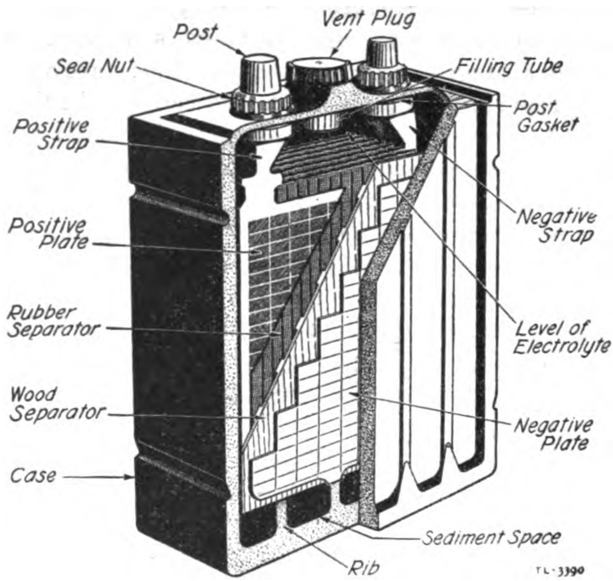

FIGURE 4.—Sectional view of typical storage cell.

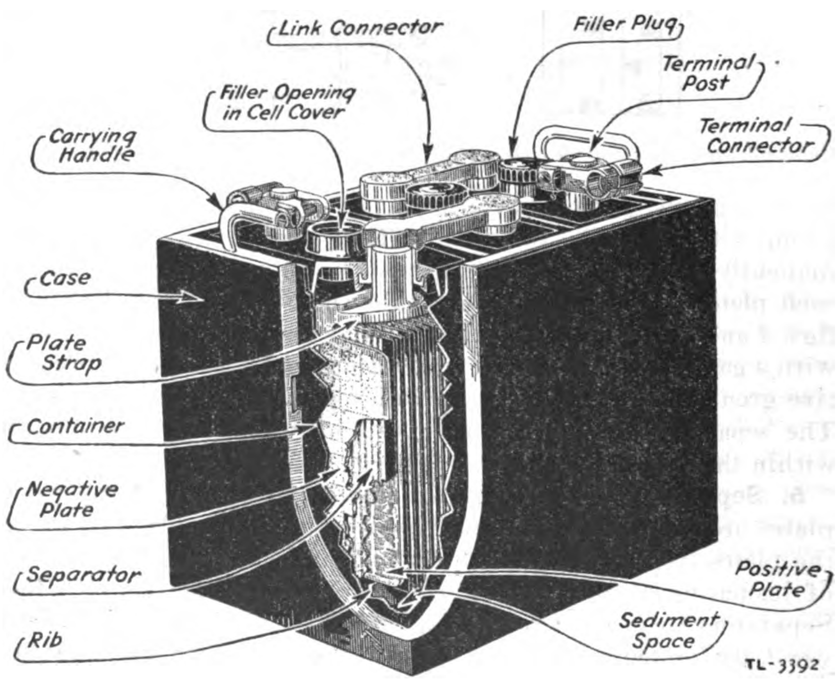

FIGURE 5.—Sectional view of typical storage battery.

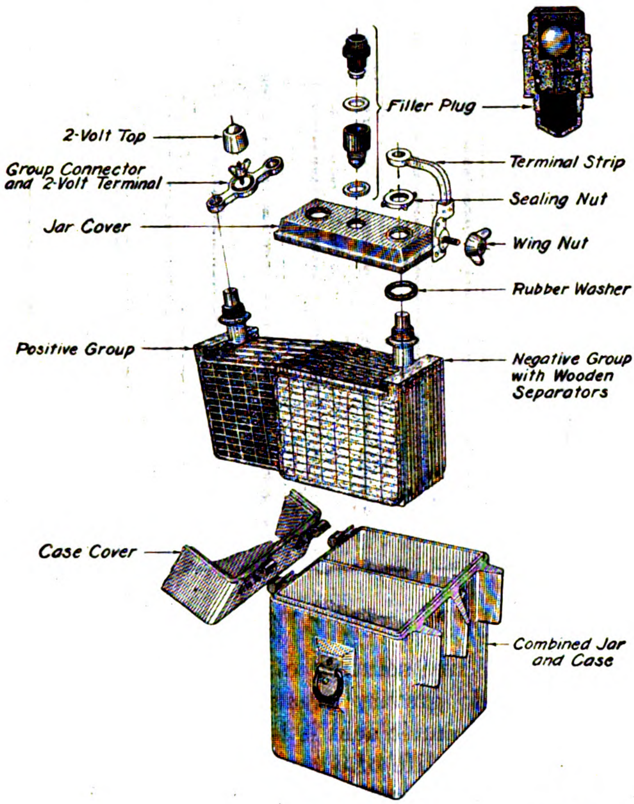

FIGURE 6.—Battery BB-29, details.

vertically to allow the escape of oxygen gas formed during charging (see par. 3*a*) and to provide room for active material which flakes from the positive plates to drop to the sediment space below. (See fig. 7.) If the oxygen is not permitted to escape rapidly it will deteriorate the wooden separators. Also the active material of the positive plates is more susceptible to flaking than that of the negative plates. When a combination of wood and perforated rubber separators is employed, the rubber separator is placed next to the positive plate.

6. Electrolyte.—Dilute sulphuric acid is used as the electrolyte in lead-acid storage cells. The strength or concentration of the acid solution is an important indication of the condition of the cell and is usually measured in terms of its specific gravity. Specific gravity is the ratio of the weight of a given volume of acid to the weight of the same volume of water. Pure sulphuric acid has a specific gravity

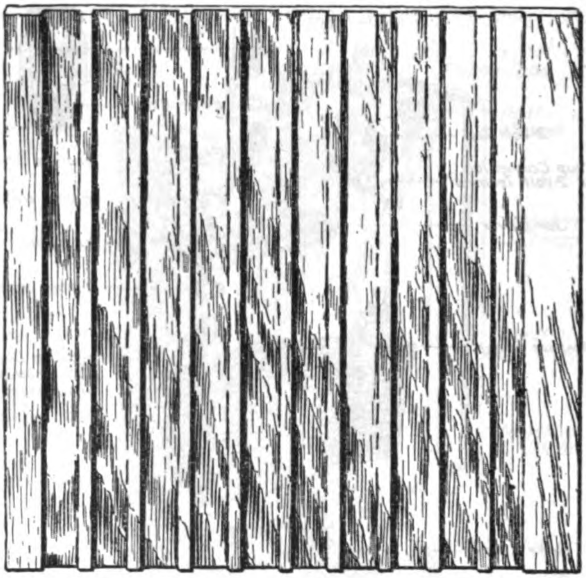

FIGURE 7.—Typical wood separator.

of 1.835. Therefore, any solution of sulphuric acid in water will always have a specific gravity greater than 1.000. The electrical resistance of dilute sulphuric acid is lowest between specific gravities of 1.150 and 1.300. The life of a storage cell shortens as the specific gravity of the electrolyte increases. Therefore, maximum life is obtained by using electrolyte of as low specific gravity as is practicable. In stationary batteries where size and weight are not so important as in portable batteries, the acid used is generally of lower specific gravity than that used in portable batteries, varying from about 1.225 to 1.250 on charge to about 1.150 on discharge. In portable batteries the question of bulk and weight and of the requirement of large currents for short periods of time outweighs the consideration of long life and, as a consequence, the acid used in portable batteries is ordinarily between about 1.270 and 1.310 when fully charged and between 1.150 and 1.210 when discharged. The intensity of any chemical action increases with rising temperature. In storage batteries using electrolyte with maximum specific gravity between 1.270 and 1.310, the action increases to such a degree above 110° F. that permanent damage may be done to the plates if the battery is used at these temperatures. In some climates the atmospheric temperature will exceed 110° F. In these localities it is better to use electrolyte of lower specific gravity than would be used in a temperate climate. For example, a stationary battery designed to use electrolyte of specific gravities varying from 1.225 to 1.250 in temperate climates will operate more efficiently and with longer life in temperatures above 110° F. if the electrolyte of the battery when fully charged is from 1.200 to 1.210 specific gravity. In portable batteries using electrolyte specific gravity of 1.270 to 1.310 at normal temperatures, it is desirable to reduce the electrolyte specific gravity to between 1.250 and 1.270 when the batteries are used at temperatures above 110° F.

7. Containers.—The containers used for storage cells may be made of any material which will not be acted upon by the electrolyte over the range of temperature encountered. Materials often used are glass, hard rubber, celluloid, treated wood, or lead-lined wood. Glass is most commonly used for the stationary batteries used in connection with signal communication and hard rubber for the portable batteries. In the case of portable batteries the container is usually made up in the form of a box with partitions separating it into compartments for two or more cells. Each cell compartment has a row of ribs across the bottom which serve to hold the plates off the bottom of the container. This provides space into which sediment from the flakes may settle without coming in contact with the plates where it would cause a short circuit of the cell. Care is taken in the design and manufacture of portable batteries to make the containers leakproof and, in some cases, spillproof by the use of specially designed vent caps which allow gases to escape but prevent the escape of electrolyte. Ordinarily each cell of the portable battery has its own cover of the same material as the container. (See fig. 6.) This cover has three holes, one for each of the two terminal posts which are part of the terminal straps holding the plates together in groups, and one for the filler plug into which the vent cap is fitted. The covers are sealed to the containers by an acid-proof thermoplastic compound. The terminal post holes are made leakproof by the use of washers or sealing compound. Stationary batteries of the glass type may be provided with hard rubber or glass covers or may be without covers.

8. Electrical connections.—In batteries of two or more cells, the cells are usually connected in series (sometimes in parallel) by connecting straps. These are usually of lead or lead-coated copper and are permanently connected to the terminal posts by burning.

9. Ratings.—Storage batteries are usually rated in closed-circuit terminal voltage at a normal discharge current and in ampere-hour capacity. The voltage rating is a function of the number of cells in series and is based on voltage of 2 volts per cell. The open-circuit voltage of a fully charged lead-acid cell is approximately 2.2 volts, but due to the internal resistance of the cell this may drop to 2 volts or less under load. The ampere-hour rating of portable batteries is normally based on an 8-hour (or sometimes 5-hour) discharge rate at 77° F. To obtain the number of amperes which may be delivered by a storage battery in order to discharge it to its normal discharged condition in 8 hours (which is 1.75 terminal volts per cell under load), divide its ampere-hour rating by 8. Thus, a battery having a rating of 4 volts and 80 ampere-hours will be delivering a current of 10 amperes at 3.5 volts at the end of an 8-hour period of discharge at 10 amperes. The ampere-hour rating is a function of the total plate area in each cell, multiplied by the number of cells in parallel. In automobile batteries, since the plates are nearly always of a standard size, the ampere-hour rating is a function of the number of plates per cell. If a battery is discharged at a current higher than its normal 8-hour rate, its ampere-hour capacity will be much less than its rated ampere-hours; if discharged at a lower rate, it may deliver considerably more than its rated ampere-hours. Batteries which are designed for special purposes may be rated in terms of other than 8-hour discharge rates.

10. Life expectancy.—*a.* The life of a storage battery depends upon several conditions, among which are the—

(1) Type of plates used.
(2) Care given to the battery.
(3) Actual cycles of charge and discharge undergone by the battery.
(4) Temperatures at which it has been charged and discharged.

b. If the battery were used intermittently and kept on trickle charge for long periods, its life might extend to 5 or more years. If, however, it is used continuously under normal conditions, its life may be anywhere from 2 to 4 years. The life is limited to a great extent by the shedding of active material (see par. 37) and by sulphation of the plates (see par. 30). If charging and discharging are conducted at normal rates and under proper conditions, the plates will remain in good condition over a long period of time. However, if subjected to abnormal load or misuse, their life will be shortened.

SECTION II

OPERATION

11. Capabilities and connections.—To obtain the best service from storage batteries, they should be discharged at as low a rate as possible. The normal rate of discharge for most storage batteries is the 8-hour rate, but if a lower rate can be used it is advantageous to do so. The voltage delivered by a storage cell is 2 volts, and sufficient cells must be connected in series to give the required voltage. Sufficient cells to provide the necessary current drain over a reasonable period of time must be connected in parallel. Suppose, for example, a particular piece of equipment requires 30 amperes at 24 volts for its operation, and that only batteries BB-29 are available. The rating of the battery BB-29 is 4 volts and 80 ampere-hours. The 8-hour discharge rate of this battery is 80 divided by 8, or 10 amperes. Since 30 amperes are required, 3 cells in parallel must be used if the 8-hour rate is not to be exceeded. To give 24 volts, 6 batteries must be connected in series. Therefore, three parallel sets of 6 batteries BB-29 in series (18 batteries, or 36 cells in all) are required to operate this equipment for 8 hours (see fig. 8). This is an unusual requirement (720 watts), and usually from 1 to 6 batteries BB-29 will operate the equipment likely to be encountered in the field. In an emergency, 24 volts at 30 amperes might be provided by 12 batteries BB-29, connected as two parallel sets of 6 batteries in series, but the drain on the batteries would be excessive and their discharge time would be *less* than ⅔ of 8 hours. For intermittent use in an emergency, this connection would probably give very satisfactory service. If plenty of batteries were available, it would be advantageous to connect 24, 30, or even more batteries (in groups of 6) in

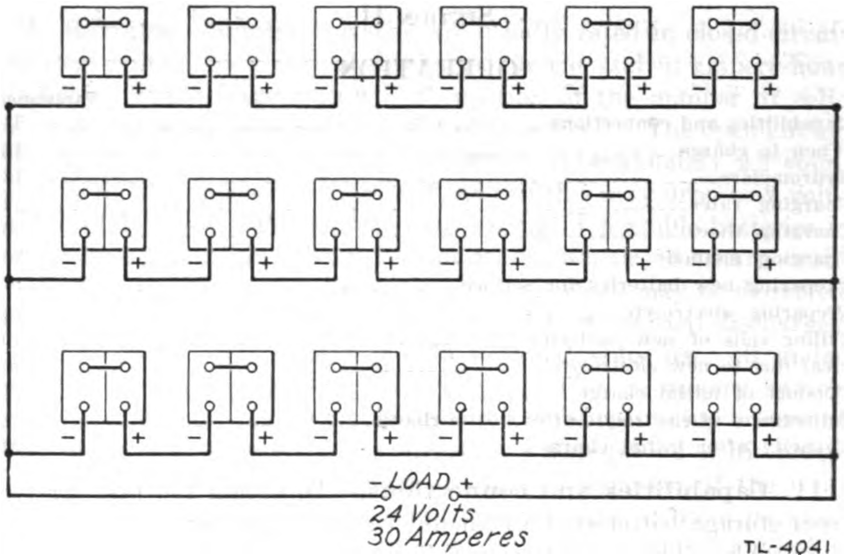

FIGURE 8.—Method of connecting batteries for heavy loads. (Those shown are batteries BB-29, connected to deliver 24 volts at 30 amperes for 8 hours.)

the circuit, thereby reducing the drain on each battery below the 8-hour rate, and extending the discharge time.

12. When to charge.—The most advantageous time to charge a storage battery is immediately after it has been used to any extent. In any event, a battery should be charged immediately if its specific gravity has fallen to 1.150. Batteries should never be left in a discharged condition longer than is absolutely necessary. Allowing a battery to remain in a partially or completely discharged condition for excessive periods of time causes the lead sulphate on the plates (see par. 3*a*) to become crystallized, thereby making it next to impossible to charge the battery without removing large amounts of active material from the plates. This is ruinous to the battery (see par. 37). In addition to this, the sulphate coating over the active material is a nonconductor and it is difficult or impossible to pass charging current through the battery.

13. Hydrometers.—*a.* A convenient tool for making rapid measurements of specific gravity of electrolyte is the hydrometer. The syringe type hydrometer consists of a glass syringe containing a glass hydrometer float (see fig. 9). The float is a long-necked bottle, weighted in the lower end and having a long, thin neck graduated from 1.100 to 1.300. Electrolyte is sucked into the syringe until the float is floated by the electrolyte. The division of the scale in line with the surface of the electrolyte in the syringe indicates the specific gravity of the electrolyte (see fig. 10). In common practice, the decimal point is omitted from hydrometer readings; thus, the specific gravities in figure 10 are read as 1275, 1200, and 1150. In stationary batteries without covers, a hydrometer consisting of the float only is used and is left floating in one cell which is called a pilot cell.

b. Care should be exercised in using the syringe hydrometer. The electrolyte should be drawn in slowly to prevent breakage of the float against the top of the syringe; similarly the electrolyte should be

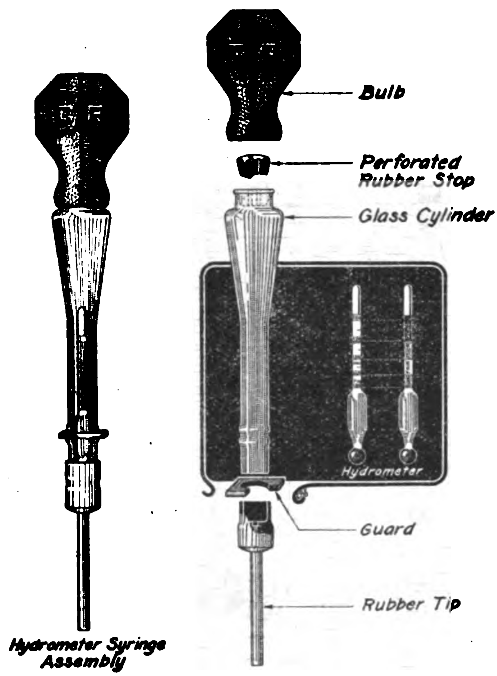

FIGURE 9.—Hydrometer HY-2.

expelled gradually to avoid breaking the float against the bottom of the syringe. The instrument must be held upright while taking a reading, otherwise the float may stick against the side of the syringe. Hydrometers should always be tested against a standard instrument before being put into service.

c. Hydrometer readings should always be corrected for temperature. This is done by adding 0.001 (or simply 1 in common practice) for every 2½° above 80° F., or by subtracting a like amount for every 2½° below 80° F. A correction table is given in figure 11.

To use this chart, add (or subtract) the figure opposite the temperature reading to the temperature reading. For example, a hydrometer reading of 1280 at 40° F. should be 1280 − 16 = 1264; a reading of 1210 at 110° F. should be 1210 + 12 = 1222.

d. Another type of specific gravity indicator, which is used in cells having glass containers, consists of two balls of different specific gravities and different colors, each about ¼ inch in diameter. They

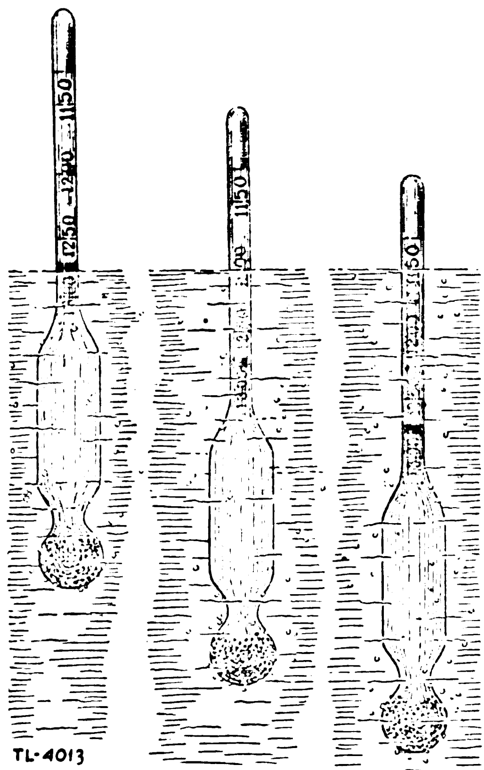

FIGURE 10.—Hydrometer readings. (Those shown are 1.275, 1.200, and 1.150 from left to right.)

are confined in a vertical cage against the container wall. When both float, the battery is approximately fully charged. When one sinks, the battery is partly discharged; when both sink, it is discharged and should be recharged. This method is unreliable above 110° F. and thereafter if the balls have ever been heated to such a temperature.

14. Charging rates.—The charging rate of a storage battery depends upon several factors, among which are the ampere-hour rating of the battery, its age, its previous history, and the charging method used (see par. 16). Under no circumstances should a battery be charged at a rate which causes the temperature of its electrolyte to rise above 110° F. A battery placed on charge should be carefully watched for several minutes for excessive gassing, which indicates too high a charging rate. Gassing is the giving off of many small bubbles at such a rate as to make a hissing sound. The occasional gurgling or bubbling sound from a battery on charge is normal and should not be confused with the hissing sound of excessive gassing.

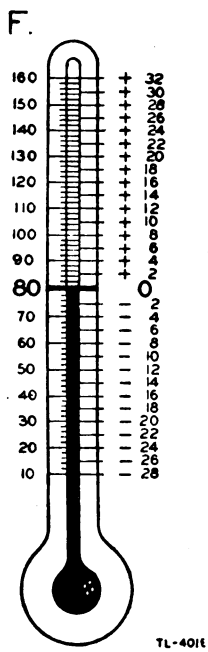

FIGURE 11.—Temperature correction chart for hydrometer readings.

Caution: *The gas given off by storage batteries is a mixture of hydrogen and oxygen and is highly explosive. No flame or spark should be allowed near batteries which are on charge or discharge.* Any rate which does not cause excessive gassing or excessive temperature rise may be used, although when high starting rates (50 percent of rated ampere-hour capacity or more) are used the batteries should be carefully watched.

15. Charging time.—Charging should always be continued until the battery is fully charged. Readings of specific gravity (corrected for electrolyte temperature) and cell voltage should be made every half hour, and charging continued until no rise in either occurs on any one of four successive readings (1½ hours' time). Accurate records of the progress of batteries on charge should be kept by the charging-station attendants. For this purpose, charts should be made for 24-hour intervals, divided into columns for half-hourly intervals, and providing space for the largest number of batteries which the charging equipment is capable of handling at one time. Provision should be made for entering batteries on the chart at any time. Each half-hourly reading for a battery should consist of a reading of specific gravity and a reading of terminal voltage (with normal charging current flowing) for each cell. If more than one type of battery is handled, separate charts may be made for two-cell, three-cell, and six-cell batteries. A convenient form for use with stationary batteries is W. D., S. C. Form No. 1173 (Storage Battery Report). By recording all the readings indicated, all question of the state and progress of charge of each battery will be eliminated, and the liability of undercharging or overcharging will be reduced. The specific gravity (corrected for electrolyte temperature) of the electrolyte should be between 1.270 and 1.300, and the cell voltage 2.3 to 2.5 volts (with half the normal charging current, or a current equal to 5 percent of the ampere-hour rating, flowing) when the battery is fully charged. In general, the time necessary to charge fully a discharged battery will be such that more ampere-hours will be put into the battery than it is capable of delivering. This is due to various losses in the battery, such as heat, local chemical action in the cells, electrolysis, etc. The actual ampere-hours necessary for full charge depend on the condition and starting state of charge of the battery. The charging time may be reduced materially by the use of a tapered charging rate, which is one which starts at a high current and gradually decreases to 5 percent of the ampere-hour capacity of the battery at full charge (see par. 16*b*). Batteries on taper charge should be carefully watched during the first hour for excessive temperature rise or gassing.

16. Charging methods.—All charging methods are fundamentally alike, in that they are all methods of applying unidirectional (direct) current of the proper voltage and current for charging. The most common methods are by the use of resistances in series with d-c mains, d-c generators, and rectifiers. Supplementary parts of battery chargers are regulating controls (rheostats or lamp banks) and measuring instruments (voltmeters and ammeters). Rectifiers are commonly used in charging stationary type storage batteries used in such installations as fixed station common battery telephone installations. The method of charging generally used in fixed installations is trickle charging and this should always be conducted in accordance with instructions supplied with the battery by the manufacturer. Portable batteries, such as the BB-29, used for field radio equipment may be charged by the use of rectifiers (see TM 10-580) or by the use of the battery charging set SCR-169 which supplies a voltage of 32 volts and may be used for either constant-current or constant-voltage charging, depending upon the number and arrangement of the batteries being charged see TM 11-302).

a. Constant-current charging.—When a voltage source considerably higher than that necessary for charging is used, through appropriate dropping resistors, lamp banks, etc. (see fig. 12), the variations in battery voltage are small compared to the voltage across the dropping resistors, and the current remains practically constant

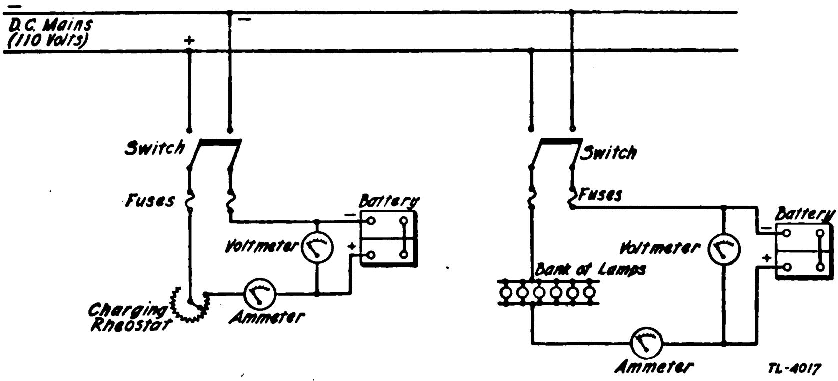

FIGURE 12.—Constant-current charging, showing connections for rheostat and bank of lamps.

throughout the charging period. This method of charging requires almost constant attention, since excessive overcharging (see par. 38) may easily take place. If a number of batteries are to be charged together, this difficulty may be largely overcome by connecting them in series, thereby decreasing the difference between the line voltage and the battery voltage, and making the method approach more nearly the constant-voltage method (see *b* below). Series connection is also more economical than separate charging from the d-c mains, because as much power is required to charge one battery as several. A safe charging current for constant-current charging is one-eighth of the 8-hour rating in ampere-hours of the battery, reduced to half of that value as the battery approaches full charge. Care should be taken that the charging rate is not too high, as evidenced by excessive gassing or temperature rise (see pars. 14 and 37).

b. Constant-voltage charging.—The time required for charging can be reduced by the use of a tapering current (see par. 15). If a source of constant voltage equal to 2.5 volts per cell is used, this is accomplished automatically (see fig. 13). The initial charging current under these conditions is much higher than the normal rate, sometimes several times the normal rate, but the current drops rapidly as the battery charges, until at full charge the current is approximately half the normal rate. Care should be taken to ascertain that the initial rate is not too high, as evidenced by excessive gassing. After the charging current drops to the normal value, little attention to batteries on taper charge is required, since the charging rate decreases automatically as the batteries become charged.

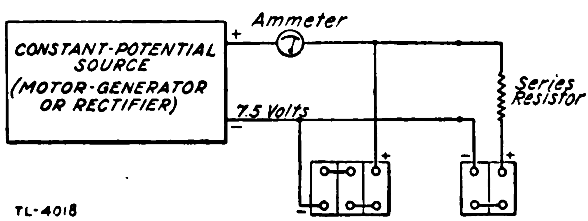

FIGURE 13.—Constant-voltage (automatic taper) charging, showing connections for 2- and 3-cell batteries.

c. High-rate charging.—Various types of high-current chargers for rapid charging of storage batteries are being developed commercially. These chargers deliver an extremely high current (100 amperes or more) initially, dropping rapidly to a normal value. They charge batteries in a very short time but are capable of completely destroying a battery if not controlled intelligently. They are not used at present by the Signal Corps.

d. Trickle charging.—Trickle charging is the continuous application of low charging current and is usually a constant-voltage method. This maintains the maximum electrolyte specific gravity and insures that the batteries will remain at full charge over long periods of time. It is particularly well suited to batteries which are used intermittently over long periods of time, such as stationary batteries. Trickle charging may be accomplished by any device capable of delivering 1 percent or 2 percent of the ampere-hour rating of the battery, or sometimes as high as 5 percent if the intermittent loads are heavy.

e. Overcharging.—Occasional overcharging, as indicated by cells gassing freely, is beneficial to batteries, but if carried to excess may destroy the plates (see par. 38).

17. Preparing new batteries for service.—New batteries may be received in either a wet or a dry condition.

a. Batteries shipped wet are always fully charged before shipping and may be put into service immediately, although a finishing charge at half the normal rate is advisable.

b. Batteries shipped dry must be filled with electrolyte and given the initial charge before being put into service. Instructions stating the amount and specific gravity of the electrolyte necessary, as well as the rate and time of the initial charge, are usually provided with new batteries. The vent plugs of a battery shipped dry are ordinarily sealed and should not be removed until the battery is to be filled and charged. If the plugs are not disturbed and the battery is properly stored (see par. 41), it may be stored dry over periods of many months without harmful effects.

18. Preparing electrolyte.—Sulphuric acid for electrolyte may be furnished as pure acid, as dilute acid of 1.400 specific gravity, or as dilute acid of 1.300 specific gravity. Unless furnished at the proper specific gravity for use, it must always be diluted to the proper specific gravity (1.300 unless otherwise specified by the manufacturer) by adding to distilled water.

a. When pure sulphuric acid (specific gravity 1.835) is furnished, great care must be exercised in its dilution, because heat is always developed when water and sulphuric acid are mixed. A container of suitable size, which will not be acted upon by sulphuric acid, should be used. ***Caution:*** *Never pour water into acid—pour the acid into water, and go slowly, stirring the mixture gently but thoroughly meanwhile. Large quantities of acid may require hours for safe dilution. Always correct hydrometer readings for temperature when measuring specific gravity of the mixture; otherwise the specific gravity will be too high when the mixture cools.*

b. If acid at 1.400 specific gravity is furnished, distilled water may safely be added slowly to it, if stirred vigorously meanwhile, since 1.400 specific gravity acid has already been made by mixing sulphuric acid and water. Not as much heat will be developed when diluting 1.400 specific gravity acid as when pure acid is added to distilled water.

c. In diluting sulphuric acid of specific gravities 1.835 or 1.400 to suitable specific gravities for use in storage batteries, it is desirable to use a table to determine the quantities by volume which should be mixed. This is because the total volume shrinks somewhat after mixing, with the result that calculations as to volume-weight relationships after mixing cannot be determined from those before mixing by simple arithmetic. Below is a table which gives proportions by volume of water and sulphuric acid which should be mixed in order to obtain a limited number of specific gravities commonly used in storage batteries.

When mixing by volume using 1.835 acid		Specific gravity desired, 80° F.	When mixing by volume using 1.400 acid	
Parts water required	to Part acid required		Parts water required	to Part acid required
1. 97	1	1. 350	0. 16	1
2. 50	1	1. 300	. 37	1
2. 90	1	1. 270	. 55	1
3. 24	1	1. 250	. 69	1
3. 77	1	1. 225	. 90	1
4. 13	1	1. 210	1. 04	1
4. 40	1	1. 200	1. 15	1

19. Filling cells of new batteries.—A hard rubber or glass funnel is suitable for filling cells. If these are not available, the electrolyte may be poured from a glass pitcher into the cells, or a temporary funnel may be made of paper to answer the purpose. After filling, the cells should be allowed to stand for 15 minutes, when they should have electrolyte added as necessary to make up for that absorbed by the plates and separators. The battery should then be allowed to stand 8 or 10 hours, when the cells should once more be filled to the proper level. Any electrolyte spilled on the outside of the battery should be washed off with water.

20. Heat due to new electrolyte.—When electrolyte is first placed in new batteries, heat will immediately be developed, sometimes raising the temperature of the electrolyte above 110° F. This cannot be avoided, but the batteries should not be placed on charge until cooled to atmospheric temperature.

21. Conduct of initial charge.—Instructions for giving a specific battery its initial charge are generally supplied with the battery. The general principles followed by these instructions are similar to those in *a* to *d*, inclusive, below.

a. Before charging, remove vent plugs and fill each cell with 1.300 specific gravity electrolyte to a height of 3/8 inch* above the top of the

*This height varies with types and manufacturers of batteries.

separators. After 15 minutes, go over the cells and fill again to this height to make up for electrolyte absorbed by the plates.

b. Allow the battery to stand 8 to 10 hours and add more electrolyte if the level has fallen.

c. Charge the battery at a current numerically equal to 5 percent of the ampere-hour capacity (i. e., 5% of 80=4 amperes for an 80 ampere-hour battery) for a period of from 70 to 80 hours. Reduce the charging current if necessary to keep the electrolyte temperature below 110° F., but the full number of ampere-hours must be put in. Never discontinue the charge until maximum specific gravity and cell voltage have been obtained.

d. After the battery is completely charged, adjust the specific gravity of the electrolyte to 1.300 unless otherwise prescribed by the manufacturer. Wipe off any electrolyte that has gassed over on the rubber cover.

e. More time than the instructions indicate may be required to charge a new battery completely. The specific gravity may rise much higher than 1.310, but in any case *the initial charge must be continued until the specific gravity has attained its highest reading for a period of at least 2 hours.*

22. Adjustment of electrolyte after initial charge.—After the initial charge, the specific gravity of the electrolyte should be adjusted to 1.300. To accomplish this, some of the electrolyte should be withdrawn from the cells with the hydrometer syringe and replaced by—

a. Distilled water if the specific gravity is above 1.300, or

b. 1.400 specific gravity acid if the specific gravity is below 1.300. Batteries thus treated should again be placed on charge at the same rate as the initial charge for 2 or 3 hours to mix the electrolyte. If still too high or too low after the mixing charge, repeat the adjusting and mixing operations.

23. Capacity after initial charge.—The capacity of any storage battery under normal conditions is only from 75 to 80 percent as great directly after its initial charge as it will be after the battery has had a few cycles of charge and discharge. Therefore, batteries should not be sent into the field to function at their full capacity immediately after their initial charge.

SECTION III

MAINTENANCE

24. Charge and discharge schedule.—The most important point in the care of storage batteries is that they should never be allowed to remain in a discharged condition any longer than is absolutely necessary. Stationary batteries should be charged and the condition of charge should be verified in accordance with the manufacturer's instructions. For portable batteries, tactical units using storage-battery powered equipment should be furnished charging equipment capable of reducing this time to a minimum. For example, a divisional signal company is furnished battery-charging equipment for charging Signal Corps storage batteries of all units of the division. All spare batteries on hand should be kept at the charging station so that they may periodically be given a freshening charge. A schedule may be worked out by the charging-station attendants whereby all spare batteries on hand will be placed on charge at regular intervals, for example, 2 hours every 2 weeks at 5 percent of rated capacity. If facilities for continuous trickle charge (1 percent or 2 percent of rated capacity) are available, all batteries not in use may be kept freshly charged over long periods of time. To obtain maximum life of the batteries they should be used in rotation, rather than having some batteries stand idle continuously while others go through rapid successive charges and discharges.

25. Electrolyte level.—The electrolyte should be maintained at its proper level (3/8 inch or more above the top of the separators, as specified by the manufacturer) by regular addition of distilled water. A certain method of ruining a storage battery is to allow the level of the electrolyte to remain below the top of the separators over a period of time. (See par. 33.)

26. Exposed metal parts.—Any electrolyte spilled on the outside of a storage battery should be wiped off with a cloth moistened with ammonia or soda solution (see par. 31), since it may come in contact with exposed metal parts and cause corrosion. Terminals may be protected from corrosion to some extent by coating with petrolatum; cell connectors and other metal parts by coating with petrolatum or painting with melted paraffin.

27. Indications of condition of storage batteries.—When batteries are returned to a charging station for attention, the first thing to be done is to determine their condition. There are several ways of accomplishing this, among which the following are probably the easiest and most reliable:

a. Take specific gravity readings of the electrolyte. If the specific gravity is approximately 1.200, a normal discharged condition is indicated. If no report of trouble with the battery is received, it is safe to charge it at its normal rate. If the specific gravity is approximately 1.250, this indicates that the battery is nearly half discharged, assuming the battery is in good condition. If no report of trouble with the battery is received, it should be placed on charge at its normal rate.

b. If a report is received that the battery would not hold its charge, was not very active, or any other report indicating unsatisfactory service, specific gravity readings of each cell and voltage of each cell under normal discharge should be taken.

(1) If all cells show about the same low specific gravity of 1.150 and terminal voltage of 1.75 volts or less at the normal discharge rate, it is probable that the battery has been subjected to accidental overdischarge, such as leaving a radio set turned on all night. In this case, the battery should be placed on charge at the normal rate.

(2) If one cell shows lower specific gravity than the others, or if its voltage under normal discharge is lower than the other cells, this cell may have internal trouble. The first thing to be done in this case is to place the battery on charge at its normal rate until the better cell or cells have reached their maximum specific gravity, when they should be cut out of the circuit and the charging of the low cell continued. The charge of the poor cell should be carried on until it has been definitely shown that the electrolyte has risen to its highest specific gravity and the cell's voltage will rise no higher. This may require many hours, and excessive heating may

require reduction of the charging rate. If the cell will not come up to normal specific gravity and voltage, look for internal trouble.

28. Troubles and remedies.—Paragraphs 29 to 40, inclusive, deal with a number of maintenance troubles encountered in caring for storage batteries and appropriate remedies for these troubles. It will be noted in many cases that the remedies include instructions for removing the groups of plates and direct treatment or replacement of plates and separators. This is practical in most types of stationary batteries and it can be done with some types of portable batteries such as the BB-29, for which it is possible to obtain replacement parts. It is not a very practical procedure with automobile type storage batteries because the amount of labor involved is frequently more costly than the price of a new battery. Removal and replacement of plates, both in automobile type batteries and in Signal Corps portable batteries such as the BB-29, should be done only by highly skilled technicians.

29. Loss of capacity.—*a. Indications and effects.*—(1) Battery will not deliver its rated current for the proper length of time.

(2) Specific gravity rapidly decreases after charging.

b. Causes.—(1) Clogging of pores of plates or separators with sulphate or other impurities, due to abuse.

(2) Contraction of the pores of the plates due to overcharging.

(3) Loss of active material from the grid. This is the most usual cause of loss of capacity (see par. 37).

(4) Formation of a layer of sulphate on the grids of the plates. This condition generally results in break-down of the plates and will necessitate replacing the unserviceable parts, or discarding the battery, depending upon its type.

(5) Loss of electrolyte.

(6) Low temperature.

(7) Charging and discharging at an excessively high rate, particularly discharging.

(8) Overcharging for long periods.

(9) Short circuits, internal or external. External short circuits may be caused by spilling electrolyte on the outside of the cell.

(10) Oversulphation.

(11) Normal wear. After a battery has been in service for an extended period, it is natural that its capacity be less than when new. The normal life expectancy of a storage battery is discussed in paragraph 10.

c. Remedies.—It is always a safe procedure to put batteries which show indications of trouble on charge at a normal rate and try to bring their specific gravity to normal. This action will provide a simple means for accurately judging the condition of a battery. If the battery has been given a normal charge and the specific gravity rises to its maximum, around 1.240 for example, the battery should then be placed on test discharge at the normal rate and readings of both specific gravity and voltage should be taken every 30 minutes. This test will indicate the number of hours of service which the battery will give. When the voltage per cell falls to 1.75, the battery has reached its normal discharge voltage. This is the indicator of capacity performance and the battery has done all it can do in its condition. If this test indicates that one or more cells are in bad condition and the battery has been in service a long time, the battery should be declared unserviceable.

30. Abnormal sulphation.—*a. Indications and effects.*—(1) Light color of both the positive and negative plates.

(2) Loss of capacity.

(3) Continued low specific gravity.

(4) Hardening of the plates.

(5) High internal resistance, which may be indicated by an abnormally high charging voltage or an abnormally low discharge voltage.

(6) Loosening of active materials.

(7) Buckling of positive plates (see fig. 14).

(8) Abnormal length of time required for charging.

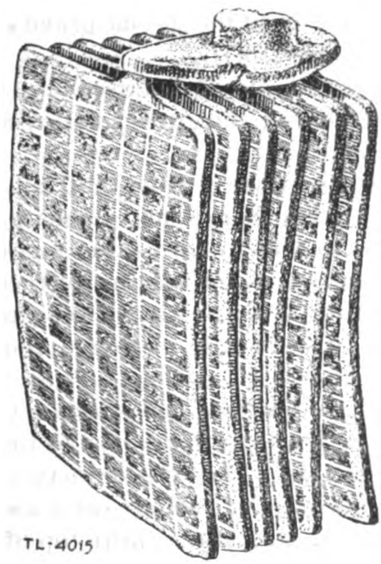

FIGURE 14.—Group of buckled plates, such as caused by abnormal sulphation or excessive heating.

(9) Low open-circuit voltage.

(10) Low charging current under normal charging voltage.

b. Causes.—(1) Neglect or misuse.

(2) Standing idle in a discharged condition too long.

(3) Habitual undercharging. That is, instead of carrying the charge to its completion where the specific gravity reading should have risen to its highest value and stayed at that value for at least 1½ hours, the charge is cut off before this condition has been obtained. Therefore, all of the sulphate has not been converted into active material.

(4) Electrolyte level too low.

(5) Neglecting trouble in individual cells of a battery.

(6) Adding raw acid or electrolyte to bring up the specific gravity of the cell when it is in a discharged or partially discharged condition. One of the most common mistakes made in storage-battery work is to give what is called a *quick* charge. This is ordinarily done by adding acid to the battery to bring up its specific gravity. For a very short time the battery will function under a nearly normal condition. The ultimate result, however, is complete break-down of the entire battery.

c. Remedy.—When a cell is not too badly sulphated, it is possible in the majority of instances to remove the sulphate from the plate and convert it into active material by long successive charges at low rates. During each charge the specific gravity should rise. It may rise to its normal value. If successive charges do not accomplish this, proceed as follows:

(1) Charge the battery until the specific gravity will rise no higher.

(2) Throw away the electrolyte.

(3) Fill the battery with distilled water.

(4) Charge it until the specific gravity will rise no higher.

(5) Throw away the water.

(6) Fill with fresh electrolyte of from 1.330 to 1.340 specific gravity.

(7) Put through several charges and discharges at normal rates. If the sulphate is not removed by this, either repeat the process, or, if the condition of the plates does not warrant further use of the battery, discard it. Be sure the specific gravity of the electrolyte is adjusted to the proper value after the last discharge and charge have been made.

31. Corrosion.—*a. Indications and effects.*—(1) Gradual deterioration and eventual destruction of any part of the battery which can be acted upon by electrolyte. The exterior metal parts of the battery, such as spring clips on covers, if any, are eaten away. The corrosion may cover the external metal and the entire top of the battery with a greenish white substance. Terminals are weakened and easily broken.

(2) Increased resistance indicated by a decreased capacity and terminal voltage while in use although a hydrometer reading of specific gravity of 1.250 to 1.300 may be indicated. There may be no indication of loose connections. The positive terminal of a battery is more susceptible to corrosion than the negative terminal, due to electrolytic action.

b. Causes.—(1) Carelessness, dust, dirt, moisture; the last particularly in the Tropics.

(2) Neglect; loose or dirty connections. The electrolytic action is greater with a loose connection than with a tight one.

(3) Adding so much water to a cell as to cause it to overflow when the battery is being charged and is gassing freely. (The electrolyte expands when charging, due to heat and the formation of bubbles.)

(4) When gassing, electrolyte is thrown out of the cell in a fine spray by the escaping bubbles, and it will attack the exterior metal parts and cause their rapid sulphation. This may result in the total loss of the battery.

(5) Poor sealing.

c. Remedies.—Use the following procedure:

(1) If the cells of the battery are interconnected by wires, remove the wires and clean them.

(2) Brush the corroded parts thoroughly with a wire brush. Make a mixture of baking soda and water to the consistency of a thin cream. Apply this mixture to the metal parts, making fresh applications until any gassing action ceases, or, in other words, until the acid has been neutralized by the soda and water. Other suitable naturalizing substances are ammonia solution or a concentrated solution of washing soda prepared by dissolving common washing soda in warm water. After neutralization has been completed, thoroughly wash the top of the battery with water and dry with a cloth. Care should be taken to see that the neutralizing material thoroughly enters each little crevice or opening between terminals or other exterior parts of the battery in order to complete the neutralizing action. ***Caution:*** *Do not allow the neutralizing mixture to enter the cells through the vent openings as this will ruin the battery.*

(3) When dry, brush the metal parts with a wire brush.

(4) Examine all of the connections and repair any poor ones.

(5) Apply petrolatum to the assembled and cleaned parts of the battery when dry.

(6) When a sealed battery is in use, the vent plugs should be kept tightly in place. This prevents electrolyte spilling and splashing. If a battery becomes wet it should be gone over before it dries with a

cloth moistened with ammonia or soda solution, and dried with a dry cloth. This neutralizes the acid and prevents corrosion.

32. Cracked or broken containers.—*a. Indications and effects.*—(1) The electrolyte gradually becomes diluted due to leakage, as indicated by the specific gravity not rising to its proper value upon charge; the capacity of the cell may diminish, and it may not develop proper voltage upon discharge.

(2) If there are any metal binders, screws, handles, etc., on the case they eventually will be eaten away by the leaking electrolyte.

(3) It becomes necessary to add much more water to the electrolyte of a cell whose container is broken than to the other cell or cells of the battery.

b. Causes.—(1) Vibration.

(2) Slight falls, such as a drop from a height of 1 or 2 inches upon a concrete floor or rough handling of the battery when loading it into a truck, might crack the container.

c. Remedies.—(1) Tear the battery down.

(2) Replace the broken container with a serviceable one. If the old container is so badly broken it will not hold electrolyte, provision must be made for keeping the plates and separators in water until a new container is available.

(3) Adjust the electrolyte to the specific gravity consistent with the condition of the battery. The proper specific gravity is sometimes difficult to determine. In cases where the battery's condition is not definitely known, that is, whether the battery is charged or discharged, it is best to add electrolyte of 1.250 specific gravity to the reassembled battery, charge it at a normal rate, and adjust the specific gravity to its proper value after it is known that the charge has been completed.

33. Consistently low electrolyte.—*a. Indication and effects.*—(1) Decreased voltage; capacity decreases in proportion to surface of plates uncovered.

(2) A band of gray sulphate across the plates indicating where they have been exposed..

(3) Rotted separators.

b. Causes.—(1) Lack of proper maintenance—not replacing the evaporated water promptly.

(2) Excessive evaporation due to some internal abnormality.

(3) Loss of electrolyte due to spilling or flooding battery. This may easily take place in field work where batteries are tipped over and some of the electrolyte is spilled.

(4) Loss of electrolyte due to leakage or broken container.

(5) Excessive gassing, indicating excessive local action which is due to some detrimental local condition.

c. Remedies.—If the condition has not lasted too long, add water to bring the electrolyte level ½ inch above the top of the plates, give the battery a long, low rate (one-half normal) charge, and continue to operate the battery. *Electrolyte should never be added to a cell under any circumstances unless it is definitely known that electrolyte has been lost from the cell.* When it becomes necessary to add electrolyte, never add it in the form of raw, concentrated acid but in a dilute form of not over 1.400 specific gravity. After the electrolyte has been adjusted, place the cell or cells on charge at the normal rate and readjust the specific gravity at the end of a complete charge. Repeat the readjustment of the specific gravity until continued charging fails to increase it above a proper maximum. Very often, the excessive use of water by a cell indicates that the cell is not in good internal condition. Where there is internal action, due often to a short circuit or partial short circuit, there will be more or less constant chemical action which uses up water in the electrolyte. Regardless of whether or not the cell is used, there is a certain amount of evaporation of water from the electrolyte. This water must be replaced, and sufficient replacement must be made to prevent the tops of the separators or plates becoming exposed to the air. When exposed to air, the plates will rapidly sulphate or oxidize and render the exposed portions inoperative. Batteries not in use should be filled with water once every 2 weeks in temperate climates, and once every week in warm climates. While in use they should be filled as often as the electrolyte drops to a dangerous level.

34. Freezing.—*a. Indications and effects.*—(1) Broken containers.

(2) Disintegration of active materials.

(3) Broken separators.

b. Causes.—Exposure to low temperatures when partially or fully discharged, or after adding water without placing the battery on charge to mix the electrolyte.

c. Remedies.—(1) Gradually let the battery thaw out by placing it in a room of normal temperature (about 73° F.). The battery may be saved if the freezing has not progressed too far.

(2) If necessary to prevent freezing, place batteries on trickle charge. This will keep up the specific gravity and, as indicated in the table in *d* below, abnormally low temperatures will be required to cause freezing. Never permit a battery to remain discharged at low temperatures.

(3) Take readings of specific gravity at proper intervals to insure that there is no abnormal drop in the specific gravity of the electrolyte. If water is added to the battery in freezing weather and not immediately mixed into the electrolyte by charging, the water will float on top of the electrolyte, since it is lighter, and may freeze.

d. A table indicating the freezing point of electrolytes of various specific gravities is given below:

Specific gravity	Freezing point	Specific gravity	Freezing point
1.000 (water)	32° F. above 0.	1.200	16° F. below 0.
1.100	18° F. above 0.	1.250	62° F. below 0.
1.150	5° F. above 0.	1.300	95° F. below 0.

Low temperatures greatly reduce the available capacity of a battery, but the normal capacity should be regained with the operation of the battery under normal temperature.

35. Frothing.—*a. Indications and effects.*—An evolution of persistent bubbles or foam in the vent-plug opening.

b. Cause.—Impurities in the cells, such as animal fat or oil.

c. Remedies.—(1) Condition of frothing usually cures itself by carrying the impurities out of the cell in the foam.

(2) If frothing continues for any length of time, empty the cell and renew the electrolyte.

(3) If the procedure prescribed in (2) above does not completely remedy the condition, the cell should be torn down and the plates examined to determine whether or not the cell should be declared unserviceable.

36. Impurities in electrolyte.—*a. Indications and effects.*—(1) Abnormal sulphation.

(2) Clogged separators, particularly rubber separators.

(3) Rapid deterioration of plates and separators.

(4) Frothing.

(5) Specific gravity drops quickly when discharging.

(6) A continued condition of low voltage per cell, which condition will prevail even when the battery is charging. This voltage may be 2.1 to 2.2 per cell and remain at this value even when the charge should be complete.

(7) Discoloration of plates and separators.

(8) Excessive local action.

b. Causes.—(1) Impurities may be present in the acid or plates. Proper precautions should be taken by purchasing agents in obtaining pure acid and high-grade plates to prevent this.

(2) Impurities may be introduced into the cell by using water containing mineral salts, such as those occurring in water used for drinking purposes. A common error is to believe that boiling water will clarify it of impurities and thus make it suitable for use in storage batteries. The only method of purifying water for battery work is distillation. Distillation will remove metallic salts or metals themselves if the distilling apparatus is constructed of materials which will not rust or oxidize.

(3) The use of freak electrolytes which may be very injurious.

(4) Using a hydrometer that has been used in Edison or other alkaline batteries.

(5) Presence of oils or greases. These may get into the cell through carelessness and will cause a rapid drop of capacity.

c. Remedies.—(1) Pour out the old electrolyte and fill the cell with water. Charge it for 3 or 4 hours. Replace this water with fresh water and charge again for about an hour. Again remove the water and immediately replace with fresh electrolyte at about 1.300 specific gravity.

(2) Adjust the specific gravity of the electrolyte after charging the cell completely.

37. Loss of active material.—*a. Indications and effects.*—(1) It may be necessary partially to remove the plates from the container to see the deterioration, but this should be done when there is any suspicion of loss of active material. The condition may often become apparent before charging. If the electrolyte seen in a hydrometer syringe is brown, this indicates active material in suspension which must have come from the plates.

(2) Excessive sediment in the bottom of the cells is the best indicator of loss of active material from the plates. The active material is heavier than the electrolyte and will sink to the bottom of the cell. Even under ideal conditions, sediment will accumulate in time. It is a conductor of electricity, and, if not removed in time, will short-circuit the cell and ruin it.

(3) Other indications of loss of active material are losses in capacity as discussed in preceding paragraphs.

b. Causes.—(1) Age.

(2) Overdischarging causes excessive sulphation. The active materials, if loosened from the grid, fall to the bottom of the cell. This shedding is hastened by any condition causing abnormal sulphation.

(3) Overcharging, if carried to excess, causes the conversion of the grid wires into active material. Upon discharge in this condition, the grid wires will become sulphated, and since this sulphate is on

the inside of the plate, it is unlikely that it will ever be converted back into active material. This conversion of the grid into active material and thence into sulphate defeats the purpose of the grid—that of supplying mechanical strength and electrical conductivity to the plate; the entire structure is weakened and shedding of active material is hastened. Any loss of active material means a corresponding loss of capacity to the cell.

(4) When a discharged or sulphated battery is charged at too high a rate, excessive heat is developed due to the high internal resistance of the cell. This heat may cause the plates to buckle, thereby placing a strain upon the active material and allowing it to shed easily (see fig. 14).

(5) Short circuits cause an intense sulphation; this sulphate may eventually become crystallized and can never be completely reconverted into active material.

(6) Chemical processes are always accelerated by heat; thus when storage batteries are operated at abnormally high temperatures (above 110° F.), the plates sulphate excessively or the grid wires may form into active material and allow the active material of the plate to loosen (see par. 6).

c. Remedies.—(1) Where the sediment in a cell has accumulated to the extent that it may short-circuit the cell, the electrolyte and element should be removed, the container flushed out, and the element washed with distilled water. If the element is still in good condition, it may be replaced in the container with fresh electrolyte of the proper specific gravity. The cell should then be given a long charge at a low rate and put through a test discharge at the normal rate. If sufficient active material has been lost to reduce appreciably the capacity of the cell, the deteriorated plate groups should be discarded. It is not unusual to find one group of plates in better condition than the other, in which case the poorer group should be replaced and the cell reassembled.

(2) If the battery must be operated in atmospheric temperatures greater than 110° F., reduce the specific gravity of the electrolyte (see par. 6).

38. Overcharging.—*a. Indications and effects.*—(1) Buckling of plates.

(2) Shedding of active materials.

(3) Overheating of the elements.

(4) Excessive loss of water.

(5) Excessive gassing.

(6) Excessive sediment.

(7) Conversion of the grid wires to active material. This always happens when overcharging is carried to excess.

b. Causes.—(1) Misunderstanding or carelessness on the part of the handler.

(2) Defective regulating equipment.

c. Remedy.—Prevent repeated overcharge by examination of the regulating equipment and clear up any misunderstanding on the part of the attendant as to the proper rate and time of charge. Consult the directions given with each battery regarding the proper rate and time of charge.

NOTE.—Occasional overcharging is beneficial but habitual overcharging decreases the life of a battery.

39. Reversal of polarity.—*a. Indications and effects.*—(1) Loss of capacity.

(2) If long continued, the plates will be destroyed.

(3) The active material becomes rough or sanded.

In the negative plate, the spongy lead shrinks and becomes solidified. This condition can best be described by stating that if a portion of the negative active material is dug out on the point of a knife, it will feel like fine sand when rubbed between the fingers.

b. Causes.—(1) Overdischarging a cell of low capacity in series with cells of higher capacity. The high-capacity cells will act as a charger to the low-capacity cell, with the terminals connected in the wrong direction.

(2) Charging the battery in the wrong direction, thus reversing all the cells. This is the most common cause of reversal of polarity, and is usually caused by carelessness on the part of the battery attendants, one battery in a group on charge being incorrectly connected. This severely oversulphates the plates.

c. Remedy.—If the reversal has not extended over too long a period, the plates may be restored to their normal condition by recharging at normal rates and continuing the charge until the cell is brought to its normal condition. Care should be taken to prevent overheating and overgassing. Although the specific gravity may not rise to its previous maximum, it will attain nearly as high a value, and can be adjusted after the maximum specific gravity has been definitely reached.

40. Short circuits.—*a. Indications and effects.*—(1) Continued low specific gravity readings as compared to other cells in the battery.

(2) Lower voltage on charge than other cells in the battery.

(3) Low open-circuit voltage. This should not be depended upon too much.

(4) Low voltage on discharge.
(5) Lack of capacity.
(6) Heating.
(7) Poor color of plates.

b. Causes.—(1) Worn-out or defective separators.
(2) Excessive sediment accumulation.
(3) Defective cell insulation.
(4) Buckled plates.
(5) Any other condition which causes electrical connection between positive and negative plates.

c. Remedies.—(1) Eliminate the cause of the short circuit.
(2) Replace defective parts, or, if too far gone, condemn the battery for further service.

SECTION IV

STORAGE AND SHIPMENT

41. Storage.—*a. Wet.*—The only definitely safe way of storing new or slightly used storage batteries without dismantling is wet storage. Batteries stored in this manner must be kept fully charged, either by a trickle charge applied continuously or by periodic charges. Distilled water should be added every 2 weeks to replace that lost by evaporation and electrolysis. Batteries may be stored several months in this manner and are available for immediate use at any moment.

b. Moist.—New batteries may be stored moist for a period of from 9 to 12 months (preferably not over 9 months). The batteries are fully charged, the electrolyte poured out (it may be stored separately and used again), the cells rinsed two or three times with water and drained for 15 minutes, and the vents closed and sealed with paraffin or sealing compound. Once stored in this manner, the batteries should not have their vent plugs disturbed until they are to be filled and charged.

c. Dry.—Batteries or their parts may be stored dry indefinitely. The plates are fully charged and dried, and may be stored in their containers or disassembled and stored separately. Wood separators are always removed and stored in water or weak electrolyte solution

(1 part of 1.200 specific gravity electrolyte to 10 parts of distilled water) in a hermetically sealed container. Rubber or spun glass separators may be stored dry. Wood separators cannot be stored dry since they will be attacked by air and will crack unless kept moist.

42. Removal from storage.—*a. Wet.*—Batteries on removal from wet storage are ready for immediate service and need no special treatment. The electrolyte level and specific gravity should be checked to be sure of the condition of the battery.

b. Moist.—Batteries which have been stored moist for more than 12 months should be opened and examined for cracked separators. When separators are in good condition, the battery may be reassembled and filled. The procedure for preparing the batteries for service is the same as new batteries (see pars. 17 to 23, incl.).

c. Dry.—Batteries stored dry must be treated as new batteries on their initial charge (see pars. 17 to 23, incl.). Before filling with electrolyte, examine the plates and separators and replace any not in good condition.

43. Preparation for shipment.—*a. Charged and filled.*—Batteries may be shipped with electrolyte, provided they are fully charged and the vent plugs sealed. Tags should be attached to the batteries stating the specific gravity of the electrolyte. When shipped in this manner, batteries should be used as soon as possible.

b. Charged and moist.—Batteries may be shipped charged and moist by preparing as for moist storage (see par. 42). Tags should be attached stating the specific gravity of the electrolyte to be used.

c. Dry.—Batteries may be shipped dry, either assembled with spacing boards in place of wood separators, or as disassembled parts. Batteries using only rubber or spun-glass separators may be completely assembled except for electrolyte, but wood separators must be shipped moist. When wood separators are to be shipped overseas or stored over long periods of time, it is advisable that they be hermetically sealed in a wooden or hard-rubber container and soaked in water or weak electrolyte solution. For domestic use, wood separators are often inclosed in paraffined paper while wet and are not hermetically sealed. A shipment of separators should not be opened until needed.

44. Shipping cases.—*a.* When shipping batteries, a shipping case should be made of 1½-inch lumber, so shaped as to prevent anyone from tipping the battery over. A space of 3 inches between the battery and the bottom and sides of the case should be allowed. This space should be packed with excelsior. Nail strongly. Before putting on the cover, place a piece of paraffined paper over the top of the battery and force a layer of excelsior tightly under the cover as the boards are put on. Mark the shipping case plainly, HANDLE WITH CARE.

b. In addition to the address and destination be sure to mark with the name of the shipper for identification on arrival.

c. When unfilled or filled batteries are shipped by freight, the proper classification in the United States is "Electric storage batteries assembled."

d. When filled batteries are shipped by express in the United States, caution labels marked ACID must be attached to each case.

45. Oversea shipment.—When shipping batteries overseas or where salt water is apt to come in contact with them, coat all exposed terminals, link connectors, etc., with melted paraffin to prevent corrosion.

46. Unpacking.—Keep the case and battery right side up when unpacking to avoid spilling electrolyte. Thoroughly brush off all dirt and excelsior and examine the case for cracks. Note height of electrolyte if battery has been shipped wet. If low, fill to proper height with distilled water and allow to stand for 10 hours; then inspect again for leakage of electrolyte.

SECTION V

CHARACTERISTICS

47. Special batteries for radio sonde.—Special meteorological batteries, classified as batteries BB–51 and BB–52, are being developed for use with the radio sonde ML–128. These are designed for operation at extremely low temperatures (−70° C.), with extreme light weight combined with high capacity for 2-hour periods (see fig. 15.) Due to the extremely small size of the batteries and the necessity of using very small vent holes for cells to avoid spilling electrolyte, it is necessary to use a hypodermic needle for filling the cells. The life expectancy of these types of batteries is approximately 20 cycles of charge and discharge, the short life being caused by the high specific gravity of the electrolyte necessary to withstand the low temperatures encountered when the cells are discharged. This condition exists because of the fact that as the altitude of the radio sonde increases, the batteries discharge, and at the same time the temperature decreases (see par. 34).

a. Battery BB–51.—The battery BB–51 (see fig. 15) is a 3-cell, 6-volt, plug-in storage battery designed to deliver 165 milliamperes (for tube filament and meteorograph motor) for a period of 2 hours. The specific gravity of its electrolyte at full charge is 1.350. The battery weighs approximately 5½ ounces when filled. Its charging rate is tentatively set at 165 milliamperes, tapering to 120 milliamperes in 4 or 5 hours. Because of the very small amount of electrolyte used, specific-gravity readings are not practicable, and the terminal

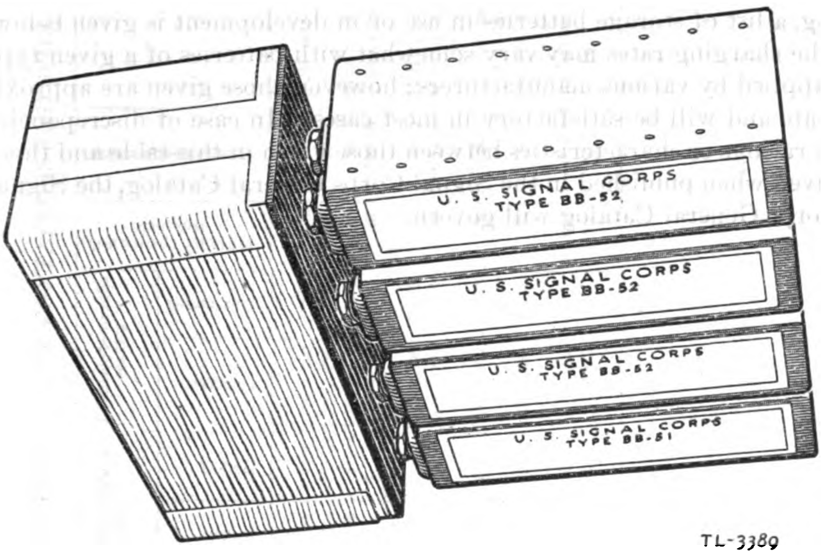

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FIGURE 15.—Power supply for radio sonde ML–128, showing battery BB–51 and 3 batteries BB–52. (A cover fits over the batteries and the jack box into which they are plugged.)

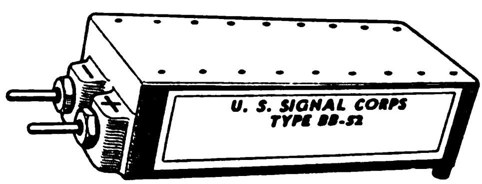

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FIGURE 16.—Battery BB–52. (Battery BB–51 is similar in appearance, except that there are only 6 filler holes, 2 for each cell; and the projections at the right are on the top instead of on the bottom.)

voltage with normal charging current flowing is taken as an indication of the battery's condition. At full charge its voltage should be 7.5 volts with normal charging current (120 milliamperes) flowing.

b. Battery BB–52.—The battery BB–52 (see fig. 16) is an 18-cell, 36-volt, plug-in storage battery designed to deliver 15 milliamperes (for tube plate, at approximately 110 volts, since batteries BB–52 are always used in groups of 3) for a period of 2 hours. The specific gravity of its electrolyte at full charge is 1.350. The battery weighs approximately 5 ounces when filled. Its charging rate is tentatively set at 15 milliamperes, tapering to 10 milliamperes in 4 or 5 hours. At full charge its terminal voltage should be 45 volts, or 135 volts for 3 batteries in series, with normal charging current (10 milliamperes) flowing.

48. Table.—Pending inclusion in the Signal Corps General Catalog, a list of storage batteries in use or in development is given below. The charging rates may vary somewhat with batteries of a given type supplied by various manufacturers; however, those given are approximate and will be satisfactory in most cases. In case of discrepancies in ratings or characteristics between those given in this table and those given when published in the Signal Corps General Catalog, the Signal Corps General Catalog will govern.

LEAD-ACID STORAGE BATTERIES (WITH HARD RUBBER CONTAINERS AND SPILL-PROOF VENTS)

Battery	Number of cells	Terminal volts	Ampere-hours (5-hour rate)	Amperes (5-hour rate)	Terminal volts (discharged)	Charging rate (amperes)		Maximum charging volts	Over-all dimensions (inches)			Electrolyte specific gravity		Weight (pounds) complete	Specification number	Use and remarks
						Start	Finish		Length	Width	Height	Charged	Discharged			
BB-29	2	4	90	18	3.5	11	5.5	5.0	8	9 7/8	8 9/16	1.270–1.290	1.210	37 1/4	70–20	SCR-197-( ).
BB-41	2	4	16	3.2	3.5	2	1.0	5.0	5 5/32	4 5/8	8 11/16	1.270–1.280	1.200	11	70–7	
BB-42	2	2	32	6.4	1.75	4	2	2.5	5 5/32	4 5/8	8 11/16	1.270–1.280	1.200	11	70–13	Same as BB-41 except cells are in parallel.
BB-45	2	4	80	16	3.5	10	5	5.0	10 (max.)	8 (max.)	11 (max.)	1.270–1.290	1.210	38 (max.)	70S–20	Commercial substitute for BB-29.
BB-46	6	12	75	15	10.5	9	4.5	15.0	15 7/8	6 1/2	14 9/16	1.270–1.290	1.210	97	70–33	SCR-177-B. [1] TC-1, TC-2.
BB-47	6	12	*185	*9.75	10.5	23	11.5	15.0	19 3/4	11 1/4	10	1.270–1.290	1.210	182	SCL–49	*20-hour rate. 1-hour rate—85 ampere-hours [1], [2], SCR-193, 209, 210, 245, etc.
BB-48	6	12	*200	*10	10.5	25	12.5	15.0	19 3/4	13 9/16	10	1.270–1.290	1.210	182	SCL–49–A	*20-hour rate. 1-hour rate—100 ampere-hours. [2], [3], SCR-193, 209, 210, 245, etc.
BB-50	6	12	*55	*2.75	10.5	6.5	3.2	15.0	12 7/8	7 1/8	9 5/8	1.270–1.290	1.210	62	70–37	*20-hour rate. SCR-177, 188, 177-A, SCR-177-A, SCR-188, SCR-299.
BB-51	3	6	See paragraph 47a.			0.165	0.120	7.5	4 3/16	1 3/8	1 1/16	1.350	[4]	5 1/2 oz.	[5]	Special battery for radio sonde ML–128.
BB-52	18	36	See paragraph 47b.			0.015	0.010	45.0	4 3/16	1 3/16	1	1.350	[4]	5 oz.	[5]	Do.

[1] Additional taps for 2 and 8 volts.
[2] Supplied by Ordnance Department. (Vehicular battery).
[3] To supersede battery BB-47.
[4] See paragraph 47.
[5] No formal specification to date.

[A. G. 062.11 (6–27–41).]

BY ORDER OF THE SECRETARY OF WAR:

G. C. MARSHALL,
Chief of Staff.

OFFICIAL:

E. S. ADAMS,
Major General,
The Adjutant General.

DISTRIBUTION:

R and H (3); Bn 4, 6, 9, 17 (3), 11 (5); I Bn 2, 5, 7, 10 (3); C 11 (10); IC 2-7, 10, 17 (3).

(For explanation of symbols see FM 21-6.)

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WAR DEPARTMENT

TECHNICAL MANUAL

TARGET RANGE COMMUNICATION SYSTEMS

January 16, 1942

TECHNICAL MANUAL No. 11–431

WAR DEPARTMENT,
WASHINGTON, January 16, 1942.

TARGET RANGE COMMUNICATION SYSTEMS

Prepared under direction of the
Chief Signal Officer

1. General.—This manual is issued for guidance in the construction of communication systems on three types of small-arms target ranges. Although it may be necessary in practice to deviate somewhat from this manual to meet local conditions, the general scheme should be followed as closely as possible so that systems throughout the Army will be of the same general type. The arrangements of the communication system to be installed depend upon the type of range, its size and importance, and upon local conditions which vary for each locality. The telephones are used for communication purposes, and loud-ringing bells are installed in the butts for use as signals in rapid firing.

2. Types of ranges and drawings therefor.—*a.* There are three types of target ranges, as follows:

Type	Description	Drawing
1	Firing from successive positions over the same ground	52011D1
2	Target butts in echelon	52011D2
3	Firing lines in echelon	52011D3

b. The drawings listed show all circuit connections and the location of the cable and apparatus with respect to the target butts and firing lines.

*This manual supersedes TR 1190–15, March 30, 1929.

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c. The above drawings will be furnished by the Chief Signal Officer upon request.

d. Simplified single line diagrams of the three types of ranges are shown in figures 1, 2, and 3, respectively.

e. In figures 1 to 3, inclusive, each single line represents an individual cable pair or pair of twisted wire, unless otherwise indicated.

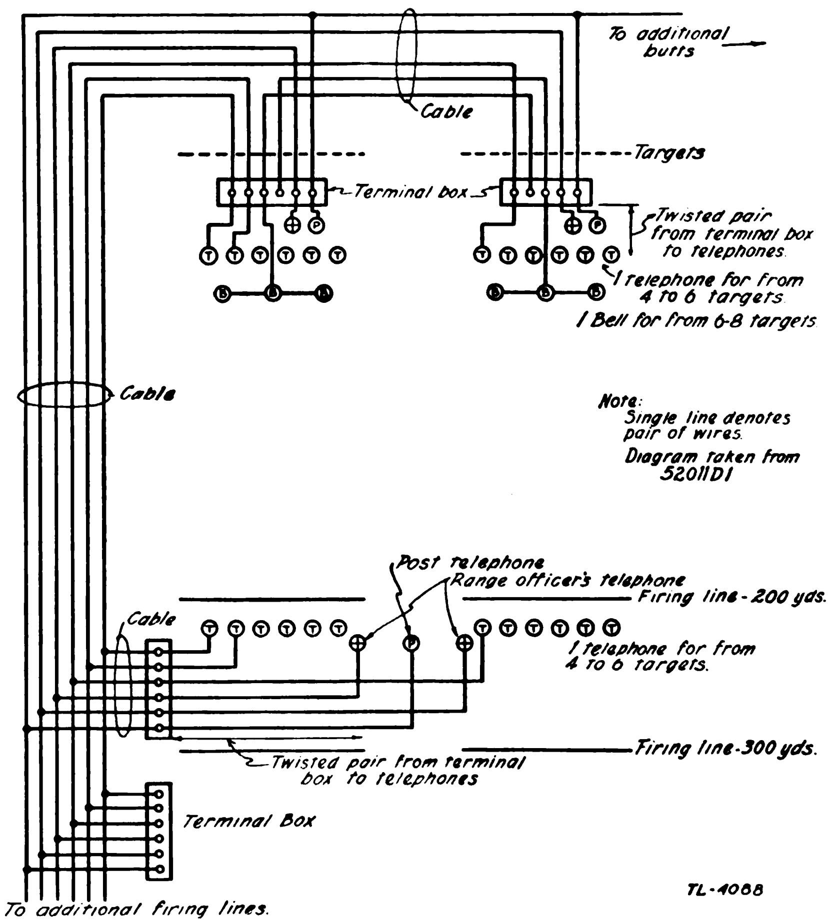


FIGURE 1.—Type No. 1 target range diagram, where firing is from successive positions over same ground.

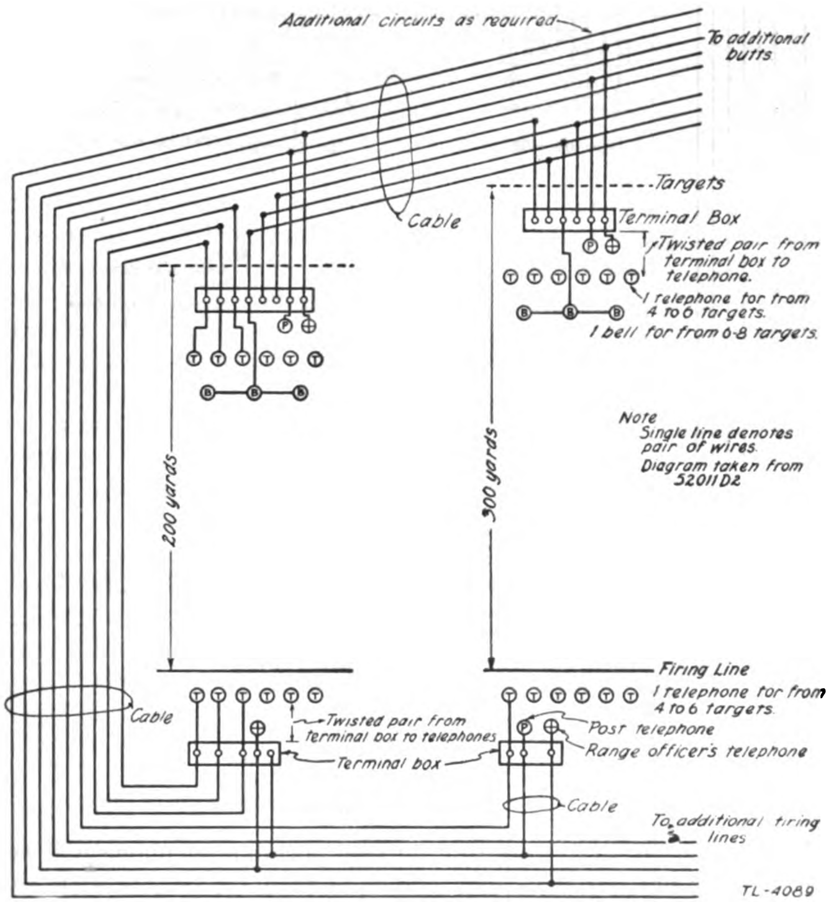


FIGURE 2.—Type No. 2 target range diagram, where target butts are in echelon.

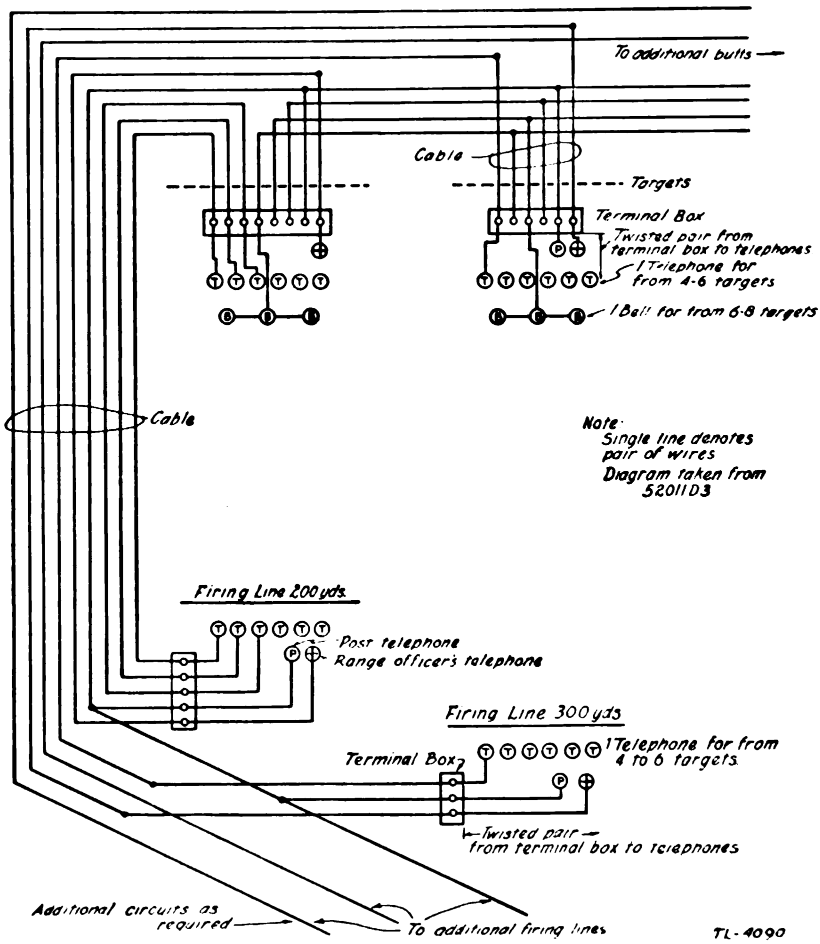


FIGURE 3.—Type No. 3 target range diagram, where firing lines are in echelon.

3. Number of instruments.—*a.* One portable telephone will be provided for not less than four nor more than six targets with an equal number at the firing lines. The minimum number of targets per telephone will, in most cases, be found to be more satisfactory than a large number.

b. In addition, there will be a range officer's telephone for administrative purposes at each section of the firing line and at each section of butt.

c. It is desirable that at least one telephone be provided at each firing line and each butt for communication with the post telephone system. The various post telephone lines may be party lines with two or more telephones connected, or they may be individual lines. The arrangements provided depend upon the facilities available and the size and importance of the range. The circuit diagrams do not show a connection to the post telephone system, but this connection should be made at the most convenient point.

d. One loud-ringing extension bell will be provided for not less than six nor more than eight targets in those butts which are used for rapid firing practice. The loud-ringing bells shown on the diagrams of the three types of target ranges will be supplied only where required.

e. It is preferable to have one terminal box for each group of not more than six telephones, exclusive of the range officer's telephone and post telephone, both at the butts and at the firing lines, except that on the flank of firing lines of type 1 range it may be desirable to connect more than six telephones to each terminal box. In addition to terminals for target telephones there will be terminals available in each terminal box for the range officer's telephone, for loud-ringing bells (butt terminal boxes only), and for connection to the post telephone system.

4. Apparatus and material.—The following types of apparatus and material will be used in the construction of target range communication systems (see Signal Corps General Catalog):

a. Cable.—Signal Corps cables, types WC-369 (10 pair), WC-370 (15 pair), and WC-371 (25 pair), 22-gage, paper-insulated, lead sheath, double steel tape armor, subterranean cable (used both in the butts and between the firing points and the butts).

b. Telephones.—Signal Corps telephones, types EE-3, EE-3-A, EE-3-B, EE-4, EE-4-A, EE-5, EE-8, or EE-8-A.

c. Terminal boxes.—Signal Corps terminal boxes, types JB-10 (10 pair), JB-11 (16 pair), and JB-13 (26 pair), each equipped with a 6-foot stub, entering either at the top or bottom, as called for.

d. Bells.—Signal Corps bells, type MC-9 (loud-ringing extension bells such as used on post telephone systems), each mounted in Signal Corps box, type BE-57.

e. Hand generators.—Signal Corps generator, type GN-36, consisting of a hand generator mounted in a suitable case.

f. Wire.—Signal Corps wire, type W-50. (Ordinarily used for extension lines from cable terminals to telephones and bells.)

g. Posts.—Posts for mounting terminal boxes should be about 6 feet long and be at least 6 inches in diameter. Old telephone poles cut to the desired length may be substituted. The posts may be cut from durable wood obtained locally and should be set approximately 3 feet in the ground.

5. Lines.—*a.* All wires between target butts and firing lines, where six or more circuits are used, should preferably be in cable. If less than six circuits are required, open wire construction is considered suitable, provided the pole line is located well to the flank and that underground construction is used at all points where open wire construction would be exposed to fire.

b. In estimating the number of pairs required, provision should be made for one pair between each target telephone in the butt and the corresponding telephone at the firing line, at least one pair for the range officer's telephone to be multipled across all butts and firing lines, and at least one other pair, connected to the post telephone system, multipled to all butts and firing lines. In the larger ranges, also where the firing lines or butts are in echelon, and where firing on the various ranges may take place simultaneously, it may be desirable to have more than one range officer's telephone circuit and also more than one circuit to the post telephone system. (See par. 3*c.*) It will probably be desirable to make provision for interconnection between the various range officer's telephone circuits, when desired.

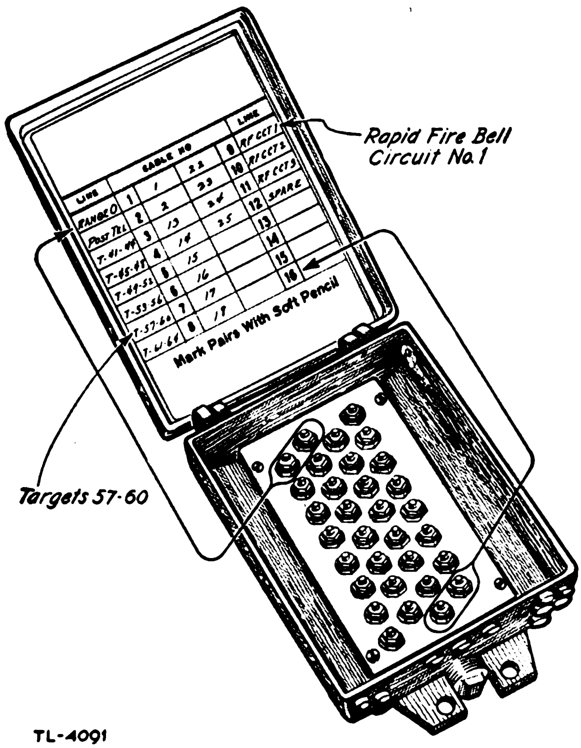
c. Armored cable should be buried not less than 30 inches below the surface of the ground. All splices should be carefully made using standard wiped joints and a board placed over each joint for protection. Lead-covered cables to terminals above ground should be protected with rigid metal conduit, if exposed to danger of mechanical injury.

6. Location of terminal boxes.—*a.* Terminal boxes at target butts should be mounted on the walls in front of the targets and at convenient heights. From each terminal box there should be provided a line of bridle rings through which wire can be run to each telephone or loud-ringing bell.

b. At firing lines, terminal boxes should be mounted on wooden posts conveniently located in the rear of the firing position, except that when successive firing lines fire over the same ground, as in type 1 ranges, the posts should be located on the least exposed flank. Distributing wires from terminal boxes to the telephones are usually laid on the ground for temporary use only. Care must, therefore, be exercised to keep them, as far as practicable, out of the way of traffic.

7. Terminal record.—A terminal record identifying the circuits for which the various cable pairs are being used should be entered on the inside of the terminal box cover (see fig. 4). Ordinarily a white surface is provided in the cover of the box for this information.

In addition, a complete record of all terminal connections should be maintained by the post signal officer.



TL-4091

Figure 4.—Terminal box JB-11, showing sample butt terminal record.

8. Connections of loud-ringing bells.—Loud-ringing bells at any one butt should be wired in multiple and this circuit should appear in all terminal boxes in all butts in the same range. It will then be possible to locate the hand generator set at any terminal box and connect it to any bell circuit desired. If fewer targets are required for rapid fire than those normally served by one loud-ringing bell circuit, the unnecessary bells may be temporarily disconnected at the bell or terminal box.

9. Tests and repairs prior to practice season.—*a.* To insure that the target range equipment is complete and in condition to give satisfactory service for the target season, the officer responsible for this service will cause a thorough test to be made of all equipment, wire, and cables at such times as will permit the making of needed repairs before the opening of the target-practice season.

b. If any material proves defective, a report stating the nature of the defects, accompanied by recommendations and a requisition for the necessary supplies, will be sent immediately to the corps area signal officer in order that the material necessary for the correction of defects may be provided and remedial action taken before the opening of the practice season.

10. Dismantling at end of practice season.—At the end of the practice season the communication equipment which can be advantageously removed will be stored for protection against theft and damage by exposure.

[A. G. 062.11 (11-6-41).]

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(For explanation of symbols see FM 21-6.)

U. S. GOVERNMENT PRINTING OFFICE · 1942

TM 11–432

WAR DEPARTMENT

TECHNICAL MANUAL

CODE PRACTICE EQUIPMENT

February 2, 1942

TM 11-432
C 1

TECHNICAL MANUAL

CODE PRACTICE EQUIPMENT

CHANGES No. 1 } WAR DEPARTMENT, WASHINGTON 25, D. C., 28 August 1943.

TM 11-432, 2 February 1942, is changed as follows:

3. Major components.

* * * * * * *

a. Keyer **TG-10-(*).** (Tone source and keyer combined.)

* * * * * * *

NOTE.—Because of the basic similarity of Keyers TG-10-A, TG-10-B, TG-10-C, TG-10-D, TG-10-F, and TG-10-J, the term "TG-10-(*)" is used throughout this manual to indicate all such Keyers of the TG-10 series. For additional information about Keyers TG-10-(*), see TM 11-447. Keyers TG-10-(*) and the Lon-Ga-Tone Keyer are made to meet the same general requirements and are interchangeable in their use.

* * * * * * *

[A. G. 300.7 (27 Jul 43).] (C 1, 30 Aug 43.)

4. Keyer TG-10-(*).—Keyers TG-10-A and TG-10-B are identical both mechanically and electrically except that the TG-10-A is equipped with transformers for 110-volt 25-cycle operation, while the TG-10-B is equipped with transformers for 110-volt 60-cycle operation. Reference will be made hereafter to **Keyers TG-10-(*) to indicate those Keyers of the TG-10 series noted in paragraph 3.** The Keyer TG-10-B * * * in over-all characteristics.

[A. G. 300.7 (27 Jul 43).] (C 1, 30 Aug 43.)

17. Interconnection of units.—*a. Switchboard BD-57-A.*—Figures 9 and 10 * * * transmission test table. If Lon-Ga-Tone, **Keyer TG-10-(*),** or McElroy modified model G-813 units are furnished, the oscillator-amplifier is connected only to the AUX SWBD TONE posts. Combinations of **Keyers TG-10-(*),** McElroy, and Lon-Ga-Tone units can be used without interference.

* * * * * * *

[A. G. 300.7 (27 Jul 43).] (C 1, 30 Aug 43.)

23. Connecting Keyer TG-10-(*).—The **Keyer TG-10-(*)** can be used wherever the use of the Lon-Ga-Tone Keyer is indicated in any of the diagrams appearing in this manual. Plug the flexible * * * chassis marked KEY.

[A. G. 300.7 (27 Jul 43).] (C 1, 30 Aug 43.)

551127°—43

30. Keyer TG-10-(*).—The general instructions given for **the** Lon-Ga-Tone unit apply to the automatic **Keyer TG-10-(*).** To disengage the * * * words per minute.

[A. G. 300.7 (27 Jul 43).] (C 1, 30 Aug 43.)

35. Preliminary adjustment of tone level.

* * * * * * *

c. Using Keyer TG-10-(*).—Same as for Lon-Ga-Tone, type 7.

* * * * * * *

[A. G. 300.7 (27 Jul 43).] (C 1, 30 Aug 43.)

39. Keyer TG-10-(*).—The circuit diagram of **Keyer TG-10-B** appears as figure 33. **Circuit diagrams for other Keyers TG-10-(*) appear in TM 11-447.** A back view of the chassis **of Keyer TG-10-B,** with the parts marked to correspond with the wiring diagram, follows as figure 34.

* * * * * * *

a. Functioning of circuit.—The circuit of * * * the 6V6 type. **Circuit details for Keyers TG-10-(*) are shown in TM 11-447.**

[A. G. 300.7 (27 Jul 43).] (C 1, 30 Aug 43.)

* * * * * * *

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U. S. GOVERNMENT PRINTING OFFICE. 1943

TM 11-432
*C 2

TECHNICAL MANUAL

CODE PRACTICE EQUIPMENT

CHANGES No. 2 } WAR DEPARTMENT, WASHINGTON 25, D. C., 20 April 1944.

TM 11-432, 2 February 1942, is changed as follows:

APPENDIX III (ADDED)

EMERGENCY CODE PRACTICE EQUIPMENT

1. **General.**—In order that field units and installations may give instructions in transmitting and receiving the International Morse characters even though the regulation code practice equipment is not available, information is furnished in this appendix to permit improvising equipment. The exercise of ingenuity will produce other means for improvising equipment. This information, however, is not to be used as authority to requisition any of the equipment mentioned.

2. **Sources of tone.**—*a.* A tone source for practice may be obtained by connecting a buzzer as shown in figure 52. The headphones are in series, with a capacitor across the coil of the buzzer. The strength of the signal in the headphones may be reduced by the use of smaller capacitors. The buzzer may be made from a doorbell by removing the gong and clapper. A better tone, and one that is more nearly identical to the note heard in the radio receiver, may be produced by the use of a vacuum tube audio-oscillator as shown in figure 53. In addition to key and headphones, the necessary parts are a grid resistor and capacitor, tube (1G4G or equivalent), socket, and audio-transformer. If the circuit fails to oscillate, one winding of the audio-transformer should be reversed. This equipment can supply power for only a few head sets, but by use of the oscillator shown in figure 53, together with a small audio-amplifier, more power can be obtained.

b. In the use of buzzers or oscillator circuits for code practice training, all necessary precaution should be taken to prevent interference with operational radio equipment.

c. An interference check can be made by the use of a radio receiver adjusted for maximum sensitivity and located near the training equipment and a check of the operational frequencies made.

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*These changes supersede section II, Training Circular No. 35, War Department, 1943.

582604°—44

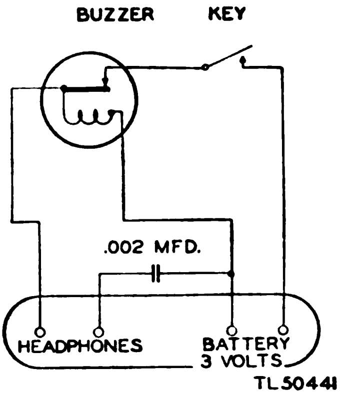

FIGURE 52.—Buzzer circuit diagram.

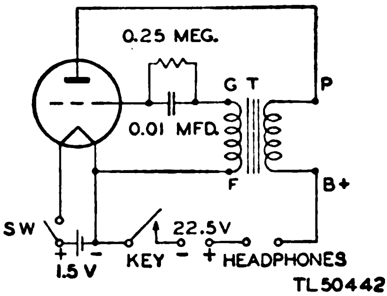

FIGURE 53.—Simple audio-oscillator.

3. Telegraph set TG–5 as source of tone.—Telegraph set TG–5 may be used as a source of tone and keying for supplying head sets. Buzzer BZ–5 may be salvaged from an unserviceable telegraph set TG–5 and used in the manner indicated in paragraph 2.

4. Instruction.—In the absence of sufficient head sets, a loudspeaker may be used for group instruction.

[A. G. 300.7 (24 Mar 44).]

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U. S. GOVERNMENT PRINTING OFFICE: 1944

TECHNICAL MANUAL

CODE PRACTICE EQUIPMENT

CHANGES No. 3 } WAR DEPARTMENT, WASHINGTON 25, D. C., 17 February 1945

~~TM 11-432, 2 February 1942, is changed~~ as follows:

14.1. Code Practice Equipment EE–94–B (Added).—Figure 5.1 is a block diagram of Code Practice Equipment EE–94–B for a school of 20 students. The equipment consists of one switchboard BD–57–( ) with auxiliary patching board, six Automatic Keyers TG–10–( ), one Oscillator VO–3–( ), one Recorder BC–791–B, one Tape Puller MC–310–B, and various accessories. The physical placement of the equipment is similar to that described in paragraph 14.

NOTE.—This paragraph and paragraphs 14.2 through 14.4 cover typical installations of Code Practice Equipments EE–94–( ), EE–95–( ), and EE–96–( ). The components of these equipments will vary with the different models, but the general arrangements will be similar to the diagrams shown. Official nomenclature followed by ( ) indicates all models of the equipment.

14.2. Code Practice Equipment EE–94–E (Added).—*a.* Figure 5.2 is a block diagram of Code Practice Equipment EE–94–E for a school of 20 students. The equipment consists of one Switchboard BD–114, six Automatic Keyers TG–34–( ), one Oscillator VO–3–( ), one Recorder BC–1016, and the various accessories. The physical placement of the equipment will be similar to that described in paragraph 14.

b. When using Switchboard BD–114, wire the auxiliary switchboard tone to a pair of terminals associated with the auxiliary tone jacks. Connect the tone to the primary of transformers C69 by inserting the plug of the white cord into the tone jack to which the auxiliary tone is wired. To connect the instructor's key and headset into the circuit, wire the key and headset to a plug. Insert the plug into the jack on the front panel.

14.3. Code Practice Equipment EE–95–B (Added).—On figure 5.3 the solid lines show the wiring of Code Practice Equipment EE–95–B for a 40-man school. The equipment consists of two Switchboards BD–57–( ) with auxiliary patching boards, six Automatic Keyers TG–10–( ), one Oscillator VO–3–( ), one Recorder BC–791–B, one Tape Puller MC–310–B, and various accessories. The physical arangement of the equipment is similar to that described in paragraph 14.

14.4. Code Practice Equipment EE–96–B (Added).—The dotted lines on figure 5.3 show the additional equipment required to convert the EE–95–B to a EE–96–B which is suitable for a 100-man

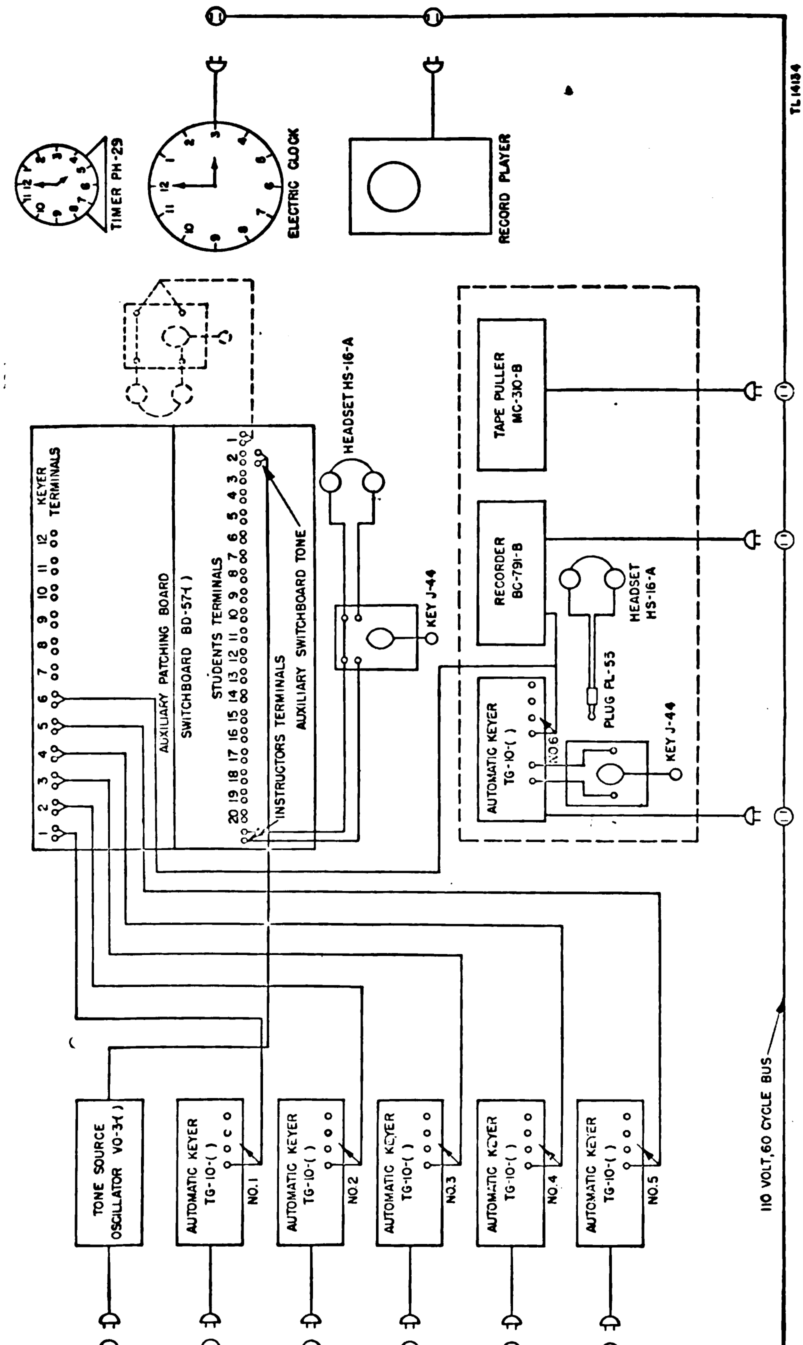

FIGURE 5.1.—Block diagram of Code Practice Equipment EE-94-B for a 20-man school.

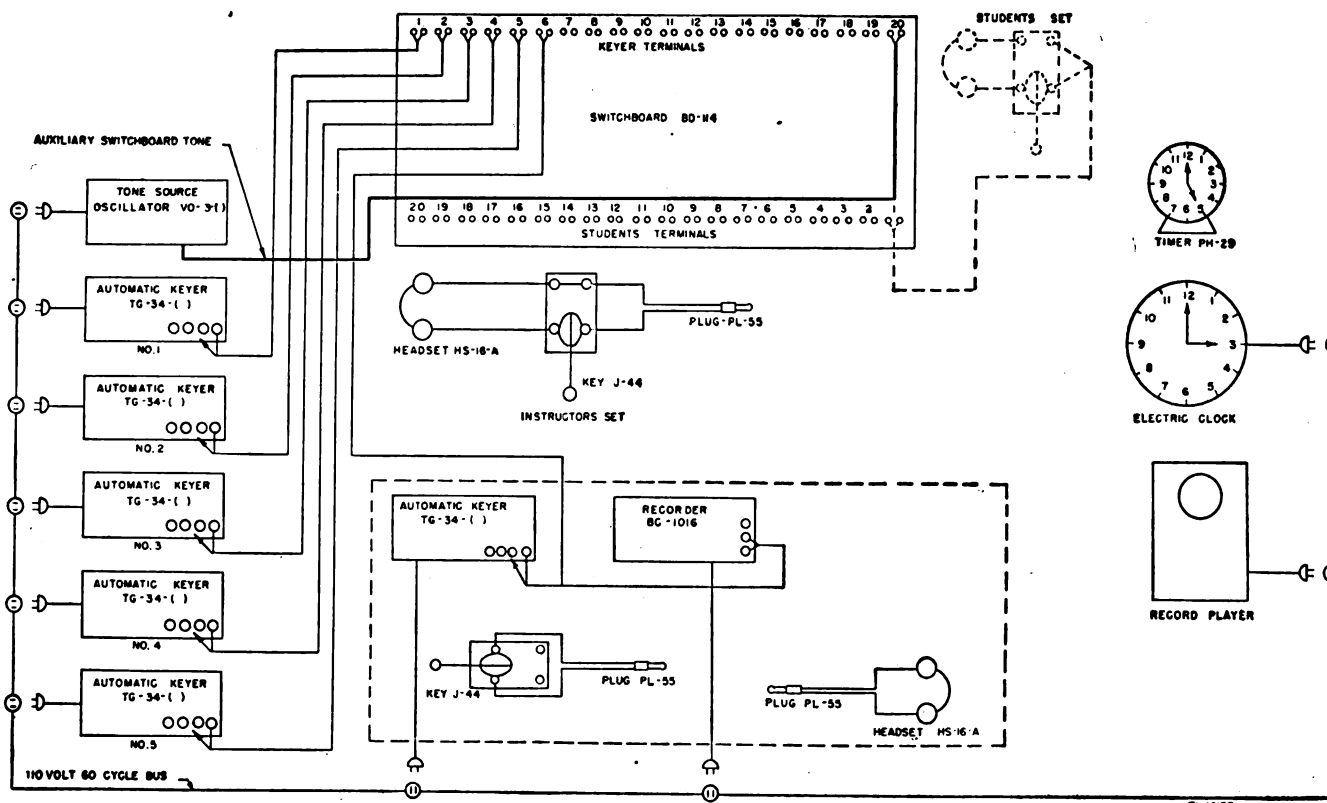

FIGURE 5.2.—Block diagram of Code Practice Equipment EE-94-E for a 20-man school.

TM 11-432

school. The additional equipment required consists of three Switchboards BD-57-( ) with auxiliary patching boards, six Automatic Keyers TG-10-( ), one Oscillator VO-3-( ), two Recorders BC-791-B, two Tape Pullers MC-310-B, and various accessories. The physical arrangement of the equipment is similar to that described in paragraph 14.

NOTE.—When Recorder BC-1016 is used in place of Recorder BC-791-B in any of the above equipments, Tape Puller MC-310-B is not required.

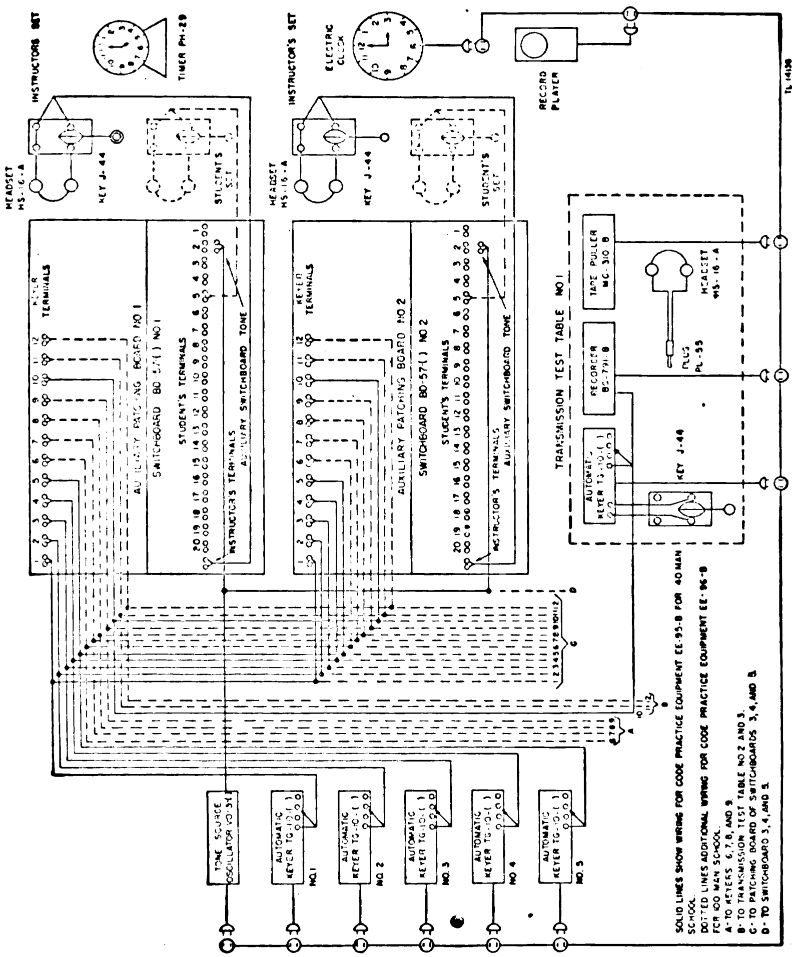

FIGURE 5.3.—Block diagram of Code Practice Equipments EE-95-B and EE-96-B.

38. Automatic Keyer, Lon-Ga-Tone, Type 7.

* * * * * * *

b. Maintenance and repair.—Clean the aperture * * * is exposed thereby. Once a week put 1 drop of **Oil, Engine, U. S. Army Spec. No. 2–104B,** in the oil ducts of the take-up motor and in the oil hole at the left end of the puller motor. If the exciter * * * to the phototube.

39. Keyer TG–10–B.

* * * * * * *

b. Maintenance and repair.—(1) *Lubrication.*—**On units which have a** worm reduction gear on the motor shaft **running** in an oil bath, **check the oil level weekly and keep the gearcase full of Oil, Engine, U. S. Army Spec. 2–104B. Drain and refill the case once every 3 months.**

(2) **On units which have an open helical gear on the motor shaft, apply a light coat of Grease, Lubricating, Special, Ordnance** Spec. **No. AXS–637 at intervals of 1 month or 400 operating hours.**

(3) **Lubricate all shaft bearings with Oil, Engine, U. S. Army Spec. No. 2–104B at intervals of 1 month or 400 operating hours.**

(4) **For detailed lubrication instructions, see TM 11–447 which covers this equipment in detail.**

Subparagraphs (2) to (6), inclusive, are renumbered (5) to (9), inclusive.

41. Automatic Keyer, McElroy Model G–813.

* * * * * * *

b. Maintenance and repair.—Clean the aperture * * * experienced instrument repairman. **Once** a week place 1 drop of **Oil, Lubricating, Preservative, Special, U. S. Army Spec. No. 2–120,** in the oil hole located at the top of the rewind. If the exciter * * * soft lead pencil.

44. Tape Puller, McElroy Model CTP–1300.

* * * * * * *

b. Maintenance and repair.—Once a day place 1 drop of **Oil, Engine, U. S. Army Spec. No. 2–104B** in the oil hole on the take-up spindle and in the oil duct leading to the puller wheel bearing. The entrance to * * * the puller wheel.

46.1. Switchboard BD–57–B (Added).—*a. Functioning of circuit.*—The complete schematic of this switchboard is shown in figure 47.1. This circuit is the same as the circuit for the BD–57–A (fig. 47) except that the motor alternator, the battery and tone switches, and the terminals for the master key have been omitted; they are not required in code practice equipment. The functioning of the circuit is covered in paragraph 46.

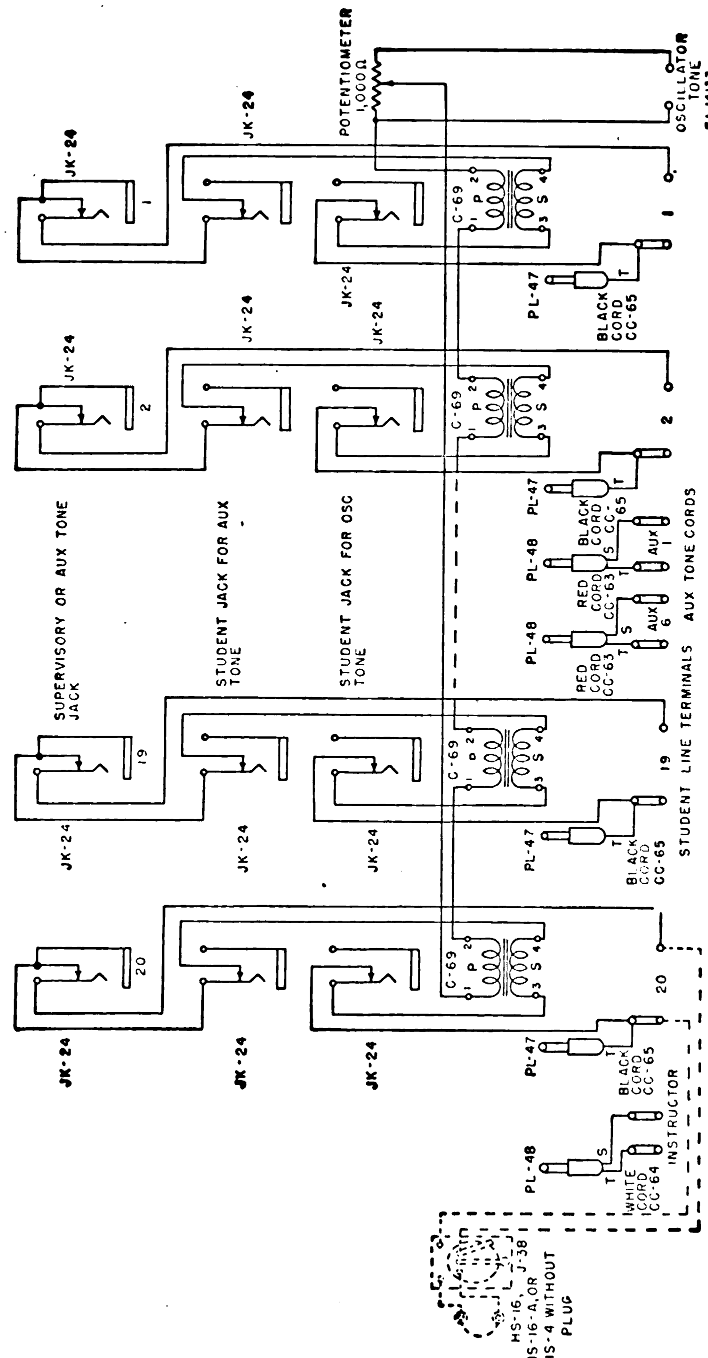

FIGURE 47.1.—Circuit diagram of Switchboard BD-57-B.

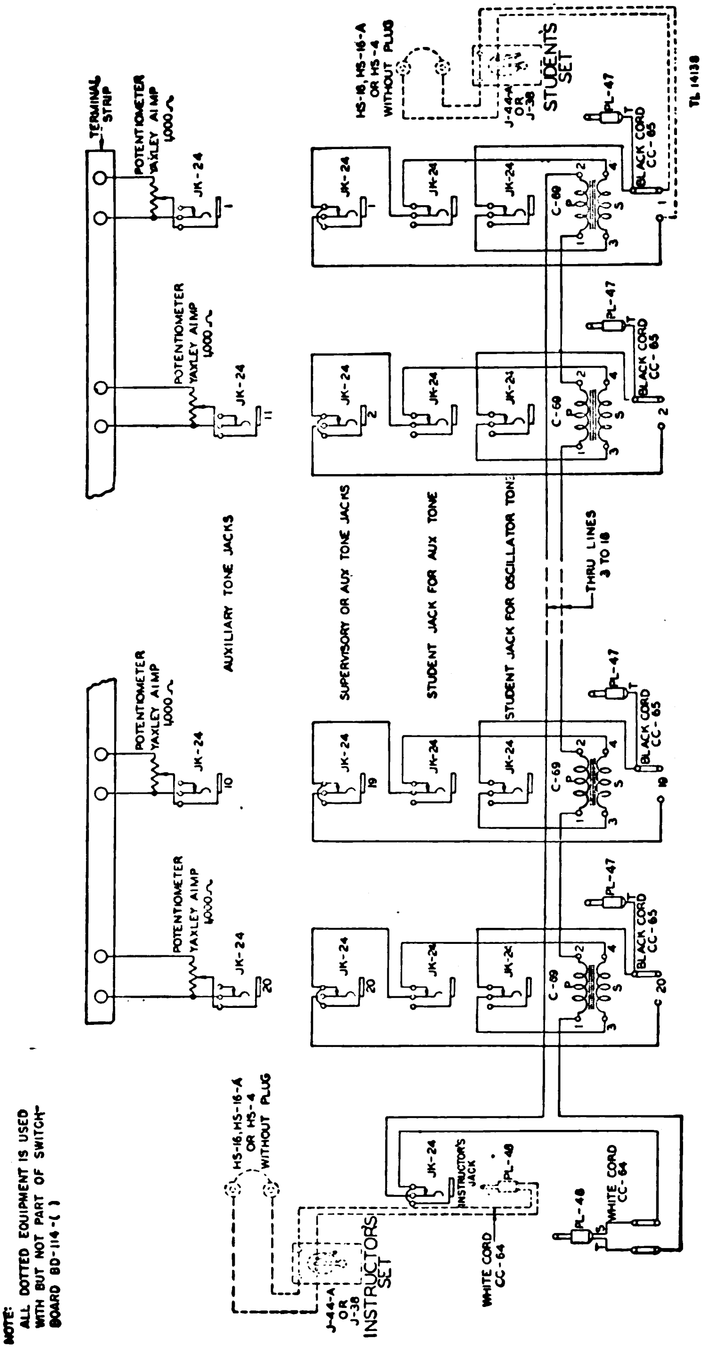

FIGURE 47.2.—Circuit diagram of Switchboard BD-114-( ).

b. Maintenance and repair.—See paragraph 45*b*.

46.2. Switchboard BD-114-( ) (Added).—*a. Functioning of circuit.*—Figure 47.2 shows the complete schematic of this switchboard. The circuit is the same as circuit of the BD-57-B shown in figure 47.1 except for the following points:

(1) A patching board has been incorporated into the switchboard unit. (See par. 2, app. I, for a detailed description of the patching board.)

(2) The potentiometer in the oscillator tone circuit has been eliminated; the same results are obtained by wiring the tone into the terminals of the auxiliary tone jacks. The tone is connected to the primaries of transformers C69 by inserting plug PL-48 of the white cord into the tone jack to which the auxiliary tone is wired. The potentiometer in the auxiliary jack circuit acts as the volume control.

(3) The terminals for the instructor's headset and key are brought out to a jack on the panel. To connect into the circuit, the instructor's key and headset is connected to a plug.

(4) The auxiliary tone cords have been omitted; they are not required when a patching board is used.

b. Maintenance and repair.—See paragraph 45*b*.

[AG 300.7 (29 Dec 44)]

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For explanation of symbols, see FM 21-6.

AGO 338C

U. S. GOVERNMENT PRINTING OFFICE: 1945

TECHNICAL MANUAL No. 11-432 } WAR DEPARTMENT, WASHINGTON, February 2, 1942.

CODE PRACTICE EQUIPMENT

Prepared under direction of the
Chief Signal Officer

*This manual supersedes TR 1215-10, and Instruction Book for Code Practice Equipment for Training Radio Operators, February 10, 1941, and supplements thereto.

432514°—42——1

SECTION I

GENERAL

1. **Purpose and scope.**—The purpose of this manual is to describe equipment for the training of radio operators in troop and special service schools. There are included a general description of major components of this equipment, detailed instructions for its installation and use, and information as to its functioning, servicing, and repairing.

2. **Basic equipment requirements.**—The basic requirement in any school for training radio operators is an audio-frequency oscillator of sufficient power to supply tone to a headset for each student in the school. Associated with this tone source must be a flexible distribution system whereby the tone supplied to individual headsets or groups of headsets can be isolated from others. The tone supplied to each group of headsets must be capable of being keyed at various speeds. Keying may be accomplished manually, but a great reduction of instructor personnel and more accurate transmissions are possible if equipment is available for automatically keying the tone by means of previously prepared tape. Of great assistance in teaching students to transmit well-formed characters is a recorder by means of which signals transmitted by them are recorded on a tape. Use of this prepared tape on the automatic keyer, retransmitting his own transmissions to the student who prepared the tape, points out his errors emphatically. The equipment described herein fulfills each of the above requirements and is intended for use in Conducting the course of instruction outlined in TM 11-454. Figure 1 shows a typical school for 100 students, using the equipment described in this manual.

3. **Major components.**—The major components of equipment for training radio operators in troop schools are as follows:

a. Keyer TG-10-A or TG-10-B. (Tone source and keyer combined.)

b. Automatic keyer, Lon-Ga-Tone, type 7. (Tone source and keyer combined.)

NOTE.—Keyers TG-10-A and TG-10-B and the Lon-Ga-Tone keyer are made to meet the same general requirements and are interchangeable in their use.

FIGURE 1.—Five 20-man tables, each with switchboard, used in typical school for training of radio operators. (Recorder for making of tapes by students is in far center; automatic keyers in separate room.)

c. Automatic keyer, McElroy model G-813, modified. (Tone source and keyer combined.) This is substitute equipment for item *a* or *b*.

d. Oscillator-amplifier, Amplifier Company of America, type ACA-10-AO. (Tone source.)

e. Automatic keyer, McElroy model G-813. This item in combination with item *d* is equivalent to item *a*, *b*, or *c*.

f. Code practice equipment EE-81, less batteries BB-29. (Distributing system.)

g. Practice tapes Nos. 1 to 15. (Master copies of practice transmissions, appendix II.)

h. Recorder, McElroy model RRD-900.

i. Tape puller, McElroy model CTP-1300. (Used with item *h.*)

j. Reels, motion picture film, 16-mm, 400 feet. (For holding tape.)

k. Record player, for disk records, Columbia model P. (For use with the record set MC-209 (radiotelegraph operator aptitude test); (see TM 11-454).

4. Keyer TG-10-A or TG-10-B.—These keyers are identical both mechanically and electrically except that the TG-10-A is equipped with transformers for 110-volt 25-cycle operation, while the TG-10-B is equipped with transformers for 110-volt 60-cycle operation. Reference will be made hereafter only to the TG-10-B, as comparatively few of the TG-10-A keyers have been manufactured. The keyer TG-10-B closely resembles the Lon-Ga-Tone keyer in over-all characteristics.

5. Automatic keyer, Lon-Ga-Tone, type 7.—This keyer combines a tone source and an automatic electronic keying system. The tone source consists of an oscillator-amplifier capable of supplying 10 watts of audio tone at 800 cycles per second ±10 percent. This keyer operates from a 110-volt 60-cycle source but satisfactory results can be obtained from a source as low as 90 volts. (See fig. 2.)

6. Automatic keyer, McElroy model G-813, modified.—This unit combines a tone source of considerably lower power output (about 1 watt) and an automatic keyer, and may be used as a substitute for the automatic keyer, Lon-Ga-Tone, type 7. Only a limited quantity has been issued.

7. Oscillator-amplifier, Amplifier Company of America, type ACA-10-A0.—This tone source is capable of supplying 10 watts of tone at 800 cycles per second ±10 percent. This power is adequate for supplying tone to 200 headsets. When the number of student groups being independently keyed on a single tone source exceeds six, some slight cross-talk between individual groups may be noticeable. In general, troop schools of 40 students require 6 automatic keyers (see par. 8) but only one oscillator-amplifier. The oscillator-amplifier operates from a 110-volt 60-cycle source but is capable of maintaining adequate output at input voltages as low as 90 volts.

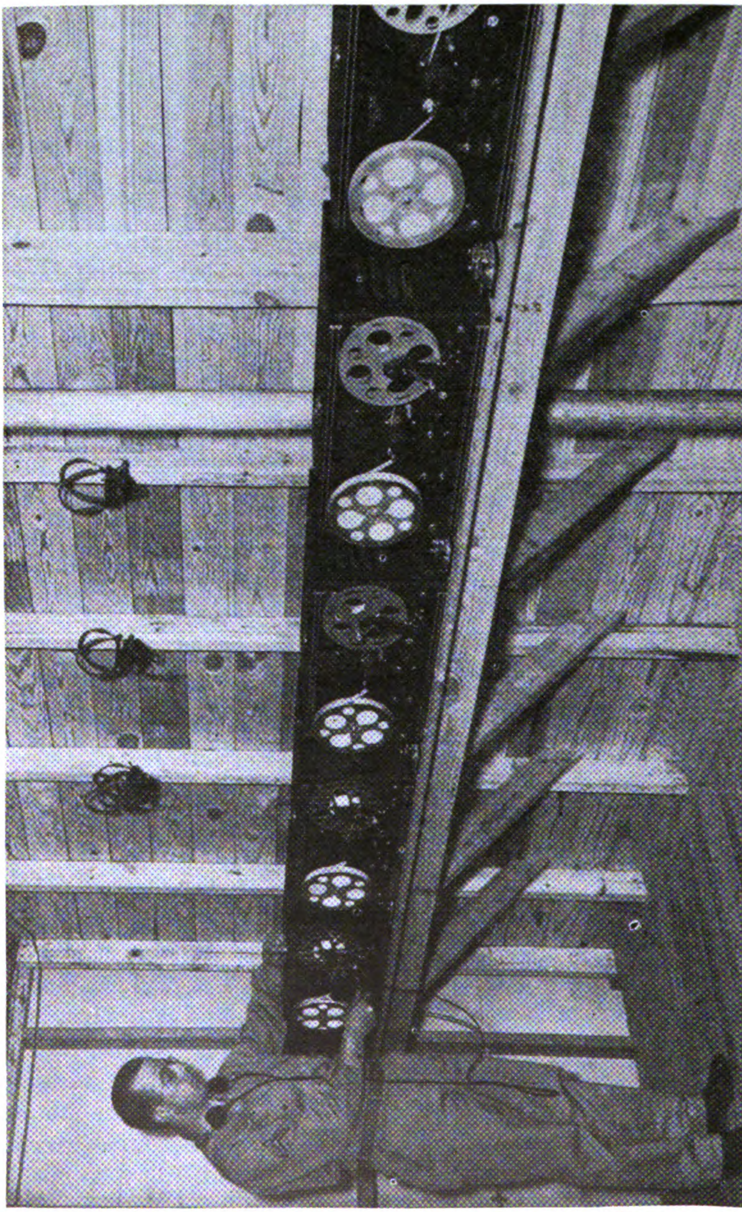

FIGURE 2.—Neat, simple arrangement of Lon–Ga–Tone automatic keyers. (Typical installation readily duplicated in any permanent or temporary building.)

Use of this oscillator-amplifier in installations for which keyer TG–10–B, Lon–Ga–Tone, or McElroy modified model G–813 units are supplied is generally restricted to furnishing constant tone to the switchboard BD–57–A which is part of equipment EE–81.

8. Automatic keyer, McElroy model G-813.—This unit is used to key automatically the separate tone source provided by the oscillator-amplifier ACA-10-AO. It can key the tone supplied to *one* and *only one* group of students; hence, for as many groups of students as it is anticipated will be formed at any one time during the process of instruction, just as many keyers are required. Keyers operate from a 110-volt 60-cycle source but are capable of keying satisfactorily at input voltages as low as 90 volts.

9. Code practice equipment EE-81.—The equipment EE-81 comprises a switchboard BD-57 or BD-57-A, 22 hand telegraph keys J-38, and 21 double headsets HS-16. Switchboard BD-57-A is a later and improved version of the BD-57. Each unit of equipment is adequate for handling 20 students; for each additional 20 students or portion thereof an additional EE-81 or EE-81-A is required. By means of each switchboard, circuits can be set up which group from 1 to 20 students on a single source of keyed tone, permit the instructor to monitor the transmissions, or permit individuals in the group to transmit to others therein.

10. Practice tapes.—A set of 15 master tapes is made available to each school. Used in connection with any of the automatic keyers, these tapes provide for practice transmissions as follows:

Tape No.	Contents	Speed per minute	
		Characters	Words
1	Receiving lesson I [1]	20	
2	Receiving lesson II [1]	20	
3	Receiving lesson III [1]	20	
4	Receiving lesson IV [1]	20	
5	Receiving lesson V [1]	20	
6	Letters and numbers in random order	25	
7	do	35	
8	Code groups		10
9	Field traffic		12
10	do		12
11	do		15
12	do		15
13	do		15
14	do		20
15	do		20

[1] See TM 11-454.

These tapes were prepared in such a way, that, regardless of the speed of transmission in words per minute, the actual characters are transmitted at a speed of 20 words per minute when the tape is running by the photoelectric cell at a constant speed of 12 feet per minute. Thus, on all tapes the speed of the characters is constant but the characters per foot of tape, and hence the words per minute transmitted, vary as indicated in the table above. (See app. II.)

11. Recorder, McElroy model RRD-900.—By means of this unit and a separate tone source (oscillator-amplifier ACA-10-AO or the oscillator-amplifier section only of the keyer TG-10-B or of the Lon-Ga-Tone automatic keyer, type 7), practice manual transmissions by a student can be recorded on a blank tape. Use of the automatic keying feature also permits the preparation of additional practice tapes from the master tapes. A switch can be used to facilitate the interconnection of tone source, automatic keyer, manual key, and recorder so as to make the recorder installation most flexible. The recorder operates from a 110-volt 60-cycle source but is capable of satisfactory recording at input voltages as low as 90 volts. Associated with the actual recorder is a tape puller, McElroy model CTP-1300, which pulls the blank tape past the recording stylus. (See fig. 3.)

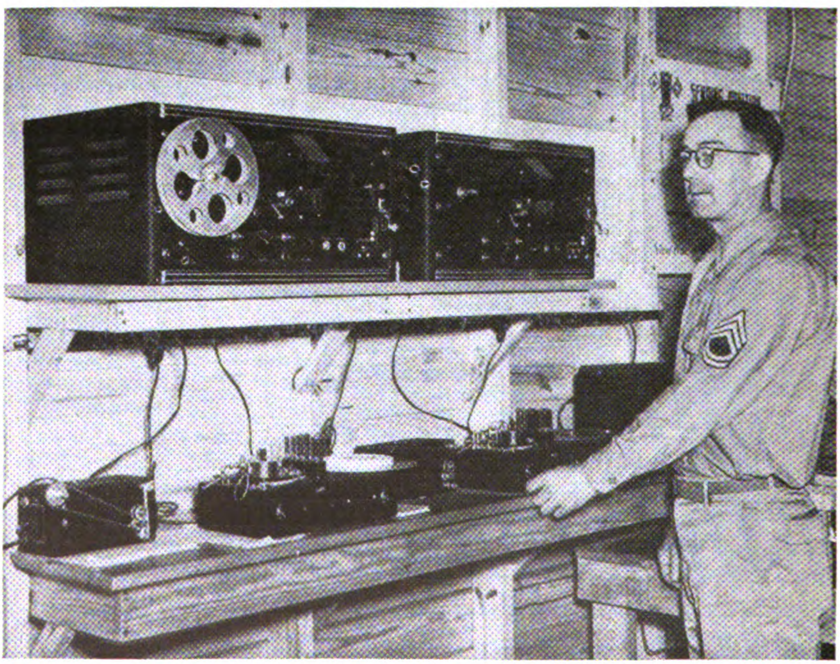

FIGURE 3.—Recorder position. (On lower shelf are two McElroy recorders with associated tape pullers; on upper shelf are two Lon-Ga-Tone units. Tapes made on recorders can be played back immediately on Lon-Ga-Tone keyers.)

12. Reels, motion picture film, 16-mm, 400 feet.—These reels hold the practice tapes and are employed in pairs on each automatic keyer. They are standard film reels and fit the TG–10–B, the automatic keyers G–813 (both models), the Lon–Ga–Tone equipment, and the tape puller used with the recorder.

13. Record player for disk records, Columbia model P.—This is a portable phonograph consisting of an electric turntable, a phonograph pick-up, an audio-frequency amplifier, and a loudspeaker. It is used for sonic transmission of the radiotelegraph operator aptitude test from disk records. The speaker can be removed from the unit and mounted in a location more suitable from an acoustical viewpoint to permit sonic transmission of the test to a group of assembled students. The record player operates from a 110-volt 60-cycle source. (See fig. 4.)

Note.—The nomenclature, "code practice equipment EE–94–A" has been assigned to the complete equipment with all accessories except the code practice equipment EE–81 and the record player for a school of 20 students. Similarly "code practice equipment EE–95–A" and "code practice equipment EE–96–A" have been assigned to those for 40 and 100 student schools, respectively.

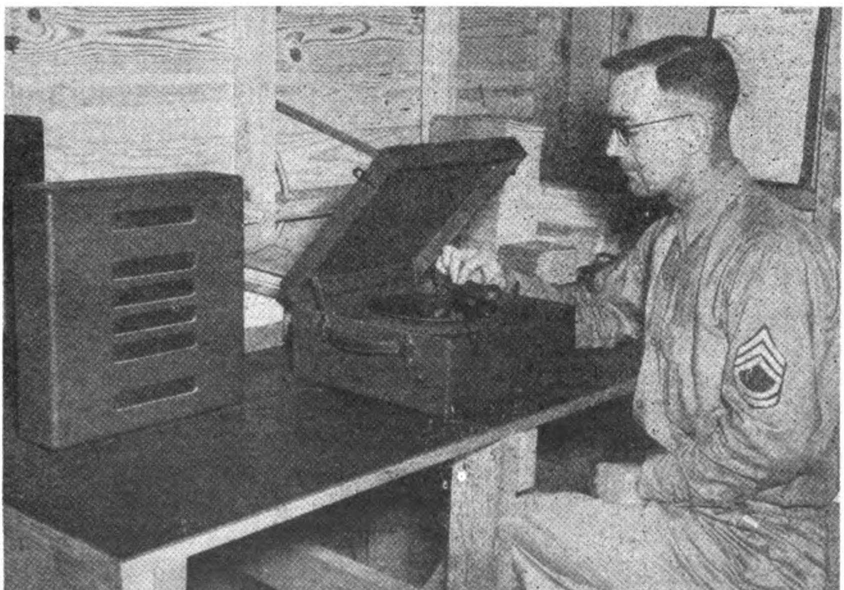

FIGURE 4.—Record player set-up for transmission of radiotelegraph operator aptitude test: (Speaker (left) is detached from cover of carrying case.)

SECTION II

INSTALLATION FOR SERVICE

14. General arrangement of equipment.—Figure 5 is a block diagram of a typical equipment lay-out for a school of 40 students, using six McElroy automatic keyers, an ACA–10–AO tone source, a McElroy recorder, two switchboards BD–57–A, and various accessories. Similar arrangements are obviously possible with Lon–Ga–Tone and keyer TG–10–B units. The physical placement of equipment and tables will vary according to building dimensions. The student tables should be arranged to allow proper lighting and sufficient aisle space. The oscillator-amplifier tone source and all automatic keyers are grouped and located with respect to instruction tables so that their operation and adjustment will neither interfere with nor annoy student operators. If space is available, the keyers should be in a separate room. Each unit of the group is placed so as to allow easy access to all connections and to facilitate operation and adjustment of controls. The automatic keyer and the recorder used for making practice records and transmission tests are placed on a table that allows room for the equipment units, table wiring, proper placement of hand key, and comfortable arm space for the student and the instructor. The switchboard preferably is mounted at one end of the table of student positions which it controls. It can be mounted on the table itself or on a switchboard bracket. A suitable method of mounting the switchboard on an instruction table is shown in figure 6. When so placed it must be at sufficient height to prevent the switchboard cords from touching the floor but not so high as to

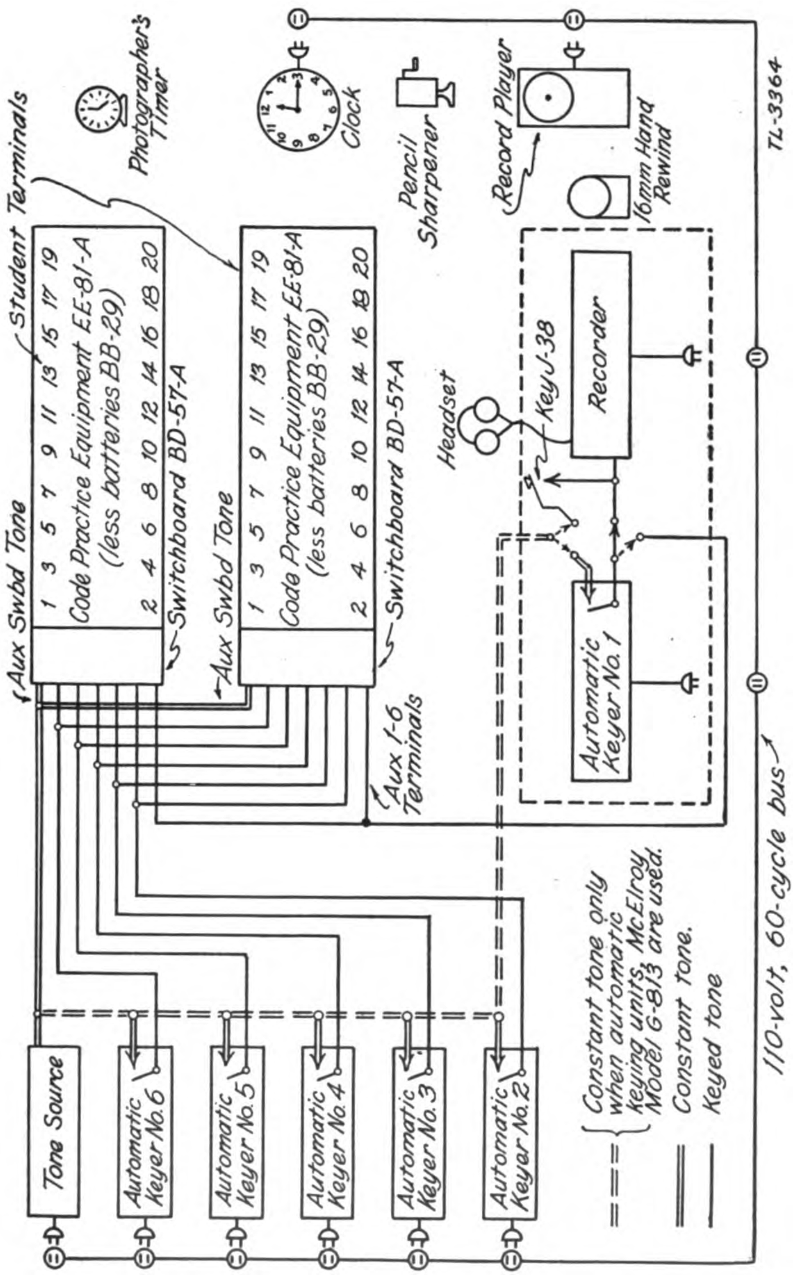

FIGURE 5.—Block diagram of typical school for 40 students.

prevent an instructor, when standing at the switchboard, from seeing all student positions. Other methods for mounting the switchboard are feasible, but regardless of the method used, it should be placed so as to allow easy access to its front for patching circuits and to its rear for making connections, so that external wiring can be brought in through the round hole at its right end (when viewed from the front).

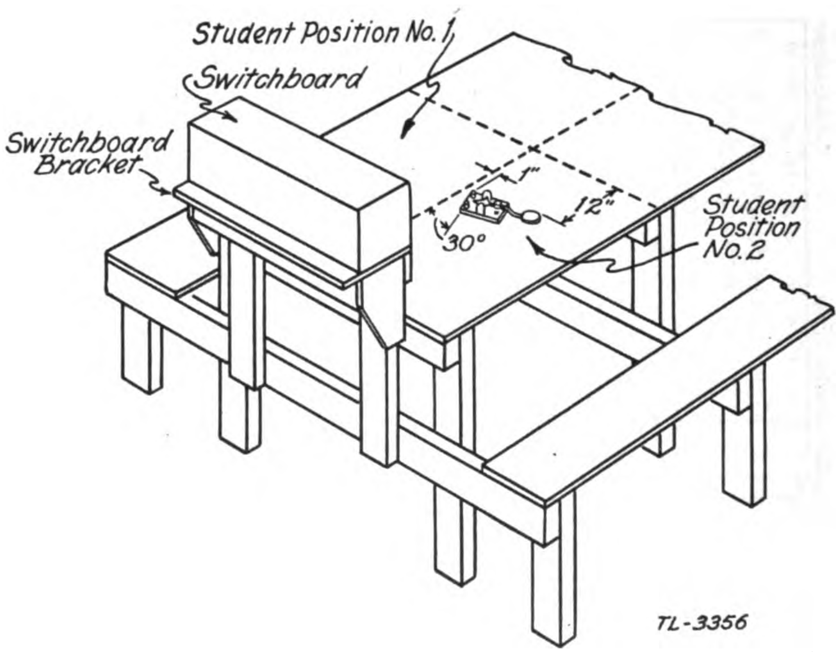

FIGURE 6.—End assembly of instruction table, switchboard bracket, and switchboard.

15. Instruction tables.—A mess type table measuring 5 feet 2 inches by 24 feet, including seats, will provide 20 student positions and sufficient space for mounting a switchboard BD–57 or BD–57–A. The table top is preferably covered with $\frac{3}{16}$-inch tempered Prestwood, or equal, to insure a good writing surface. Construction drawings are given in figures 7 and 8 for a 10-position instruction table and a switchboard bracket. Standard sizes and lengths of lumber are employed in their construction. Wood screws, with all screw holes countersunk, are employed for the assembly of the table. This construction facilitates assembly and disassembly for moving the table from one room to another or for storage. Two tables can be bolted together to make a 20-student table if space permits. If the 10-position table is used as a unit, only one switchboard bracket for each two tables is needed. The 20-student positions on the switchboard will then be divided equally between the two tables.

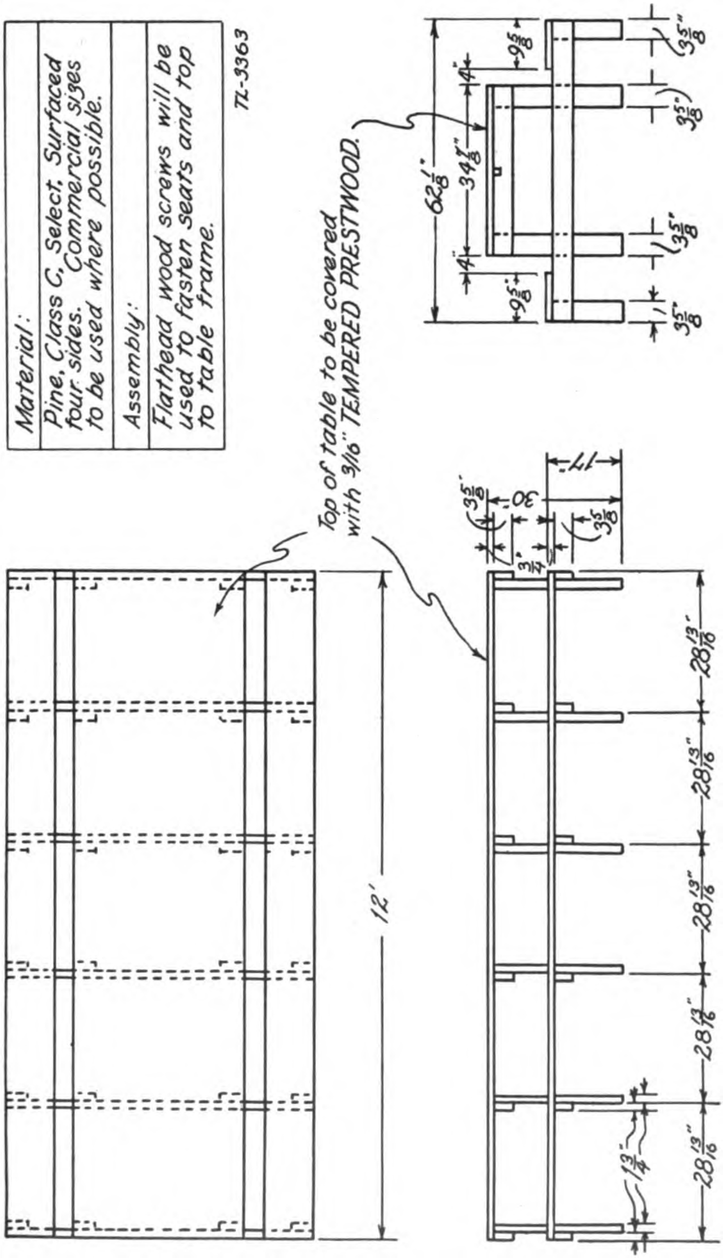

FIGURE 7.—Ten-position instruction table.

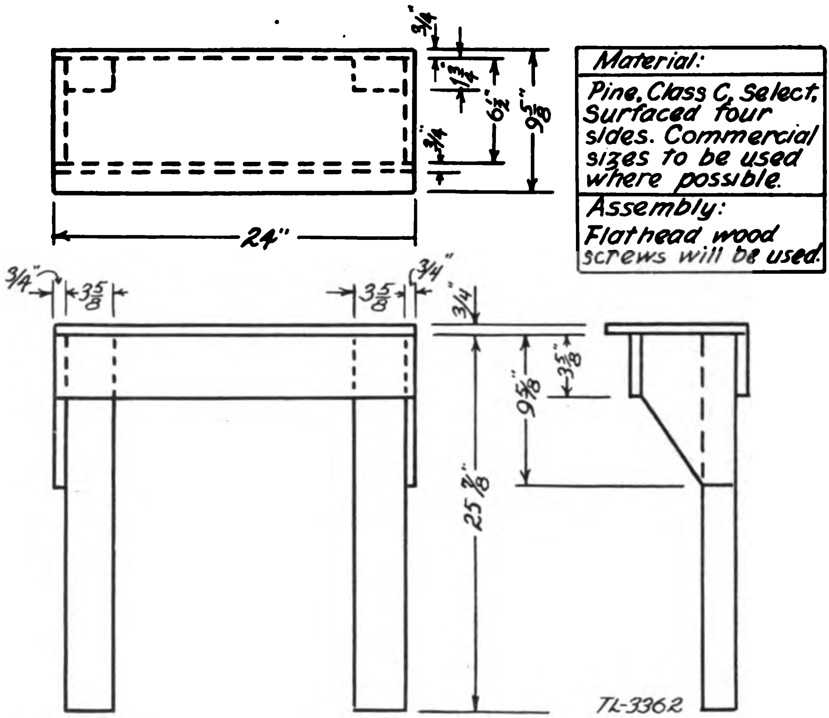

FIGURE 8.—Details of switchboard bracket.

16. Total space requirements.—Approximately 260 square feet of floor space are required for each group of 20 students and an additional 12 square feet per keyer, recorder, and oscillator-amplifier. A code room for 100 students should have approximately 1,500 square feet of floor space to provide for aisles. A room less than 20 feet wide is unsatisfactory.

17. Interconnection of units.—*a. Switchboard BD–57–A.*—Figures 9 and 10 are block diagrams of an installation for a school of 40 students, using two switchboards BD–57–A as the distributing system. If the McElroy G–813 automatic keyers are furnished, the M and S terminals are all paralleled to the 1 and 2 posts of the ACA-oscillator-amplifier, to the AUX SWBD TONE posts of the switchboards, and across to the transmission test table. If Lon–Ga–Tone, keyer TG–10–B or McElroy modified model G–813 units are furnished, the oscillator-amplifier is connected only to the AUX SWBD TONE posts. Combinations of keyers TG–10–B, McElroy, and Lon–Ga–Tone units can be used without interference.

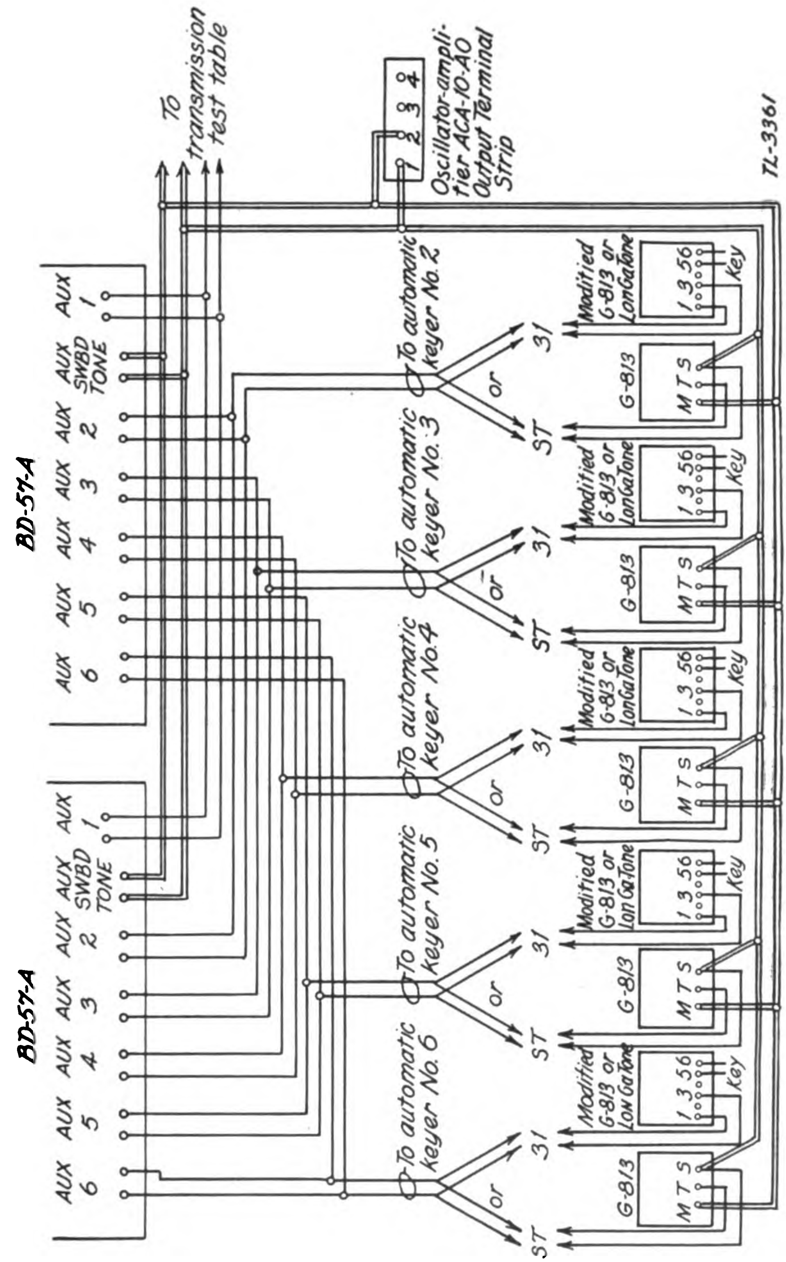

FIGURE 9.—Diagram of typical set-up of code practice equipment for school of 40 students.

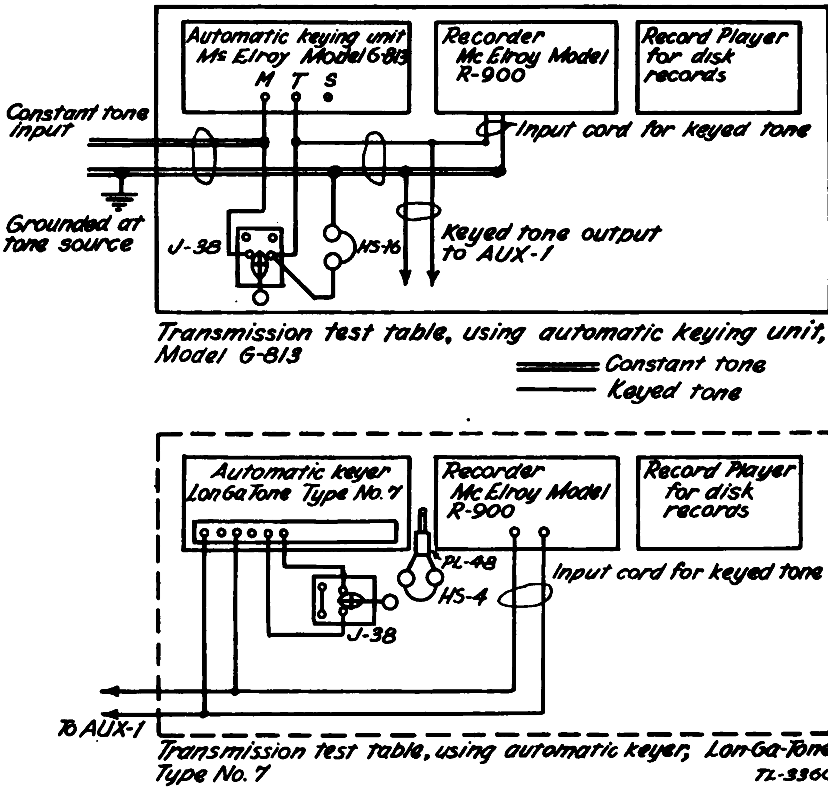

FIGURE 10.—Transmission test table diagrams showing use of both McElroy and Lon-Ga-Tone automatic keyers.

b. Switchboard BD-57.—This switchboard has only one connection for outside tone source. Therefore, all students must take the same keyed tone, or all must practice sending to themselves or to each other at the same time. This arrangement has serious shortcomings from the standpoint of progressive instruction. The switchboard can be rewired to make it the equivalent of the newer BD-57-A by following the special instructions given in appendix I. If the switchboard is to be used as issued, only one keyer at a time can be connected to each, and students of approximately the same speed ability must be assigned to the respective tables. Figure 11 shows the simple connections of this switchboard.

18. Connecting switchboard BD-57 or BD-57-A.—Figure 12 is a schematic diagram of the terminal board on a switchboard BD-57-A. This terminal board is an integral part of the switchboard and is accessible from the rear thereof.

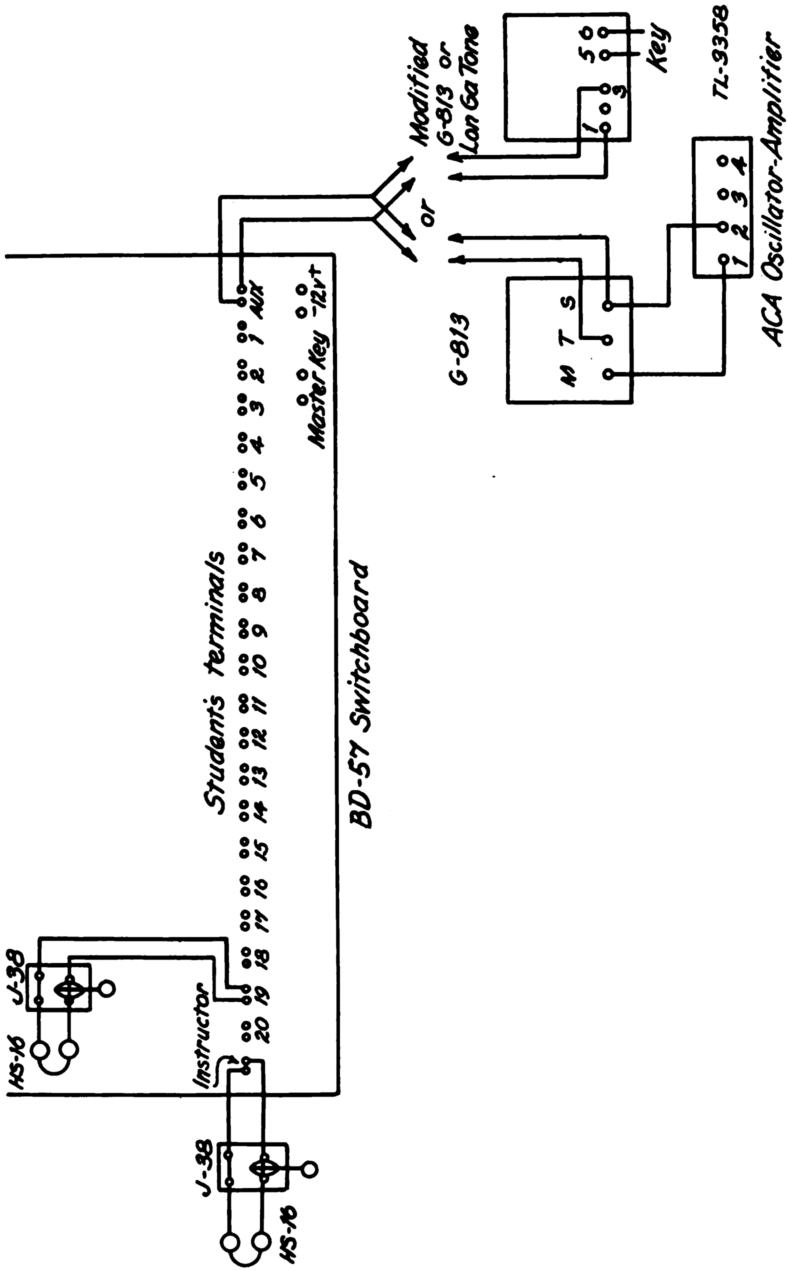

FIGURE 11.—Diagram of switchboard BD–57 used with either McElroy or Lon–Ga–Tone keyers. (If more than one switchboard is used with McElroy model G–813 automatic keyers, tone source connections are parelleled across as in fig. 9.)

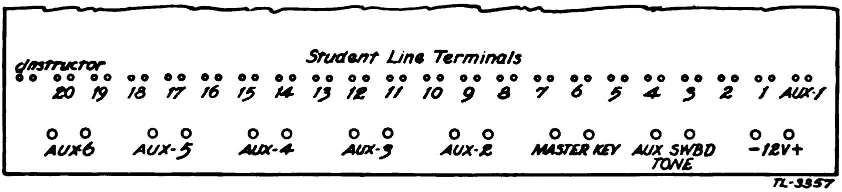

FIGURE 12.—Terminal board of switchboard BD-57-A.

a. Student positions.—Mount a key J-38 at each student position as shown in figures 6 and 14. At approximately 1 percent of the student positions mount the key so as to facilitate operation by left-handed operators; that is, 12 inches from the left of the student position and rotated 30° to the left instead of the right. Connect a headset HS-16 to each key J-38, as shown in figure 13. Tie the stay cord on the cord of each headset HS-16 to one of the terminals on each key J-38. Starting at the end of the table nearest the switchboard BD-57-A (see fig. 6) and alternating left and right, connect the student line terminals on the keys J-38 to student line terminals 1 through 20 on the switchboard BD-57-A. Use twisted pair wire W-33, or equal, for all student lines. Run the wire to each student position through a small hole in the top of the instruction table located to the right of the key. Cable the wires or group them in cable hooks under the table. Blake No. 3 insulated staples or equal can be used to support individual pairs until they are picked up in the cable or rings. Run the wires (or cable) through the 1¼-inch square holes in the table braces under the table top as shown in the end view of a 10-position instruction table (fig. 7). Pass the wires (or cable) through the round hole in the right side of the switchboard BD-57-A.

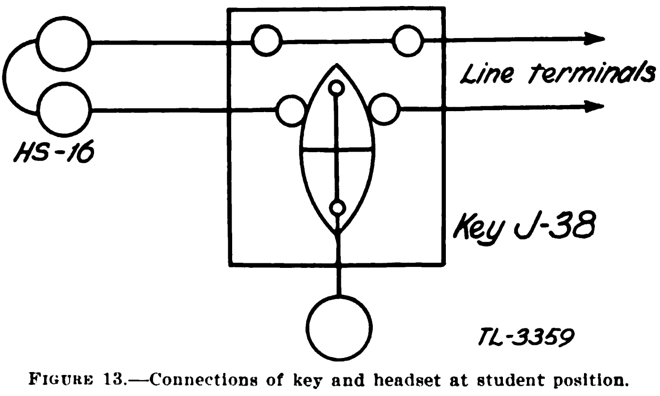

FIGURE 13.—Connections of key and headset at student position.

FIGURE 14.—Appearance of facing student positions, with student participating in actual keying practice.

b. Instructor's key.—Mount a key J-38 for convenient operation by an instructor at the switchboard BD-57-A. Connect a headset HS-16 thereto as indicated in figure 13. Using twisted pair wire W-33 or equal, connect the line terminals of the key to the terminals marked INSTRUCTOR on the terminal board of the switchboard BD-57-A. This wire can be included in the cable indicated in *a* above.

c. Auxiliary tone cords.—Connect each of the terminals marked AUX 1, AUX 2, AUX 3, AUX 4, AUX 5, and AUX 6 to similarly marked terminals on other switchboards BD-57-A (figs. 9 and 12). The number of switchboards so paralleled is determined from a consideration of the number of available automatic keyers and the number of switchboards to which it is desired to supply keyed tone from a particular keyer. In 40-student schools when only six automatic keyers are made available, all switchboards are paralleled. In large schools, it may be advisable to use terminal strips to provide for increased flexibility in the interconnection of switchboards and the keyers. One pair of terminals on a single terminal strip is provided for each of the auxiliary switchboard cords on each switchboard, and on an adjacent strip there is provided a pair of terminals for the output of each automatic keyer. Interconnection between strips can then be made to connect any automatic keyer to any or all auxiliary tone cords on any switchboard. Jack boards with interconnecting plugs may be substituted for the terminal strips. Use twisted pair wire W-33 or equal in the wiring to all auxiliary tone cords.

d. Master key.—Connect a short piece of jumper wire across the terminals marked MASTER KEY (see fig. 12). A master key is not used in this circuit.

e. Battery terminals.—The terminals marked −12V+ are left open, as no battery is required. The motor-alternator mounted inside the case of the switchboard is not used and may be ignored.

f. Auxiliary switchboard tone.—Connect in parallel, using twisted pair wire W-33 or equal, the terminals marked AUX SWBD TONE (fig. 12) on each of the switchboards BD-57-A which are to be supplied constant tone from a single source.

19. Input power circuit.—A decision having been reached as to the exact location of each tone source, automatic keyer, recorder, and record player, install a 110-volt 60-cycle bus, so that standard outlets thereon will be readily accessible at the location of each of these units (see fig. 5). Use a wire of sufficient size to insure good voltage regulation over the bus. Each unit requiring power for its operation is equipped with an input power cord with standard plug. If power outlets are already available in the instruction room, their location may influence the location of each of the units mentioned above. In general, it is better to extend the length of the power input cords on individual pieces of equipment than it is to disperse units in accordance with available power outlets.

20. Connecting oscillator-amplifier ACA–10–AO.—The terminals of the oscillator-amplifier ACA–10–AO are located on the rear of the chassis and are shown in figure 15.

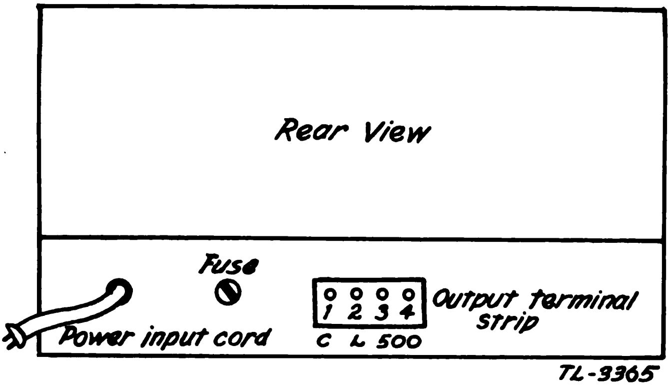

FIGURE 15.—Terminal board of ACA oscillator-amplifier.

a. Power input cord.—When ready for operation, plug the power input cord into the available outlet on the 110-volt 60-cycle bus (see par. 18).

b. Output terminal strip.—(1) Connect the terminals marked 1 and 2 on the output terminal strip (also marked C and L, respectively) to the terminals marked AUX SWBD TONE on the nearest switchboard BD–57–A. Use twisted pair wire W–33 or equal. This lead connects the constant tone output of the oscillator-amplifier to the primary circuits of the switchboards BD–57–A which were connected parallel as indicated in paragraph 18*f*. Connect the terminal marked 1, the common terminal, to ground.

(2) Connect a second twisted pair lead from terminals 1 and 2 on the oscillator-amplifier to the proper relay terminals on each of the automatic keying units, McElroy model G–813, which are to key the output of the oscillator-amplifier (see figs. 9 and 16). The relay terminals are not marked as such on the automatic keyer; however, they are properly labeled in figure 1 and the correct wiring is indicated thereon.

21. Connecting automatic keyer, McElroy model G–813.—The terminals of the automatic keyer, McElroy model G–813, are located on the top of the chassis to the right rear adjacent to the relay, as shown in figure 16.

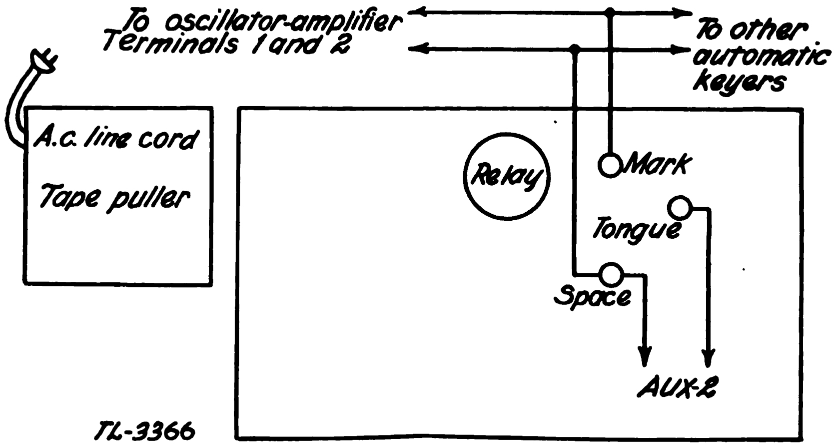

FIGURE 16.—Connections to McElroy keyer, model G–818.

a. Power input cord.—When ready for operation, plug the power input cord, located at the left end of the tape puller chassis, into the available outlet on the 110-volt 60-cycle bus. Polarize this plug so that no difference of potential exists between the chassis of the unit and ground. No harm will result when the plug is inserted with either polarization, but with one polarization a slight voltage will exist between chassis and ground which may be annoying to the touch.

b. Relay terminals.—(1) *Constant tone input.*—Constant tone input from the oscillator-amplifier is obtained by connecting the lead mentioned in paragraph 20*b*(2) across the mark and space terminals (see fig. 16).

(2) *Keyed tone output.*—Using twisted pair wire W–33 or equal, connect the tongue and space terminals on successive automatic keying units to successive pairs of terminals marked AUX 2, AUX 3, AUX 4, AUX 5, and AUX 6 on the terminal board of the nearest switchboard BD–57–A (see fig. 9). A systematic numbering of automatic keying units to conform with the numbering of the auxiliary tone cords on the switchboards BD–57–A is desirable. Connection is made to auxiliary tone cords by means of the terminals AUX 2, AUX 3, AUX 4, AUX 5, and AUX 6. When more than six automatic keying units are supplied, the connections described above may be modified as indicated in paragraph 18*c*.

22. Connecting automatic keyer, Lon–Ga–Tone, type 7.—The terminals of automatic keyer, Lon–Ga–Tone, type 7, are located on the rear of the chassis and are as shown in figure 17.

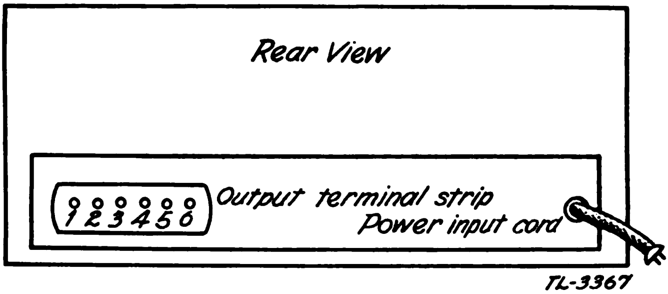

FIGURE 17.—Connections of Lon-Ga-Tone keyer, type 7.

a. Power input cord.—When ready for operation, plug the power input cord into the available outlet on the 110-volt 60-cycle bus (see par. 19).

b. Output terminal strip.—(1) *Automatically keyed output.*—Using twisted pair wire W-33 or equal, connect terminals 1 and 3 of the output terminal strip (fig. 17) on successive automatic keyers to successive terminals marked AUX 2, AUX 3, AUX 4, AUX 5, and AUX 6 on the terminal board of the nearest switchboard BD-57-A (see fig. 9). A systematic numbering of automatic keyers to conform with the numbering of the auxiliary tone cords on the switchboards BD-57-A is desirable. Connection is made to auxiliary tone cords by means of the terminals AUX 2, AUX 3, AUX 4, AUX 5, and AUX 6. When more than six automatic keyers are supplied, the connections described above may be modified in a manner indicated in paragraph 18*c*.

(2) *Manually keyed output.*—If it is desired that a constant tone output from the unit be arranged for manual keying, mount a key J-38 near the automatic keyer, and connect this key to terminals 5 and 6 on the output terminal strip (fig. 17).

23. Connecting keyer TG-10-B.—The keyer TG-10-B can be used wherever the use of the Lon-Ga-Tone keyer is indicated in any of the diagrams appearing in this manual. Plug the flexible power input cord into the nearest 110-volt outlet. Take the tape-keyed tone output from the screw binding posts on the right back edge of the chassis. There are four such posts, marked COM, 4, 8, 16. The first is the common secondary connection, and the others represent the different impedance taps. Use the COM post and *one* only of the others, depending on how many student positions are to be fed keyed signals. A few quick trials will determine the best output impedance. To key the tone output of this instrument by hand, connect a key to the posts on the back of the chassis marked KEY.

24. Connecting automatic keyer, McElroy model G–813, modified.—A top view of the chassis, showing the binding posts, is given in figure 18. On the actual instrument, the terminals are not marked at all, but they are identified by numbers as indicated for convenience in establishing external connections. This keyer, having its own tone source, is installed in the same manner as the Lon–Ga–Tone. Where any of the preceding diagrams show terminals 1 and 3, and 5 and 6, of the Lon–Ga–Tone unit, the same connections are used to the correspondingly numbered posts of the modified G–813 unit.

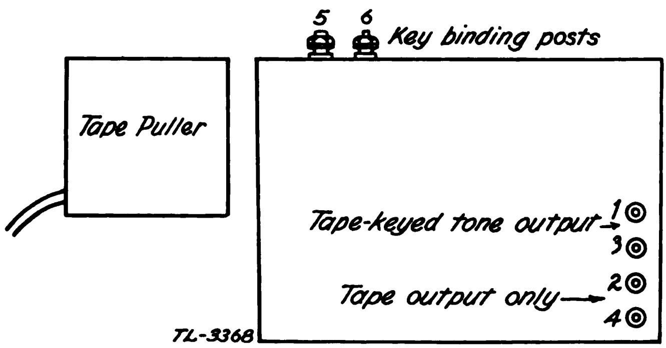

FIGURE 18.—Arrangement of binding posts on McElroy keyer, model G–813, modified. (Tape-keyed tone output is obtained from posts 1 and 3. If it is desired to use keying elements only of this unit to key external tone source (as from ACA oscillator-amplifier), terminals 2 and 4 are employed.)

25. Connecting transmission test table using automatic keying unit, McElroy model G–813.—*a. General.*—Figure 10 shows a method of interconnecting the automatic keying unit, McElroy model G–813, a recorder, a manual key, and a headset to provide for transmission tests, for the preparation of additional practice tapes, or for using the keyed tone output of the automatic keying unit on the auxiliary tone cords No. 1 of the switchboards BD–57–A. Note that the input cord for keyed tone and *not* the local keying posts (fig. 19) is used for connecting the keyed tone input to the recorder. Note also that on this particular automatic keying unit the mark and tongue contacts of the relay (fig. 16) are merely connected in series with the constant tone bus and the recorder. This method of connection facilitates the play-back of tapes prepared by students in that no switching is required. The manual key is connected in parallel with the mark and tongue contacts. A headset HS-16 is connected in parallel with the keyed tone input to the recorder. Auxiliary tone cord No. 1 on switchboards BD-57-A may also be connected in parellel with the input to the recorder.

b. Recorder, McElroy model RD-900.—Figure 19 indicates the location of the terminals of the recorder, McElroy model RD-900.

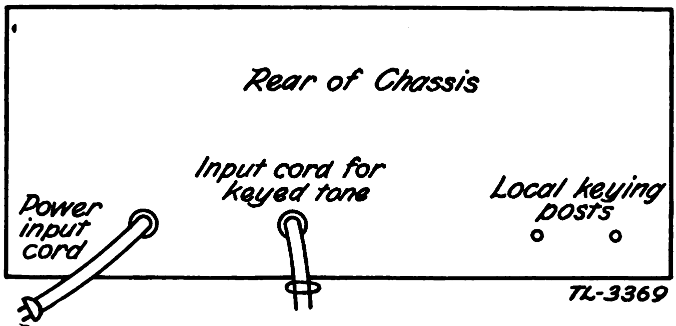

FIGURE 19.—Connections of McElroy recorder.

c. Tape puller, McElroy model CTP-1300.—The only connection to this unit is the power input cord located on the left side of the chassis.

d. Power input cords.—When ready for operation, plug the power input cords (figs. 16 and 19) into the available outlets on the 110-volt 60-cycle bus. Polarize these plugs so that no difference of potential exists between the chassis of any unit and ground.

26. Connecting transmission test table using Lon-Ga-Tone automatic keyer, type 7.—*a. General.*—Figure 10 shows a method of interconnecting a Lon-Ga-Tone automatic keyer, a recorder, a manual key, and a headset to provide for transmission tests, for the preparation of additional practice tapes, or for using the keyed tone output of the automatic keyer on the auxiliary tone cords No. 1 of the switchboards BD-57-A. The input cord for keyed tone on the recorder (fig. 19) is connected directly to terminals 1 and 3 (fig. 17) on the automatic keyer. A manual key is connected to terminals 5 and 6 on the automatic keyer. A headset with standard two-conductor plug inserted in the jack marked MONITOR on the front panel of the automatic keyer permits a student to monitor his transmission and play-back. Terminals 1 and 3 on the automatic keyer also can be connected to the auxiliary tone cords of the switchboards BD-57-A.

b. Power input cords.—When ready for operation, plug the power input cords of the automatic keyer, the tape puller, and the recorder into the available outlets on the 110-volt 60-cycle bus. Polarize the plugs as indicated in paragraph 25*d*.

SECTION III

OPERATION

27. Oscillator-amplifier ACA-10-AO.—The controls on this unit are located as shown in figure 20.

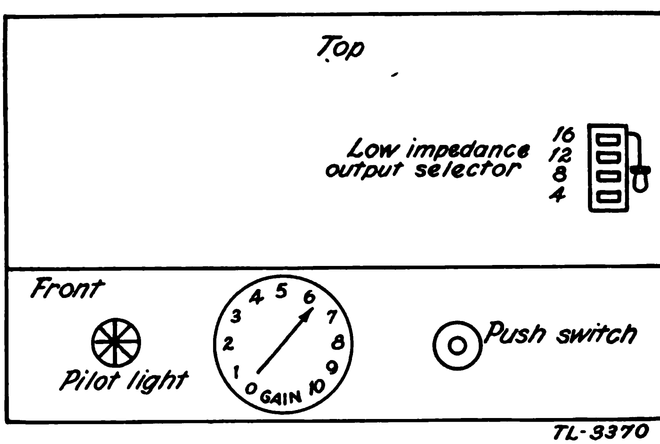

FIGURE 20.—Oscillator-amplifier chassis controls.

a. Low impedance output selector.—Remove the four screws holding the chassis cover in place and lift cover upward off the chassis. The low impedance output selector is located on the right side of the chassis top. Place the pin plug in the connector marked "4" for preliminary tests. Replace the chassis cover.

b. Push switch.—The oscillator-amplifier is turned on by pressing in the push switch. When the pilot light is on, the oscillator-amplifier is turned on.

c. Gain control.—The control marked GAIN varies the output tone level, increasing the level as the knob is rotated clockwise from 0 to 10.

28. Automatic keyer, McElroy model G-813.—The controls on the automatic keying unit, McElroy model G-813, are located as shown in figure 22.

a. Mounting practice tapes.—Mount an empty 400-foot reel on the take-up spindle located on the left of the tape puller unit. Mount the desired practice tape on the rewind spindle located on the right front of keying unit so that the tape comes off the bottom of the reel, i. e., the inked side of the tape is up. Lift the lamp house and tape guide upward and lay the tape over the aperture bar and replace the tape guide. Slip the tape toward the practice tape reel until the end of the tape is just to the right of the aperture in the aperture bar (see fig. 21). Move the aperture bar so that the aperture is directly

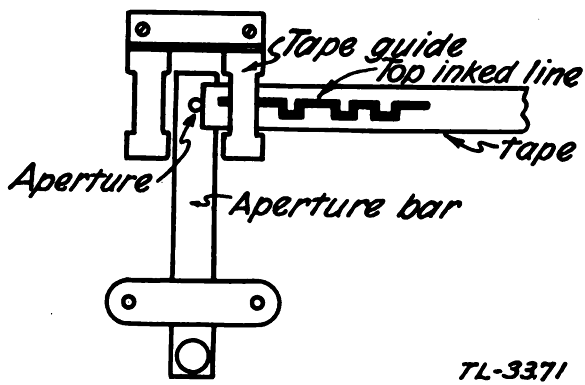

FIGURE 21.—Adjustment of photoelectric cell aperture on McElroy automatic keyer.

opposite the top inked line where a dot or dash is made. As the tape is drawn over the aperture the light from the exciter lamp is interrupted by the inked dots and dashes. Lower the lamp house into position. Thread the tape around the guide and puller, then onto the take-up reel as shown in figure 22. This tape path gives the best pulling action. No other should be used.

b. Controls.—(1) *Keying unit line switch.*—The automatic keying unit is turned on by an upward movement of the toggle switch located near the rear on the right end of the chassis. Operation of this switch turns on the exciter lamp located in the lamp house and supplies power to all vacuum tubes in the unit. This switch should be operated 20 to 30 seconds prior to initiating complete operation of the unit so as to permit tubes therein to warm up.

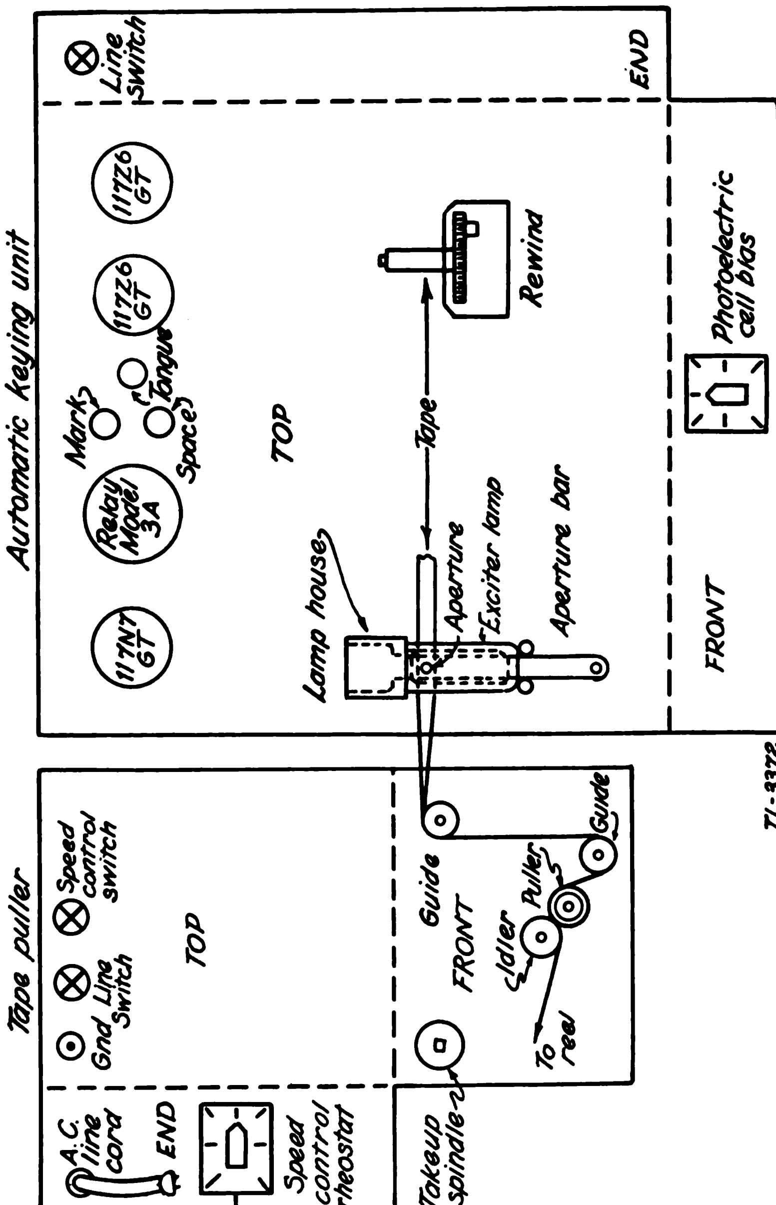

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FIGURE 22.—Controls of McElroy model G-818 automatic keyer.

(2) *Tape puller line switch.*—The tape puller motor is started by a rearward movement of the toggle switch next to the ground binding post of the tape puller. When starting, the speed control toggle

switch should be in its forward position and the speed control rheostat located on the left end of the tape puller should be set at 5. After the motor has started, throw the speed control toggle switch to the rear and adjust the speed control rheostat for desired speed. A clockwise rotation of the speed control rheostat increases the motor speed. The tape puller motor should be operated for approximately 15 minutes prior to initiating complete operation of the unit so as to allow it to reach a constant speed. The motor should be operated for this period of time prior to insertion of the tape as indicated in *a* above More constant speeds are obtained with the speed control toggle switch in its rear position. The switch is left in its forward position only for starting and for very high speeds.

(3) *Photoelectric cell bias.*—The knob control marked "photoelectric cell bias" in figure 22 is adjusted to obtain clean keying. Initially set this control between 1 and 4. If the adjustment of the aperture as indicated in *a* above has been incorrectly made there will be no setting of this control which will result in proper keying. If this is the case recheck the aperture adjustment.

c. Relay model 3A.—The relay model 3A located at the rear of the keying unit should be adjusted only by experienced instrument repairmen. Under normal operating conditions it should require little attention. If clean keying does not result after proper adjustment of the aperture and photoelectric cell bias, the relay should be examined through its glass cover. If maladjustment is noted remove the relay from its plug-in socket and replace with a spare relay properly adjusted.

29. Automatic keyer, Lon–Ga–Tone, type 7.—The controls on the Lon–Ga–Tone automatic keyer, type 7, are located as shown in figure 23.

a. Mounting practice tapes.—Mount an empty 400-foot reel on the spindle indicated in figure 23. Mount the desired practice tape reel on the spindle of the rewind located on the right of the front panel. The rewind is hinged to the panel so that it can be moved away from the panel to facilitate the mounting of the reel. This reel is mounted so that the tape leaves the bottom of the reel, for example, so the inked side of the tape is upward. The tape is passed under the guide, through the track in the photoelectric cell house, between the idler and puller wheels, into a slot on the hub of the empty reel mounted as indicated above. To relieve the tension on the tape between the idler and puller wheel, pull out and upward on the knurled knob on the idler wheel shaft. This locks the idler wheel arm in a position that allows the tape to be pulled between the two wheels for rewind purposes as well as for threading the tape between the wheels. To disengage the idler wheel arm from its raised position, push in on it, and the idler wheel will drop onto the tape into its pulling position.

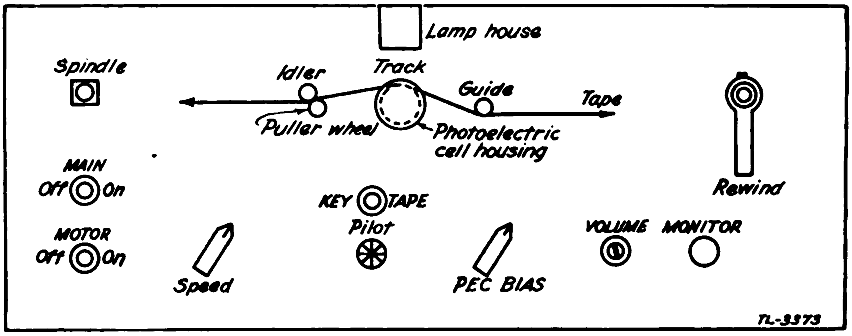

FIGURE 23.—Front-panel controls of Lon-Ga-Tone keyer.

b. Controls.—(1) *Main switch.*—The toggle switch marked MAIN controls the 110-volt 60-cycle supply. When the switch is thrown to the ON position, the pilot lamp, the exciter lamp in the lamp house, and all vacuum tubes are turned on.

(2) *Speed control.*—The control knob marked SPEED varies the speed of the tape puller, hence the speed of the tape passing the light beam. A clockwise rotation of the knob gives an increase in speed. The knob is turned so that it points to the letter "S" in the word INCREASE for starting speed. Immediately after the motor switch is turned to the ON position, and the tape reels have started, the speed control is adjusted for the desired keying speed. The puller will not properly start the reels at low tape speed.

(3) *Motor switch.*—The toggle switch marked MOTOR controls the 110-volt 60-cycle supply to the tape puller and take-up motors. This switch is not turned on until the speed control has been adjusted for starting as explained in (2) above.

(4) *Key-tape switch.*—For automatic keying from the tape, the toggle switch is thrown to TAPE position. For manual keying, the toggle switch is thrown to KEY position, and the key J-38 connected as explained in paragraph 22*b* (2) is used.

(5) *Monitor.*—The jack marked MONITOR is used for headset monitoring of the automatic or manual keying. A headset HS-4 with plug PL-48 is used. Plugging into the monitor jack does not affect the output of the automatic keyer.

(6) *Volume control.*—The screw driver control marked VOLUME controls the output level of the keyed tone. A clockwise rotation increases the tone level. Move this control to the left as far as possible, then move clockwise until the screw driver slot is vertical (1/8 to 1/4 of a turn) and leave in this position for preliminary tests.

(7) *Photoelectric cell house aperture and PEC.BIAS.*—Turn PEC BIAS knob so as to point toward the volume control. Pull the sliding barrel with knurled top outward as far as it will go, then push inward gradually until the small square aperture comes under the lower line of the inked tape as shown in figure 24. It is important to note that while the same practice tapes are used in both the McElroy and Lon-Ga-Tone keyers, the adjustments of the apertures are different. The McElroy unit keys on the *inked* sections of the tape; the Lon-Ga-Tone on the *uninked* sections. This adjustment is best accomplished by slipping the tape end to the right of the track and watching the inward motion of the aperture. After threading the tape, throw the main switch to the ON position and, after 30 seconds, the motor switch to the ON position. The PEC BIAS knob is slowly rotated counterclockwise until keying is heard in the monitoring head set. Slight adjustments of the sliding barrel and the PEC BIAS knob will give proper keying.

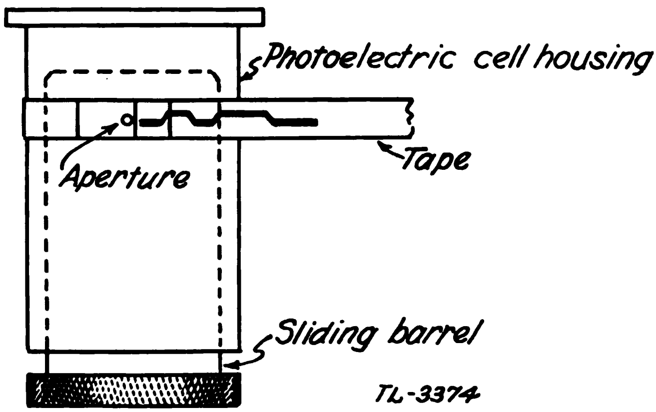

FIGURE 24.—Correct adjustment of tape in relation to aperture of Lon-Ga-Tone keyer.

30. Keyer TG-10-B.—The general instructions given for the Lon-Ga-Tone unit apply also to the automatic keyer TG-10-B. To disengage the puller roller, when threading on a tape, push it to the right, and it will stay open. To reengage it, raise the puller idler and the assembly will snap back into position. Figure 25 shows a general front view of the TG-10-B, with a tape in correct position. Of the front-panel controls, the tape speed, monitor, volume, and bias functions are exactly the same as in the Lon-Ga-Tone. However, the power control is different. This is a three-position rotary switch, with the positions marked OFF, KEY, and TAPE. In the first or OFF position, the entire apparatus is dead. In the second or KEY position, the oscillator-amplifier section is turned on, and the hand key controls the tone output; both the puller motor and the exciter lamp are inoperative. In the third or TAPE position, the motor and the lamp are turned on in addition to the oscillator-amplifier, and the unit then functions as a full automatic tape keyer. The numbers on the tape speed dial indicate the number of feet of tape per minute, not words per minute.

31. Automatic keyer, McElroy model G-813, modified.—*a. General.*—The adustments and controls of this equipment are shown in figure 26. The model G-813, modified, closely resembles the model G-813 as described in paragraph 28. The identical tape mechanism is used on the keyer itself, and the tape puller differs only in that the auxiliary speed control switch found on the G-813 is not present. All instructions regarding the threading of the tape, the adjustment of the various guides and spindles, as given for the G-813, apply as well to the G-813 modified.

b. Controls.—(1) *Line switches.*—The line switch S1, which is mounted on the back of the keyer chassis, is left in the ON position, and the keyer circuits are controlled by switch S2 mounted on the case of the tape puller. As supplied by the manufacturer, the keyer and the tape puller are already wired together, and a single 110-volt plug provides power for both units.

(2) *Bias control.*—This is adjusted as described in paragraph 28*b*(3).

(3) *Tone frequency control.*—This is located on the back edge of the chassis. Adjust it for a pleasing signal, and then leave it alone.

(4) *Manual keying.*—Two binding posts for a manual key are provided on the back edge of the chassis. Normally, these are kept short-circuited by a brass strap, as there will be little occasion to hand-key the output of the instrument directly at the position at which it is mounted.

(5) *Monitoring.*—A monitoring jack is mounted under the binding posts on the right side of the chassis. A pair of phones can be plugged into it without affecting the keyed output.

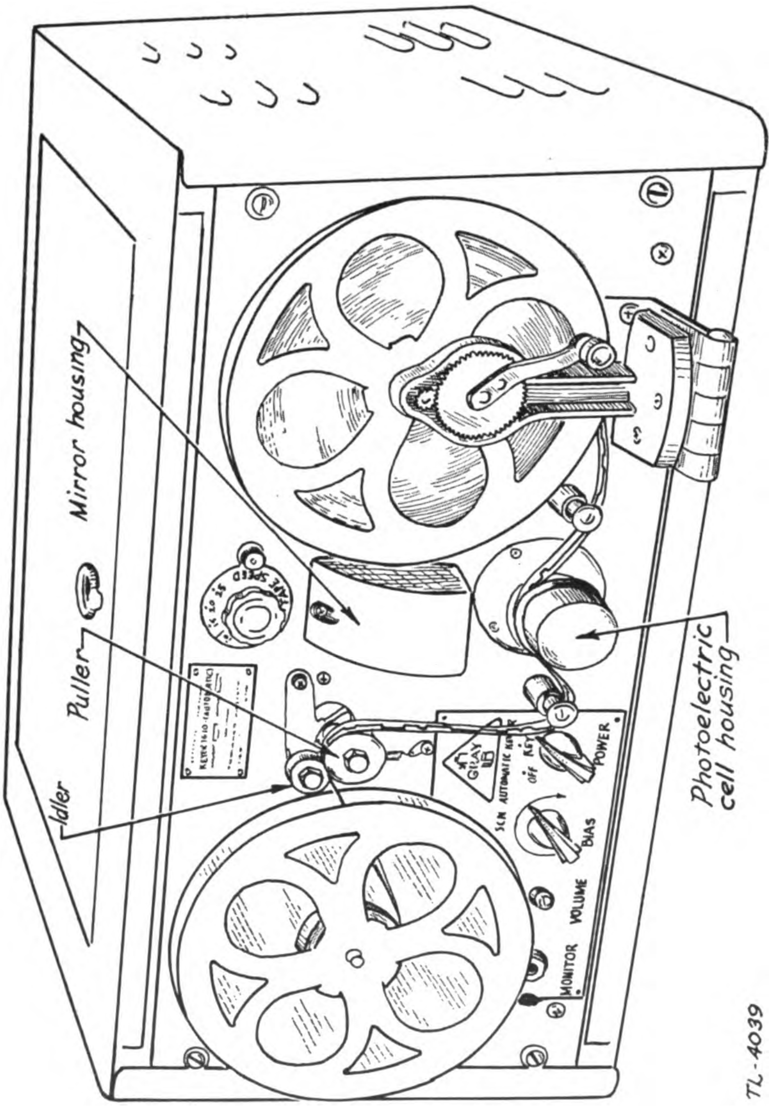

FIGURE 25.—Front view of keyer TG–10–B with tape in position.

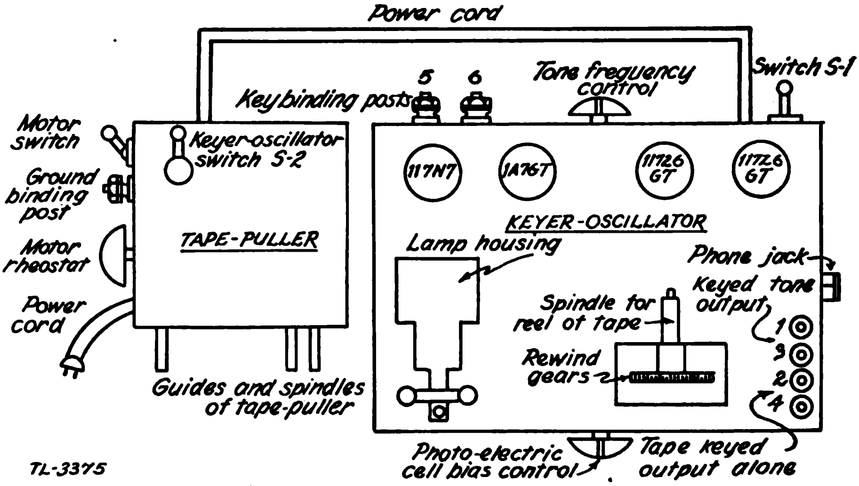

FIGURE 26.—Arrangement of essential parts and controls of McElroy keyer, model G-813, modified.

(6) *Relay.*—The keying relay is mounted on the underside of the chassis. This is not adjustable, and is not likely to give trouble during the normal life of the equipment.

32. Recorder, McElroy model RRD-900.—Adjustments and controls on the recorder, McElroy model RRD-900, are located as shown in figue 27.

a. Mounting blank tapes.—Place a standard roll of ⅜-inch ungummed tape on the tape plate so that the tape will feed to the left from the back of the tape plate. Thread the tape around the back of guide 1, the back of guide 2, the front of the tape roller, and the back of guide 3. Pull enough tape from the roll to reach the tape puller associated with the recorder. This tape puller should be so mounted that guide 3 is lined up vertically and horizontally with the top guide on the tape puller (see fig. 22). Rotate the tape a quarter turn so that the top side of the tape over the latter guide is that on which the stylus of the recorder operates. Thread the tape through the tape puller as shown in figure 22. It is inadvisable to use a take-up reel on the puller while a tape is being prepared, particularly so if the tape puller is mounted adjacent to the recorder. Ink is likely to smear on adjacent turns of tape. Furthermore, if the tape is taken up while recording, a rewind operation is required. A more suitable practice is to allow the inked tape to feed off the puller into a waste basket or other receptacle on the floor, and if required, to rewind the tape therefrom upon completion of a recording. A rewind of a student transmission test tape is seldom required as this short tape may be fed directly into an automatic keying unit.

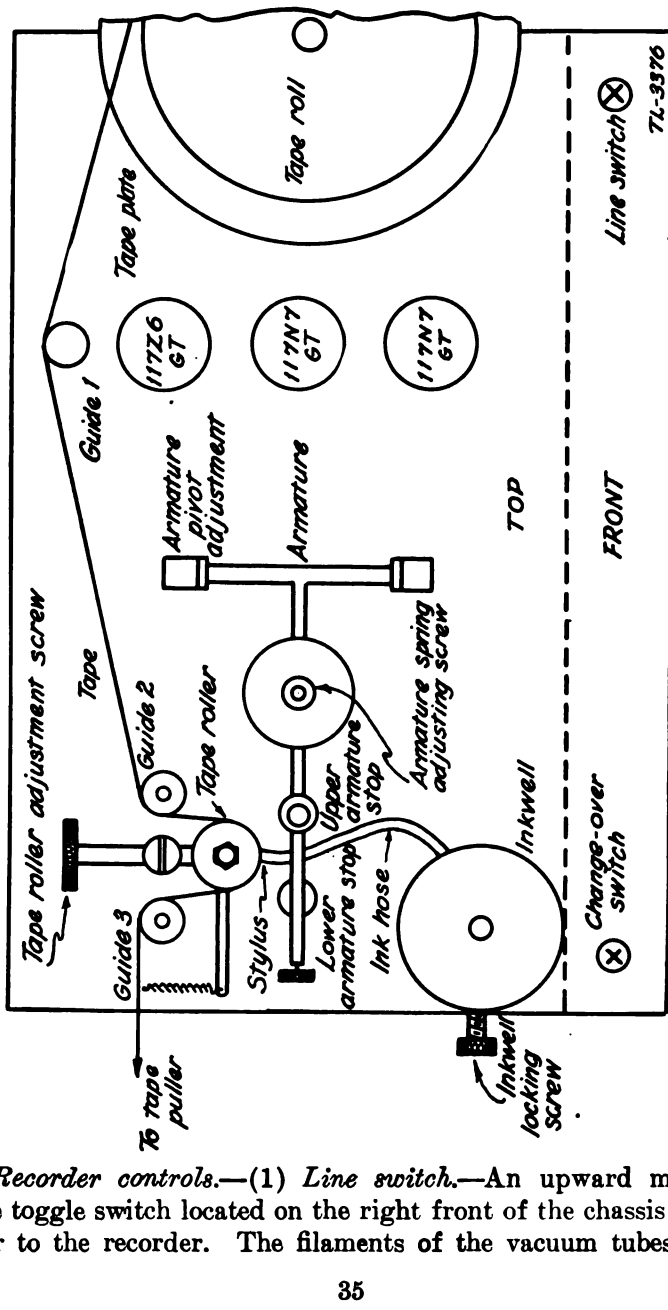

FIGURE 27.—Controls and adjustment on McElroy recorder.

b. Recorder controls.—(1) *Line switch.*—An upward movement of the toggle switch located on the right front of the chassis supplies power to the recorder. The filaments of the vacuum tubes therein should light. A flash may be observed within these tubes which is characteristic of the tubes employed. Allow 30 seconds for warming up of tubes prior to initiating operation of the recorder.

(2) *Change-over switch.*—A change-over switch, located on the left front of the chassis, controls the input to the armature coil of the recorder mechanism. Since use of the local keying posts on the rear of the chassis is not recommended, this switch may be used as the off-on switch of the recorder output circuit. An upward movement connects the armature coil to the output of the recorder amplifier. When it is desired to keep the recorder warm but to maintain it in an inoperative condition, leave this switch in its down position.

c. Ink supply.—Loosen the inkwell locking screw and lower the inkwell to its lowest position. Remove the top of the inkwell and fill the well about three-fourths full with Higgins Eternal black ink, or equal. Replace the inkwell top.

d. Adjustments.—(1) *Lower armature stop.*—Turn the tape roller adjusting screw in a clockwise direction (when viewed from the front of the recorder) until the stylus just leaves the tape. Loosen the lock nut on the lower armature stop. Adjust the stop until the bottom of the stylus is about one-third way up the tape. Tighten the lock nut.

(2) *Upper armature stop.*—Loosen the lock nut on the upper armature stop. Adjust this stop until the travel of the armature between its upper and lower stops is 1/8 inch. Tighten the lock nut.

(3) *Armature spring tension.*—Loosen the lock nut on the armature spring adjusting screw. Adjust this screw until the armature is firmly held against the lower armature stop by the tension in the armature spring. Tighten the lock nut. This adjustment is not critical but may require readjustment after operation of the recorder is initiated in order to effect clean keying.

(4) *Ink adjustment.*—Rotate the tape roller adjusting screw in a counterclockwise direction (when viewed from the front of the unit) until the tape just makes contact with the stylus. Loosen the inkwell locking screw and raise the inkwell until the level of the ink therein is about 1 inch above the stylus. Tighten the locking screw. Pull the tape by hand slowly by the stylus. A solid black line should be recorded about one-third of the way up the tape. If this line is not smooth and solid, move the tape roller adjusting screw in a counterclockwise direction so as to increase slightly the pressure between the stylus and the tape roller. If no line is recorded, the stylus may be clogged. If this is the case, lower the ink-

well and remove the ink hose from the stylus. By means of the tape roller adjusting screw, move the tape roller away from the stylus. Insert a fine wire in the ink hose end of the stylus and remove any obstructions therefrom. Replace the ink hose, raise the inkwell to the proper level, and readjust the tape roller against the stylus by means of the tape roller adjusting screw.

33. Record player, Columbia model P.—The control marked VOLUME should be turned completely to the left prior to plugging the input power cord into a 110-volt 60-cycle outlet. The desired disk record is placed on the turntable, and the 110-volt 60-cycle supply is turned on by turning the knob marked VOLUME to the right. The initial movement operates a switch in the 110-volt 60-cycle supply; the remainder of the clockwise rotation increases the speaker volume. The needle held in the pick-up head is lowered gently into the outermost groove in the record. The tone control is adjusted for the reproduction quality desired. When the tone control is turned to the left, bass is accentuated; when turned to the right, treble is accentuated. For use in a large room the speaker compartment is removed by sliding it to the left so as to disengage the hinges. A hook is provided on the speaker compartment for use in hanging the speaker on a wall. The wall gives baffle effect to the speaker, resulting in better tone reproduction and sound direction for large rooms.

34. Switchboard BD–57–A.—*a. General.*—Figure 28 shows the jack field and the cords of the switchboard BD–57–A. The red cords indicated thereon are the auxiliary tone cords which furnish the keyed tone output of the automatic keyers for use at the switchboard. The black cords are student cords and hang directly under the student jacks with which they are associated. They are used for interconnecting student positions for various purposes. The white cord is the instructor's cord and is used for monitoring transmissions or for manually keying to students from the switchboard BD–57–A. This switchboard permits the establishment of circuits to its student positions so as to furnish groups of students with the following instruction:

(1) Practice transmissions by each student which are monitored only by that student.

(2) Grouping of all or several of the students into a net so that a transmission by any one of the students is received by all students in the group. This is subsequently referred to as net operation.

(3) Grouping of all or several of the students so as to receive keyed tone from any one of five automatic keyers.

(4) Grouping all or several of the students so as to receive signals from a radio receiver or from the automatic keyer associated with a recorder on the transmission test table.

b. Individual student keying.—When constant tone is supplied to the switchboard BD-57-A and none of the plugs is inserted into any jack, every student connected to the switchboard receives constant tone as long as his key J-38 is closed. Opening the switch on his key permits any student to key this tone and to monitor his transmission independently of any other student.

c. Net operation.—Assume that it is desired to interconnect the student at position No. 1 with the student at position No. 5 in order that each may transmit to the other. Insert the plug associated

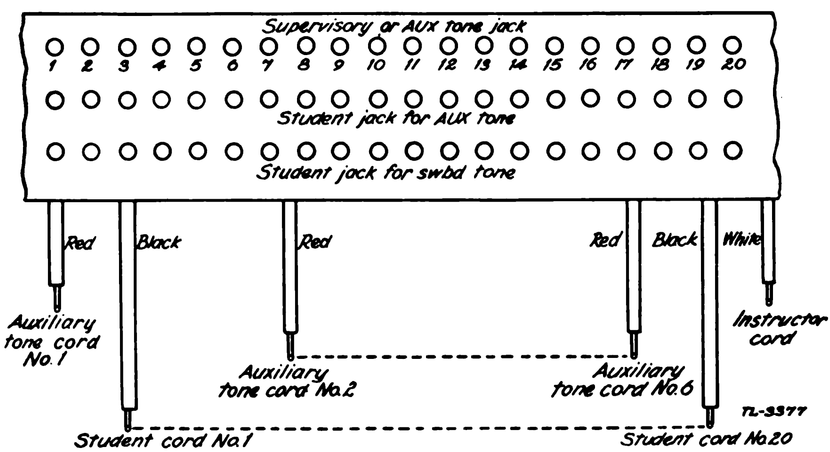

FIGURE 28.—Jack and cord arrangement of switchboard BD-57-A.

with student position No. 1 into jack No. 5 of the row of jacks marked STUDENT JACK FOR SWBD TONE. Insert the plug associated with student position No. 5 into jack No. 1 on the row of jacks marked STUDENT JACK FOR SWBD TONE. The students at positions Nos. 1 and 5 are now connected in series and either may transmit to the other as long as the other's key is closed. Such a transmission is interrupted when the receiving student opens his key. Assume that it is desired to interconnect all students for net operation. Insert the plug associated with student position No. 1 into jack No. 2 of the row of jacks marked STUDENT JACK FOR SWBD TONE. Insert the plug associated with student position No. 2 into jack No. 3 of the row of jacks marked STUDENT JACK FOR SWBD TONE. Proceed in a similar manner until the plug associated with student position No. 19 has been inserted in jack No. 20 of the row of jacks marked STUDENT JACK FOR SWBD TONE. Insert the plug associated with student position No. 20 into jack No. 1 on the row of jacks marked STUDENT JACK FOR SWBD TONE. All students are now connected in series and as long as the keys of all other positions are closed, any student may transmit to all others. If any other key is open, the transmission is interrupted.

d. Reception of automatically keyed tone.—Assume that it is desired to furnish the student at position No. 1 with keyed tone from the automatic keyer No. 2 which is associated with the auxiliary tone cord No. 2. Insert the student cord associated with position No. 1 into jack No. 1 on the row of jacks marked STUDENT JACK FOR AUX TONE. Insert auxiliary tone cord No. 2 into jack No. 1 on the row of jacks marked SUPERVISORY OR AUX TONE JACK. The student at position No. 1 will now receive the keyed tone output of automatic keyer No. 2. Assume that it is desired to connect the students at positions Nos. 1 and 5 on the keyed tone output of automatic keyer No. 2. Insert the plug associated with student position No. 1 into jack No. 5 on the row of jacks marked STUDENT JACK FOR AUX TONE. Insert the plug associated with student position No. 5 in jack No. 1 of the row of jacks marked STUDENT JACK FOR AUX TONE. Insert the auxiliary tone cord No. 2 into jack No. 1 or No. 5 on the row of jacks marked SUPERVISORY OR AUX TONE JACK. The students at positions Nos. 1 and 5 may be connected as indicated above, while other students remain interconnected as indicated in *c* above for practice transmissions. Assume that it is desired that all students receive the keyed tone output of automatic keyer No. 3. Insert the plug associated with student position No. 1 into jack No. 2 on the row of jacks marked STUDENT JACK FOR AUX TONE. Insert the plug associated with student position No. 2 into jack No. 3 on the row of jacks marked STUDENT JACK FOR AUX TONE. Proceed in a similar manner until the plug associated with student position No. 19 is inserted in jack No. 20 on the row of jacks marked STUDENT JACK FOR AUX TONE. Insert the plug associated with student position No. 20 into jack No. 1 on the row of jacks marked STUDENT JACK FOR AUX TONE. Plug the auxiliary tone cord No. 3 into any one of the jacks on the row of jacks marked SUPERVISORY OR AUX TONE JACK.

e. Reception of other signals.—Auxiliary cord No. 1 may be used to introduce into the switchboard BD–57–A the output of a radio receiver or the keyed tone output of the automatic keying unit associated with the recorder on the transmission test table. When so used, circuits for receiving the output of these units are set up in a manner identical to that described in *d* above, except that auxiliary switchboard tone cord No. 1 is used.

f. Monitoring operations.—When it is desired to monitor the transmission on any student line, insert the instructor's white cord into the jack on the row of jacks marked SUPERVISORY OR AUX TONE JACK which is associated with the student's line. The signal which is present in the line actuates the headset HS–16 associated with the instructor's position at the switchboard BD–57–A. If several students are interconnected for the reception of a single transmission, a jack on the row of jacks marked SUPERVISORY OR AUX TONE JACK which is associated with any one of the student positions may be employed. When the instructor's cord is inserted in a jack, the switch on the key J–38 at the instructor's position should be closed.

g. Panel controls.—(1) *Potentiometer.*—Mounted at the right side of the front panel is a potentiometer by means of which the volume level of constant tone which is supplied to students for individual keying or for net operation may be adjusted.

(2) *Battery switch.*—With the equipment described herein the switch marked BATTERY is not used. Leave it in the OFF position.

(3) *Switchboard tone switch.*—The switch marked SWBD TONE as used with the equipment described herein is an off-on switch for the constant tone supplied to the switchboard. When rotated to the right (to AUX), constant tone is supplied to the switchboard from the external oscillator-amplifier. Rotation to the left (to GN–33) opens the constant tone circuit.

35. Preliminary adjustment of tone level.—*a. Using automatic keyer, McElroy model G–813.*—(1) Patch a circuit on a switchboard BD–57–A which will permit each student position connected thereto to receive the keyed tone output of automatic keyer No. 2 (see par. 34).

(2) Turn on the oscillator-amplifier ACA–10–AO. Set the control marked GAIN at 5 (see par. 27).

(3) Mount a practice tape on automatic keyer No. 2. Turn on the automatic keyer and adjust for clean keying (see par. 28).

(4) Note the keyed tone level at any one of the student positions.

Adjust the oscillator-amplifier low impedance output selector (fig. 20) by connecting successively to terminals 4, 8, 12, and 16 until a suitable level of keyed tone is noted in a student headset. A suitable level will be produced by an output of 3.5 to 7 volts, as measured at a student position with an output meter. The oscillator-amplifier has a rated audio output of 10 watts, which is more power than is needed for the largest contemplated school; therefore, the choice of terminals on the low impedance output selector will not be critical. The lowest impedance output that will give a comfortable signal under maximum load conditions is used. The 500-ohm termination on the oscillator-amplifier should never be used as it would give a voltage that would cause serious inductive trouble in adjacent circuits.

(5) Mount a blank tape on the recorder, McElroy model RRD–900. Adjust the recorder for proper operation (see par. 32).

(6) Operate the manual key at the transmission test table. The tone level adjustment effected in (4) above should be adequate to effect clean recording. If not, readjust the low impedance output selector on the oscillator-amplifier ACA–10–A0 until satisfactory recording is accomplished.

(7) With a permanent adjustment made as indicated above, adequate variation in tone levels to conform with major load variations is accomplished by means of the control marked GAIN on the oscillator-amplifier.

(8) With the tone level set as indicated above, variation in the level of constant tone supplied to students for individual keying or for net operation may be accomplished by means of the control marked POTENTIOMETER on the switchboard BD–57–A.

b. Using automatic keyer, Lon–Ga–Tone, type 7.—(1) Patch a circuit on a switchboard BD–57–A which arranges all student positions for net operation (see par. 34). Set the control marked POTENTIOMETER approximately at the center of its range. Turn the switch marked SWBD TONE to AUX.

(2) Turn on the oscillator-amplifier ACA–10–AO. Set the control marked GAIN at 5 (see par. 27).

(3) Operating a key at a student position, note the keyed tone level in the headset. Adjust the oscillator-amplifier low impedance output selector (fig. 20) by connecting successively to terminals 4, 8, 12, and 16 until a suitable level of keyed tone is noted (see *a*(4) above).

(4) Adjustment of the keyed tone output level from the Lon–Ga–Tone automatic keyers is accomplished individually on each

keyer. Utilizing the output terminals, adequate variation in output level for all major changes in load is accomplished on the control marked VOLUME.

c. Using keyer TG-10-B.—Same as for Lon-Ga-Tone, type 7.

d. Using automatic keyer, McElroy model G-813, modified.—This unit is employed in the same manner as the Lon-Ga-Tone. However, it contains no volume control of its own, and its full output is used at all times. This will cause no discomfort in the ears of students, as the actual output is very much lower than that of the Lon-Ga-Tone keyer or that of the ACA oscillator-amplifier when the latter is keyed by the G-813 keyer alone.

36. Initiating complete operation.—*a. Automatic keyers* (see fig. 9).—(1) Check to see that adjustments on all units have been made as previously indicated.

(2) Turn on all tape puller motors about 15 or 20 minutes prior to the hour at which instruction is to be initiated. A practice tape should be mounted on each Lon-Ga-Tone automatic keyer in order that a load be maintained on the take-up motor.

(3) Patch desired circuits on switchboards BD-57-A.

(4) About 5 minutes prior to the hour instruction is to be initiated, adjust the speed of each tape puller so that 12 feet of tape per minute pass the aperture, that is, the speed of the tape is 12 feet per minute. This is the tape speed which must be maintained in order to transmit the actual characters from all practice tapes at a speed of 20 words per minute. Tape speeds can be checked by counting the number of characters transmitted per minute and comparing the count with data as to the words-per-minute speed which are furnished with these tapes (see par. 10). A more accurate speed determination may be made by a speed measurement with a tachometer equipped with a calibrated wheel. If the latter instrument is not available a map measurer and a stop watch may be substituted.

(5) About 2 minutes prior to the hour instruction is to be initiated, shut off the tape puller motors and rewind all practice tapes used during the warm-up period. Remove the tape from all guides and from the puller wheel during this operation. Also remove the spring belt from the take-up spindle on the McElroy tape pullers.

(6) Mount the desired practice tape on each automatic keyer. Turn on the oscillator-amplifier and all keyers. Check the tape speed.

(7) After instruction is initiated, check tape speed at 5-minute intervals for the first 15 minutes and hourly thereafter.

(8) Each reel of practice tape is designed for about 1 hour of

transmission. When transmission from each tape is completed, rewind tapes as indicated in (3) above, and repeat operations (6) and (7).

b. Transmission test table (see fig. 10).—(1) Check that the adjustments on all units have been made as previously indicated.

(2) Turn on tape puller motors about 20 minutes prior to the hour at which recording is to be initiated. About 5 minutes prior to the hour at which recording is to take place, adjust the speed of the tape pullers as indicated in *a*(4) above.

(3) Turn on the line switches on the recorder and on the McElroy automatic keying unit. Shut off the tape pullers. Mount a blank tape and thread it through the recorder and onto the tape puller.

(4) To record a student's practice transmission, start the take puller and allow about 4 feet of tape to feed through the puller. This portion of the tape is used as a leader for subsequent play-back. The student's name and other pertinent data are written in pencil thereon. Throw the change-over switch on the recorder to its up position. If the Lon-Ga-Tone keyer is used, throw the KEY-TAPE switch to KEY. The student now operates the key J-38 and his transmission is recorded on the tape.

(5) While the student is still transmitting, the tape leader can be mounted in the automatic keyer without the use of any feed or take-up reels so that when his transmission is completed play-back may be initiated immediately. However, be sure first that the ink is thoroughly dry.

(6) Upon completion of a student's transmission, stop the tape puller, throw the recorder change-over switch to its off position, and cut the tape to the left of the tape puller. Start the tape puller on the automatic keyer and play back to the student his prepared tape.

(7) To prepare copies of the master tapes, mount the tape to be copied on the automatic keyer. Adjust the automatic keyer to a tape speed of 12 feet per minute. If the Long-Ga-Tone automatic keyer is used, throw the KEY-TAPE switch to TAPE. Start the recorder tape puller and allow about 4 feet of tape to feed through the puller. Throw the recorder change-over switch to its up position. The recorder will record the keyed tone received from the automatic keyer.

SECTION IV

FUNCTIONING OF CIRCUITS; MAINTENANCE AND REPAIR

37. General.—The electrical circuits of the units of code practice equipment described in this manual are rather simple, and most of the individual parts are operated well below their rated maximums. Because of the number of moving parts, maintenance is more of a mechanical than an electrical problem. If the various chassis are kept clean, and the bearing surfaces of the rotating elements well-lubricated, the equipment will give long, trouble-free service. Any necessary repairs can be accomplished by a competent radio repairman.

38. Automatic keyer, Lon-Ga-Tone, type 7.—The circuit diagram is shown in figure 29, and the accompanying caption includes a detailed list of parts. The latter are standard radio replacement parts. The outside and inside appearance of the unit is shown in figures 30, 31, and 32. In these illustrations, the parts are numbered to correspond with the markings in the schematic diagram, figure 29.

V1	Type 923 gas photoelectric cell.
V2, V3	Type 6SJ7 tube.
V4, V5	Type 6N7 tube.
V6, V7	Type 6V6 tube.
V8	Type 5Y4G tube.
R1	50-megohm resistor.
R2	500,000-ohm resistor.
R3	2-megohm resistor.
R4	60,000-ohm resistor.
R5	750-ohm resistor.
R6, R7	50,000-ohm resistor.
R8	25,000-ohm potentiometer.
R9	400-ohm resistor.
R10, R11	50,000-ohm resistor.
R12	100,000-ohm resistor.
R13	5,000-ohm resistor.
R14	100,000-ohm resistor.
R15	200-ohm resistor.
R16	1,500-ohm resistor.
R17	5,000-ohm resistor.
R18, R19	1,000-ohm resistor.
R20	1,000-ohm potentiometer.
R21	300-ohm potentiometer.
C1	Triple 8-μf capacitor.
C2	0.00025-μf capacitor.
C3	0.01-μf capacitor.
C4	0.1-μf capacitor.
C5	0.2-μf capacitor.
C6, C7	0.1-μf capacitor.
S1, S2	D. P. S. T. switch.
S3	S. P. D. T. switch.
T1	Power transformer.
T2	Output transformer.
L1	20-henry filter choke.
L2	200-mh choke.

Exciter lamp, double filament auto headlight bulb.
Pilot light, 6.3 volts.

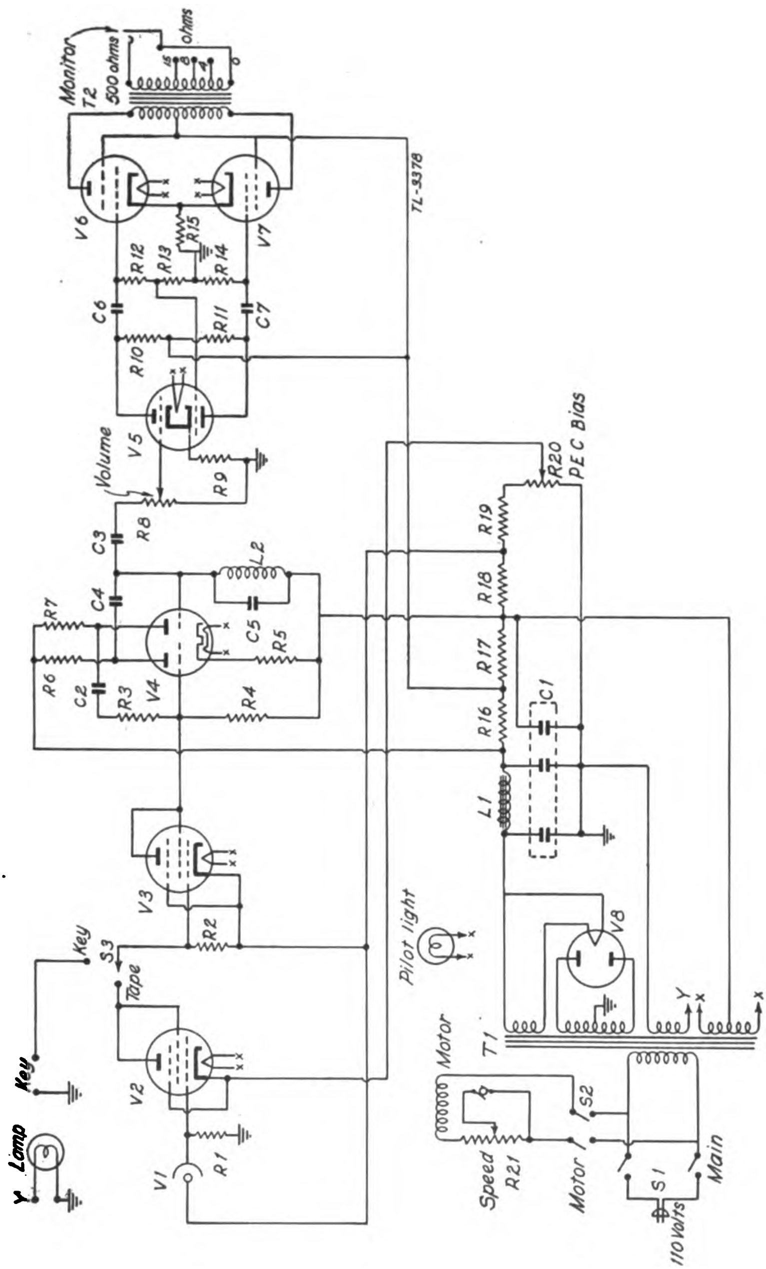

FIGURE 29.—Circuit diagram of Lon-Ga-Tone automatic keyer, type 7.

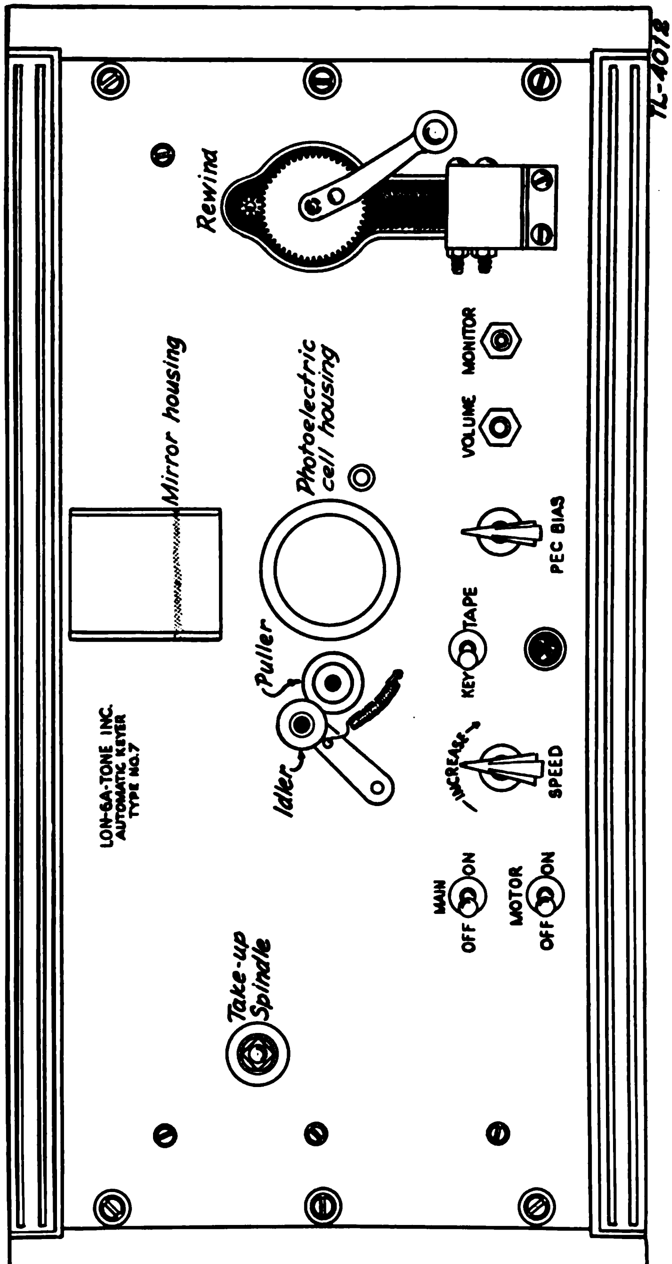

FIGURE 30.—Front panel view of Lon-Ga-Tone automatic keyer unit.

a. Functioning of circuit.—Tube V4 is a double triode functioning as the tone oscillator. The frequency of oscillation is determined by the constants of inductor L2 and capacitor C5, which are connected to the grid-cathode circuit of the right-hand section of V4. The plate of the right-hand section of V4 is connected to the grid of the left-hand section through capacitor C2 and resistor R3; the plate of the latter triode section is in turn connected back to the grid circuit of the right-hand section of V4 through the capacitor V4. Thus, in-phase feed

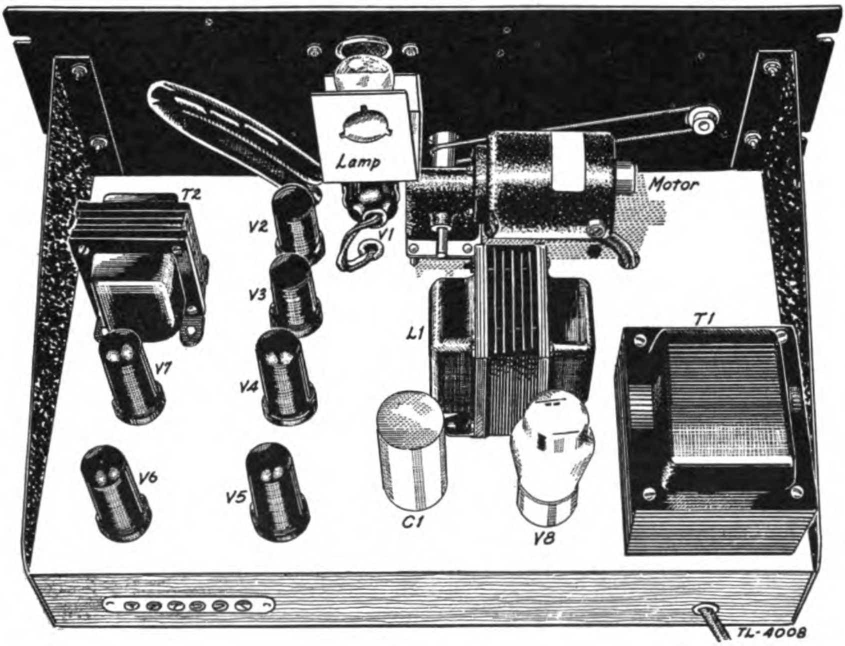

FIGURE 31.—Rear chassis view of Lon–Ga–Tone unit.

back of energy takes place from the left-hand section of the tube to the right-hand section, and oscillation in the L2–C5 circuit is maintained. The output of L2–C5, which is about 800 cycles, is amplified by a two-stage audio-frequency amplifier consisting of the upper half of the double triode V5 and the push-pull output stage using the tubes V6 and V7. The lower triode section of V5 acts as a phase inverter to produce the necessary 180° phase difference between the signals appearing on the grids of V6 and V7, through capacitors C6 and C7, respectively. Tubes V2 and V3 constitute a two-stage direct-coupled amplifier. The voltages applied to the elements of these tubes, and the bias on the photoelectric cell V1, are so adjusted that when no light is shining into the photoelectric cell the effect of the direct connection of V3 to the left-hand grid of oscillator tube V4 is to block the latter tube completely, thus preventing the oscillator from functioning. This

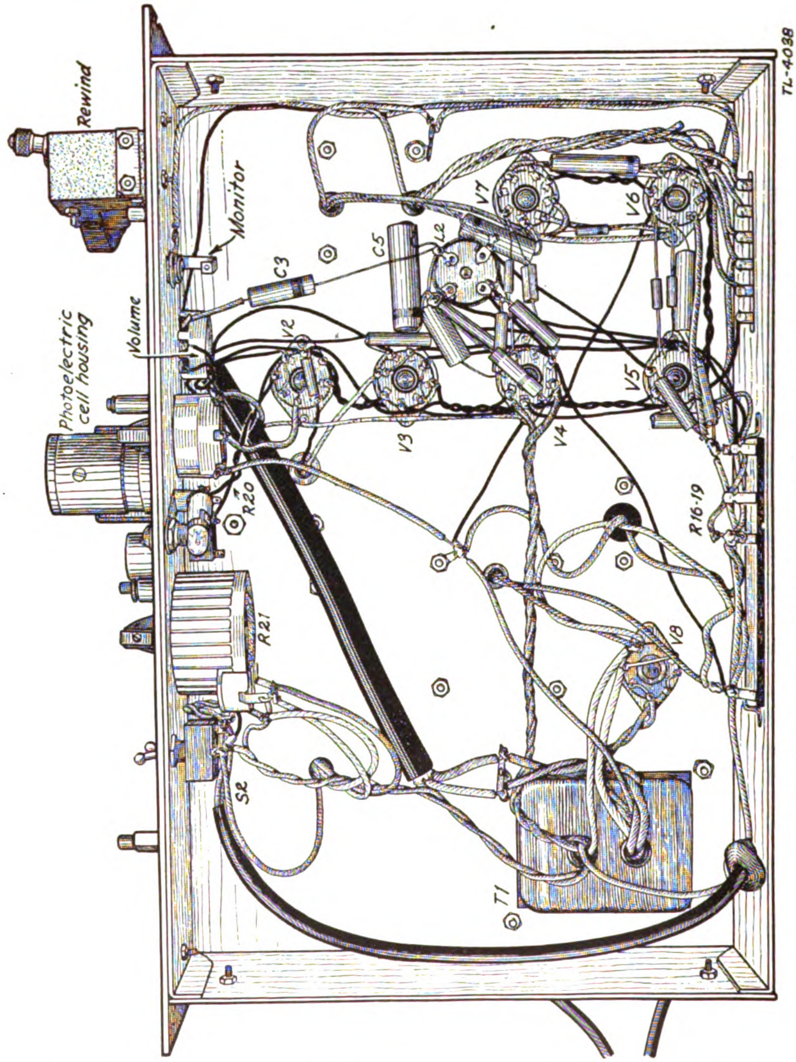

FIGURE 32.—Under view of chassis of Lon-Ga-Tone keyer.

condition exists when a practice tape is properly adjusted so that the bottom black line of the recorded transmission covers the photoelectric cell aperture, as illustrated in figure 24. When the tape is drawn through and light hits the photoelectric cell through an uninked section of tape, the photoelectric cell generates current and the previous bias conditions are upset to the extent that the left-hand grid of V4 is no longer blocked. Therefore the tone oscillator functions, and a signal is heard in the connected output circuit. This form of electronic keying is very smooth and positive. Manual keying is accomplished by short-circuiting the control grid of V3 to ground. The power supply is entirely conventional, and comprises the transformer T1, the full-wave rectifier V8, the filter L1–C1, and the bleeder resistor network R16 to R20. The speed of the take-up motor is controlled by the potentiometer R21.

b. Maintenance and repair.—Clean the aperture in the sliding barrel in the photoelectric cell house thoroughly at least once a day. Dust collecting therein will materially interfere with proper keying. Wipe off the exciter lamp, its reflecting lens, and the exposed surfaces of the concentrating lens daily. About once a week remove the cover of the lamp house and clean the inner surfaces of the concentrating lens and the mirror. About once a week remove the photoelectric cell house by unscrewing the two screws which hold it to the chassis, and clean the envelope of the photoelectric cell which is exposed thereby. Once a week put 1 drop of light oil in oil ducts of the take-up motor and in the oil hole at the left end of the puller motor. If the exciter lamp burns out, replace with a 6-volt 32–32-candlepower No. 1000 automobile headlight bulb. To replace a burned out pilot lamp, remove the chassis from its cabinet, unscrew the pilot lamp from its socket and replace with a 6.3-volt 0.25-ampere miniature base lamp. Replace burned out vacuum tubes with the types indicated for each socket in figure 31. If copies of master practice tapes should tear, always make the necessary splice through a section of the *bottom* of the inked line, using glue, rubber cement, cellulose cement, etc. If the splice is made through a clear section, the double thickness of tape will be opaque enough to prevent light from shining through to the phototube.

39. Keyer TG–10–B.—The circuit diagram of this unit appears as figure 33. A back view of the chassis, with the parts marked to correspond with the wiring diagram, follows as figure 34.

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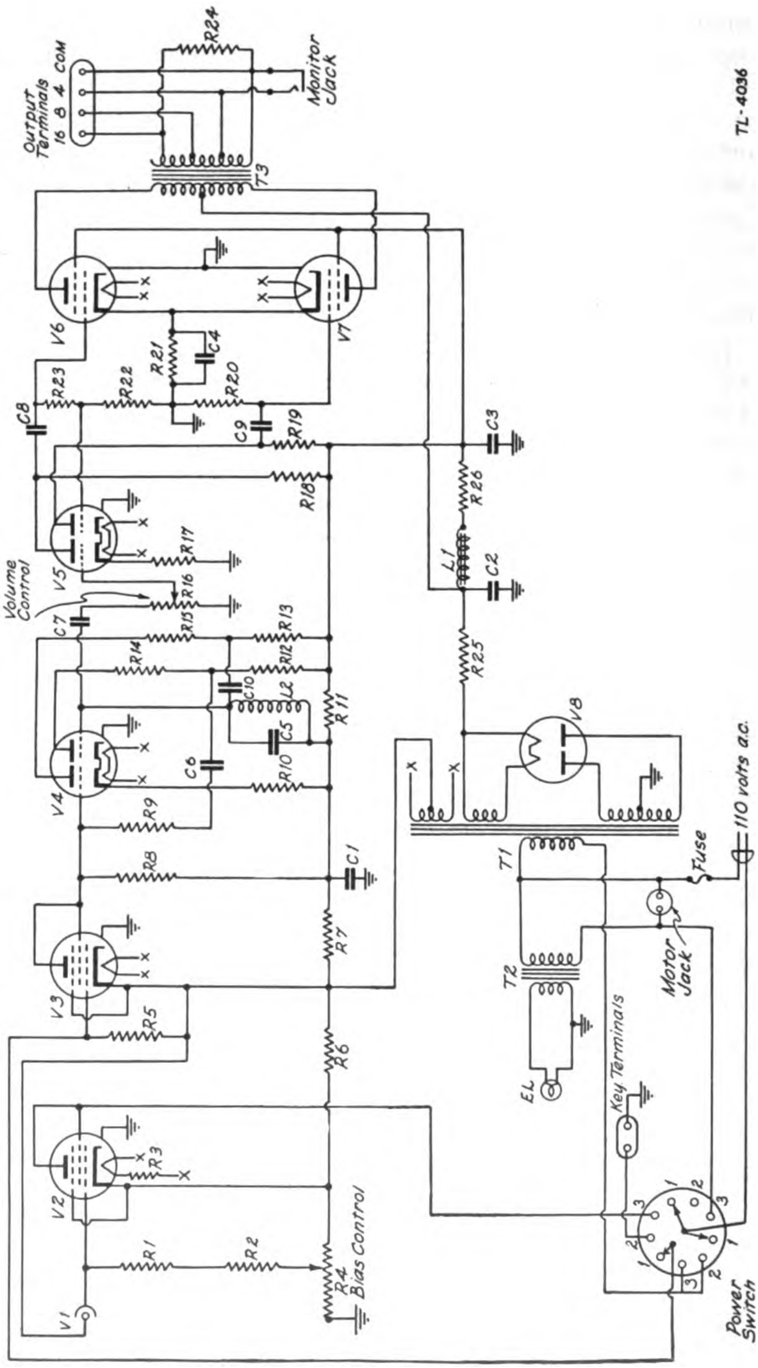


FIGURE 33.—Diagram of keyer TG-10-B.

V1	Type 923 gas photoelectric cell	
V2, V3	Type 6SJ7	
V4, V5	Type 6N7	
V6, V7	Type 6L6	
V8	Type 5U4G	
R1, R2	20-megohm, ½-w resistor	27350
R3	4.7-ohm, 1-w resistor	27358
R4	1,000-ohm potentiometer	27310
R5	270,000-ohm, ½-w resistor	27351
R6, R7	4,700-ohm, 2-w resistor	27357
R8	68,000-ohm, ½-w resistor	27352
R9	390,000-ohm, ½-w resistor	27353
R10	470-ohm, 1-w resistor	27359
R11	10,000-ohm, 10-w resistor	27363
R12, R13, R14, R15	27,000-ohm, ½-w resistor	27354
R16	500,000-ohm potentiometer	27311
R17	1,500-ohm, 1-w resistor	27360
R18, R19	100,000-ohm, 1-w resistor	27356
R20	270,000-ohm, ½-w resistor	27351
R21	250-ohm, ½-w resistor	27355
R22	9,100-ohm, ½-w resistor	27355
R23	270,000-ohm, ½-w resistor	27351
R24	100-ohm, 10-w resistor	27362
R25	200-ohm, 10-w resistor	27364
R26	4,000-ohm, 10-w resistor	27365
C1, C2, C3, C4	10-μf capacitor block	27304
C5	0.1-μf capacitor	27303
C6	0.0005-μf capacitor	27300
C7	0.01-μf capacitor	27301
C8, C9	0.01-μf capacitor	27302
C10	0.1-μf capacitor	27303
T1	Power transformer	27117
T2	Exciter lamp filament transformer	27116
T3	Output transformer	27291
EL	Exciter lamp	27234
L1	Filter choke	27234

a. Functioning of circuit.—The circuit of the keyer TG–10–B is virtually the same as that of the Lon–Ga–Tone, type 7, and functions in the same manner. The only important difference is that the exciter lamp in the TG–10–B works off a separate filament lighting transformer. Also, the output tubes are of the 6L6 type, whereas the Lon–Ga–Tone uses the 6V6 type.

b. Maintenance and repair.—(1) *Lubrication.*—The worm reduction gear on the motor shaft runs in an oil bath and requires no additional lubrication. Since the speed of the other shafts is very low, they need little attention. A graphite grease is recommended for these bearings and also for the sliding bearings on the speed adjustment mechanism.

(2) *Rollers.*—To replace the rubber portion of the puller roller, remove the acorn nut on the front of the roller and take off the outer washer. Remove the old roller, slide on the new one, and replace the washer and the nut. To replace the drive roller, remove the old one by taking the spring belt from its driving puller and releasing the set

screw holding it to the puller shaft. The entire shaft can now be pulled forward. Roll off the old Neoprene ring and roll on the new one. In reassembling, be careful to set up the pulley to prevent excess end play of the puller shaft. The friction surface driving the take-up reel is identical with that used to drive the puller shaft. It can be rolled off its wheel and a new one rolled into place without otherwise disturbing the mechanism.

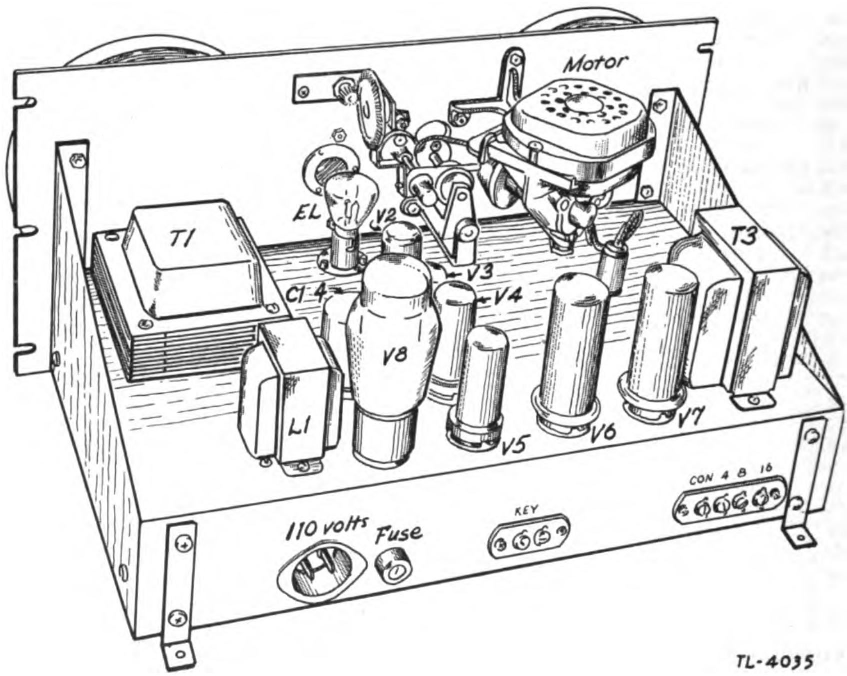


FIGURE 34.—Chassis view of keyer TG-10-B with parts marked to correspond with figure 33.

(3) *Exciter lamp.*—This is a standard six-volt double-filament 32-32 candlepower No. 1000 automobile headlight bulb. When one filament burns out, turn the bulb halfway around in its socket and use the other filament.

(4) *Fuse.*—The keyer is shipped with a fuse in place. This is a standard 3AG automotive fuse, rated at 3 amperes at 250 volts.

(5) *Transformers.*—The power and audio units used in the TG–10–B can be replaced by standard radio replacement parts as follows:

	Thordarson
Power transformer	T13R15.
Output transformer	T17S11.
Filament transformer	T19F98.
Oscillator coil	T18C92 (less core).
Filter choke	T57C52.

(6) *Voltage readings.*—The following table gives the normal voltage readings between the socket terminal numbers indicated, as measured with a 20,000-ohm-per-volt meter when the line voltage is approximately 115 volts:

Tube	Plate		Filament		Cathode		Screen		Switch position	
	Pins	Volts	Pins	Volts	Pins	Volts	Pins	Volts	Tape	Key
1	4–GD	87	------	------	------	------	------	------	x	x
2	8–5	26	2–7	4.9	5–GD	14	------	------	x	----
	8–5	0	------	------	------	------	------	------	----	x
3	8–5	65	2–7	6.2	5–GD	70	------	------	x	----
	8–5	19	------	------	------	------	------	------	----	x
4	8–3	66	2–7	6.2	8–1	140	------	------	x	----
	8–3	132	------	------	------	------	------	------	----	x
	8–6	62	------	------	------	------	------	------	x	----
	8–6	58	------	------	------	------	------	------	----	x
5	8–3	145	2–7	6.2	8–1	3.5	------	------	x	----
	8–3	160	------	------	------	------	------	------	----	x
	8–6	150	------	------	------	------	------	------	x	----
	8–6	162	------	------	------	------	------	------	----	x
6	8–3	370	2–7	6.2	8–1	20	8–4	240	x	x
7	8–3	370	2–7	6.2	8–1	20	8–4	240	x	x
8	Plate to Plate	760AC	2–8	5.0	------	------	------	------	x	x

40. Oscillator-amplifier ACA–10–AO.—*a. Functioning of circuit.*—Electrically, this unit closely resembles the oscillator-amplifier section of the Lon–Ga–Tone automatic keyer. As shown in figure 35, V1 is the oscillator. Tubes V2, V3, and V4 comprise a two-stage amplifier, with one section of V2 functioning as a phase inverter. No provision is made for internal keying. In installations in which this

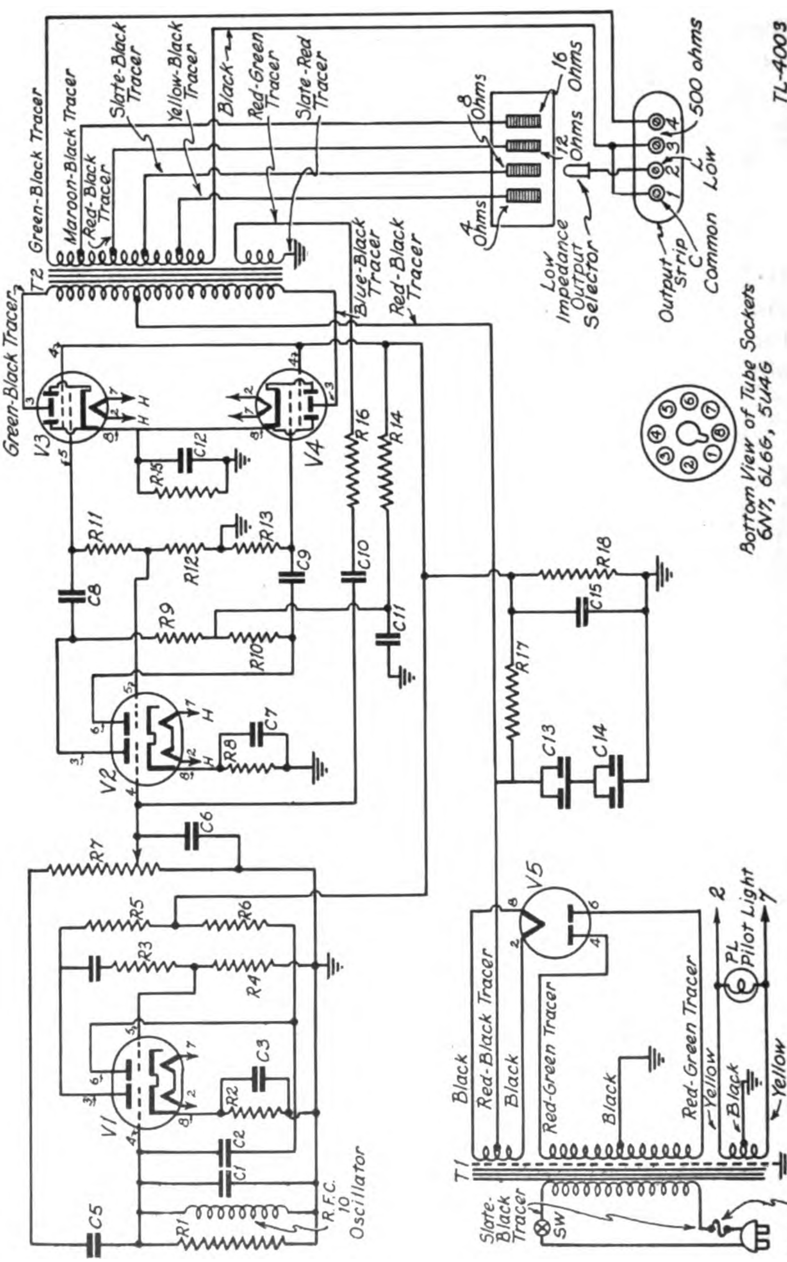


FIGURE 35.—Circuit of ACA amplifier-oscillator.

V1, V2	Type 6N7 tube.
V3, V4	Type 6L6G tube.
V5	Type 5U4G tube.
C1, C2	0. 1-μf, 400-v capacitor.
C3	10-10-10μf, 250-v capacitor.
C4	0. 1-μf, 400-v capacitor.
C5	0. 01-μf, 400-v capacitor.
C6	0.001-μf, 400-v capacitor.
C7	10-10-10-μf, 400-v capacitor.
C8, C9	0. 1-μf, 400-v capacitor.
C10	0.0005-μf, 400-v capacitor.
C11	10-10-10-μf, 450-v capacitor.
C12	10-10-10-μf, 450-v capacitor.
C13, C14, C15	10-10-μf, 450-v capacitor.
R1	50,000-ohm, ½-w resistor.
R2	1,000-ohm, ½-w resistor.
R3	½-megohm, ½-w resistor.
R4	6,000 plus 1,000 (7,000)-ohm, ½-w resistor.
R5, R6	50,000-ohm, ½-w resistor.
R7	½-megohm potentiometer.
R8	3,000-ohm, ½-w resistor.
R9, R10	50,000-ohm, ½-w resistor.
R11	100,000-ohm, ½-w resistor.
R12	6,000-ohm, ½-w resistor.
R13	100,000-ohm, ½-w resistor.
R14	50,000-ohm- ½-w resistor.
R15	250-ohm, 10-w resistor.
R16	¼-megohm, ½-w resistor.
R17	5,000-ohm, 10-w resistor.
R18	25,000-ohm, 20-w resistor.
SW-S. P. S. T.	On-off switch.
FP	3 ampere, 250-volt fuse.
T1	Power transformer, manufacturer's type No. L6PT34AO.
T2	Output transformer, manufacturer's type No. L60T34AO.
PL	6.3-v, ¼-ampere pilot light, miniature screw base.
RFC 10	Oscillator inductor.

oscillator-amplifier is used, keying is performed automatically by a separate McElroy keyer, model G-813, or manually by students.

b. Maintenance and repair.—If excessive hum is present in the output circuit, it indicates an unbalance in the output tubes V3 and V4. One or both tubes should be replaced. When the set is turned on, if the pilot lamp does not light, examine the red screw fuse located on the rear of the chassis. Replace with standard 3-ampere fuse if burned out. If not, unscrew the ruby reflector and replace the pilot lamp with

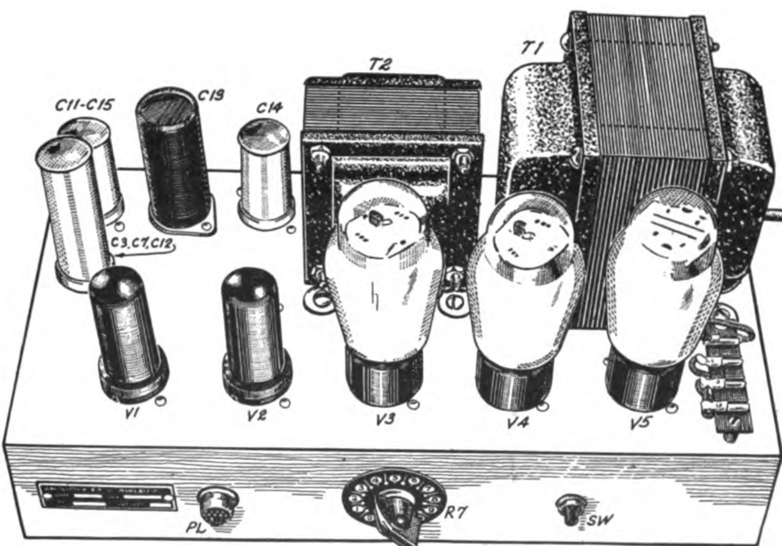


FIGURE 36.—Front view of ACA oscillator-amplifier, with protective screen cover removed to show placement of parts.

a 6.3-volt, 0.25-ampere miniature base lamp. If the oscillations stop, examine the tubes for burned out filaments. Replace tube, if necessary, with the type tube indicated on the socket. A general front view of the oscillator-amplifier chassis is shown in figure 36 and an under view of the chassis in figure 37.

c. Resistance and voltage chart.—The following resistance and voltage chart will be of assistance to the radio repairman in tracing troubles that develop in the ACA oscillator-amplifier:

RESISTANCE AND VOLTAGE CHART

Measure direct voltage with 1,000 ohms per volt meter.

Measure alternating voltage with 1,000 ohms per volt meter.

Measure resistance with 0–50,000 and 0–5 megohm ohmmeter ranges (tubes removed).

DIRECT VOLTAGE (measured from ground)*

Tube No.	Tube type	Prong terminals							
		1	2	3	4	5	6	7	8
V1	6N7	0	------	[3] 190	------	------	[3] 180	----	[4] 4
V2	6N7	0	------	[3] 160	------	------	[3] 160	----	[4] 4
V3	6L6G	0	------	[2] 420	[2] 300	------	------	----	[4] 23. 5
V4	6L6G	0	------	[2] 420	[2] 300	------	------	----	[4] 23. 5
V5	5U4G	0	[2] 420	------	[1] 360	------	[1] 360	----	[2] 420

*Measured with all controls set at zero.

RESISTANCE (measured from ground)**

Tube No.	Tube type	Prong terminals							
		1	2	3	4	5	6	7	8
V1	6N7	0	0	[6] 80M	[5] 7M	[5] 350	[6] 80M	0	[5] 1M
V2	6N7	0	0	[6] 150M	[5] 6M	[6] 500M	[6] 150M	0	[5] 3M
V3	6L6G	0	0	[6] 30M	[6] 25M	[6] 106M	------	0	[5] 250
V4	6L6G	0	0	[6] 30M	[6] 25M	[6] 100M	------	0	[5] 250
V5	5U4G	0	[6] 30M	------	[5] 70	------	[5] 75	----	[6] 30M

**Measured with all controls on full.

NOTE.—±10 per cent tolerances in all readings are permissible.

[1] 750-volt a-c scale.
[2] 750-volt d-c scale.
[3] 300-volt d-c scale.
[4] 30-volt d-c scale.
[5] 0–50,000-ohm scale.
[6] 0–5-megohm scale.

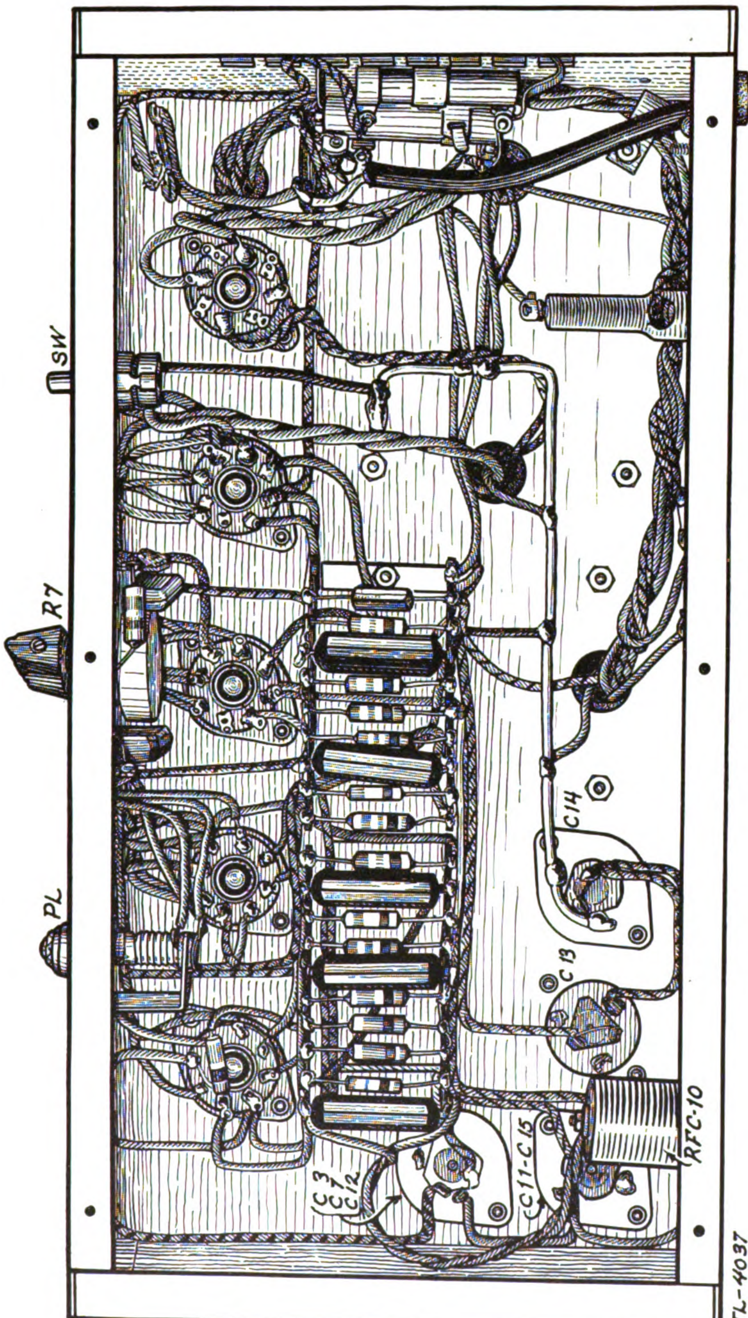


FIGURE 37.—Under view of chassis of the ACA oscillator-amplifier.

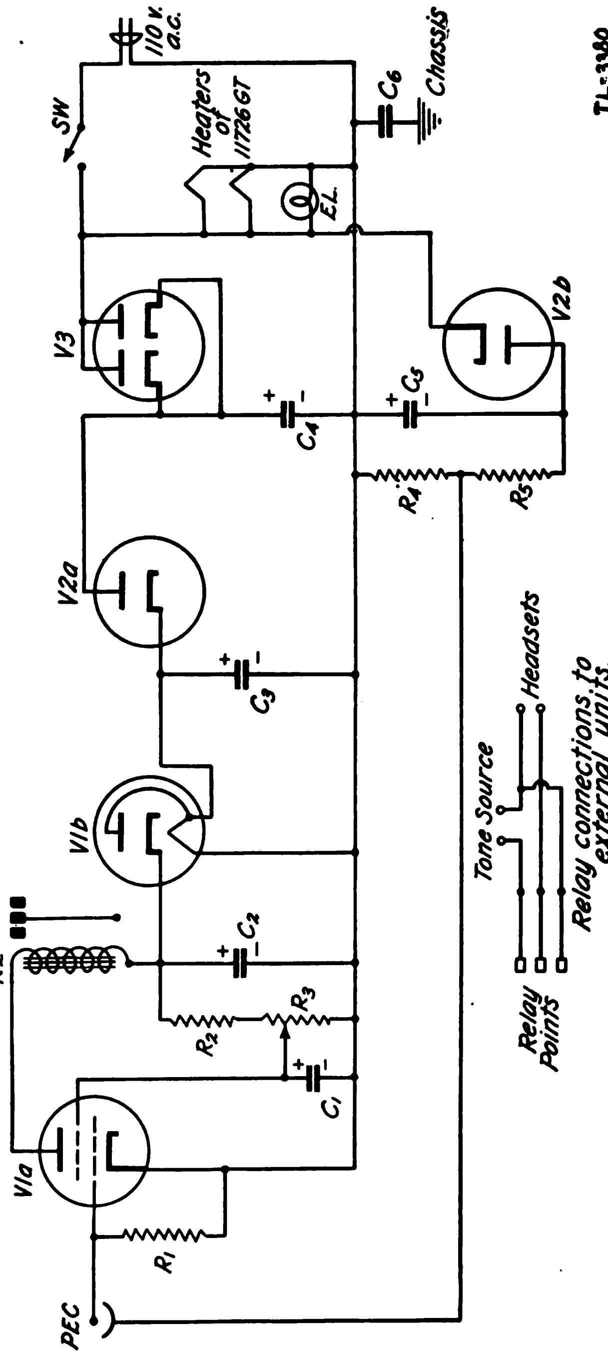


FIGURE 38.—Schematic wiring diagram of McElroy automatic keyer, model G-813.

V1	Type 117N7GT tube.
V2, V3	Type 117Z6GT tube.
R1	40-megohm, 1-w resistor.
R2	35,000-ohm, ½-w resistor.
R3	0.1-megohm potentiometer.
R4	35,000-ohm, ½-w resistor.
R5	20,000-ohm, ½-w resistor.
C1, C2 / C3, C4	10-μf, 200-v capacitor.
C5	20-μf, 200-v capacitor.
C6	0.05-μf, 209-v capacitor.
PEC	Type 923 gas photoelectric cell.
RL	Relay, Sigma No. 3A.
EL	Exciter lamp, 15-watt, 120-volt, intermediate base.
SW	Line switch.

41. Automatic keyer, McElroy model G–813.—*a. Functioning of circuit.*—The electrical circuit of this keyer is shown in figure 38. Although the unit actually employs only three tubes, these are of the multielement type, and the individual sections are separated in the diagram for the sake of clarity. V1, a type 117N7GT, which consists of a tetrode and a diode in the same envelope, is split up as V1a for the tetrode and V1b for the diode. Note especially that the plate of V1b is *internally* connected to one side of the heater. V2 and V3 are 117Z6GT full-wave rectifiers. The sections of V2 are used separately (as indicated by V2a and V2b, while the sections of V3 are paralleled to form a single half-wave rectifier element. The tetrode V1a acts as a single high-gain amplifier stage for the photoelectric cell PEC, and operates the relay connected in its plate circuit. Plate and screen voltages for V1a, and also heater current for the entire tube V1, are furnished by V2 and V3 in a conventional "transformerless" voltage-doubling circuit. Closing the switch SW actuates the entire keying unit.

b. Maintenance and repair.—Clean the aperture in the aperture bar thoroughly at least once a day. Dust collecting therein will materially interfere with proper keying. The photoelectric cell, particularly that portion directly under the aperture bar, must also be free from dust. Whenever needed, clean the contacts of the relay by drawing a strip of bond paper, previously dipped in carbon tetrachloride, through the space between contacts. *Adjustment* of this relay should be accomplished only by an experienced instrument repairman. About once a week place 1 drop of light oil (typewriter or sewing machine oil) in the oil hole located at the top of the rewind. If the exciter lamp burns out replace with a 120-volt 15-watt clear glass, intermediate screw-in base lamp. The photoelectric cell should remain serviceable for very extended periods. The units must be removed from service to effect replacement of this tube. If copies of tapes should tear, always make the necessary splice at a section of the

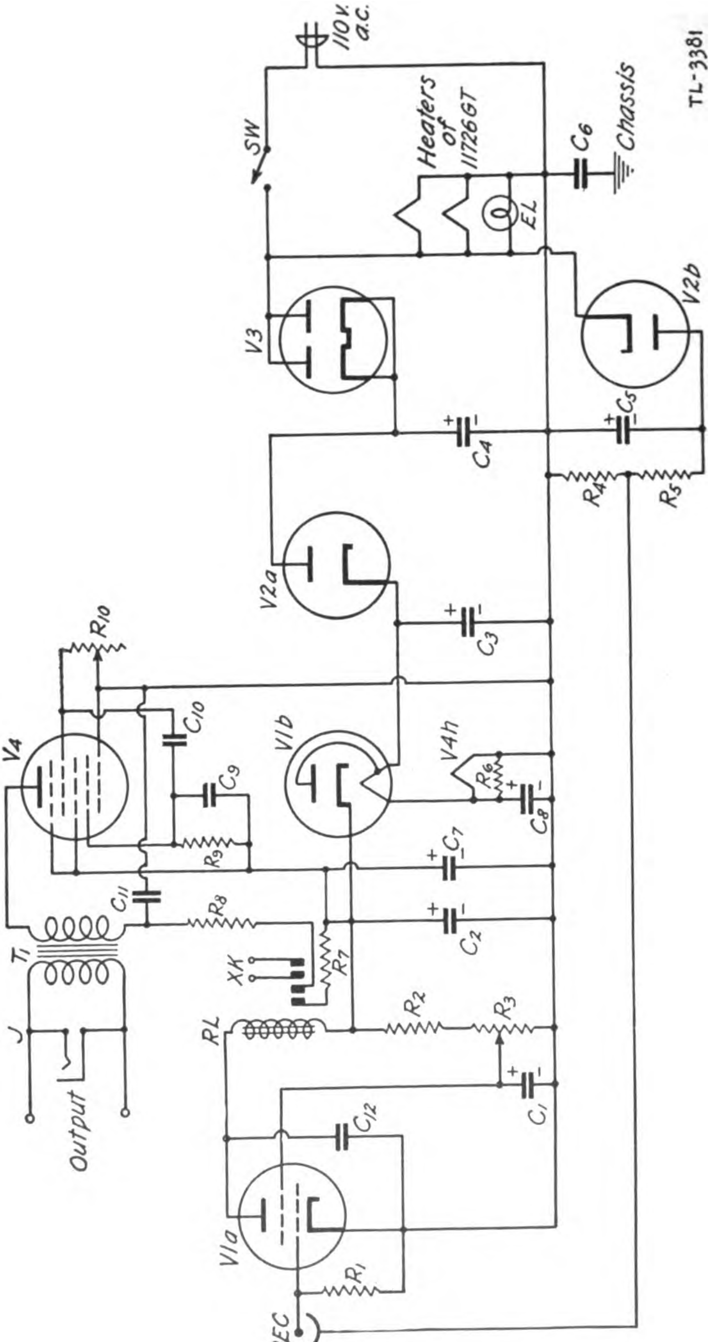


FIGURE 39.—Schematic diagram of McElroy automatic keyer, model G-813, modified.

V1	Type 117N7GT tube.
V2, V3	Type 117Z6GT tube.
V4	Type 1A7GT tube.
PEC	Type 923 photoelectric cell.
R1	40-megohm, 1-w resistor.
R2	35,000-ohm, ½-w resistor.
R3	0.1-megohm potentiometer.
R4	35,000-ohm, ½-w resistor.
R5	20,000-ohm, ½-w resistor.
R6	30-ohm, ½-w resistor.
R7, R8	5,000-ohm, ½-w resistor.
R9	7,000-ohm, ½-w resistor.
R10	0.1-megohm potentiometer.
C1, C2	10-μf, 200-v capacitor.
C3	40-μf, 200-v capacitor.
C4	10-μf, 200-v capacitor.
C5	20-μf, 200-v capacitor.
C6	0.05-μf, 200-v capacitor.
C7	20-μf, 200-v capacitor.
C8	50-μf, 25-v capacitor.
C9	0.01-μf, 200-v capacitor.
C10	0.02-μf, 200-v capacitor.
C11	0.1-μf, 200-v capacitor.
RL	Relay, guardian No. 27298.
XK	External keying contacts.
T1	Output transformer.
J	Single open circuit jack.
SW	Line switch.
EL	Exciter lamp, 15-watt, 110-volt intermediate base.

A general view of this keyer, with its associated tape puller, appears as figure 40.

top inked line. If a small clear space remains after the splice has been made, make the line continuous by using black ink or even a soft lead pencil.

42. Automatic keyer, McElroy model G–813, modified.—*a. Functioning of circuit.*—This unit differs from the model G–813 described in paragraph 41 in that it includes a tone source which is keyed by the automatic keyer. The complete circuit is shown in figure 39. Tube V1 is a 117N7GT, and V2 and V3 are both type 117Z6GT. These are split up into their constituent elements as V1a, V1b, V2a, V2b, and V3, and function exactly as indicated for the model G–813 in paragraph 41. The 1A7GT operates somewhat in the manner of a dynatron oscillator, the frequency of oscillation being controlled by the variable resistor R10. The filament of this tube, which is intended normally for battery operation, is energized by direct current produced by the rectifier system of the unit. This filament is shown separately as V4h and is connected in series with the heater of V1. Because V1 takes 75 milliamperes and V4h takes 50 milliamperes, V4h is shunted by a small resistor R6 to equalize the current distribution in the circuit.

b. Maintenance and repair.—The same data given for the model G–813 should be observed for the G–813, modified. However, the relay used in the latter unit does not require adjustment. Also, it is advisable to provide spare oscillator tubes, as the filament life may be expected to be shorter than usual.

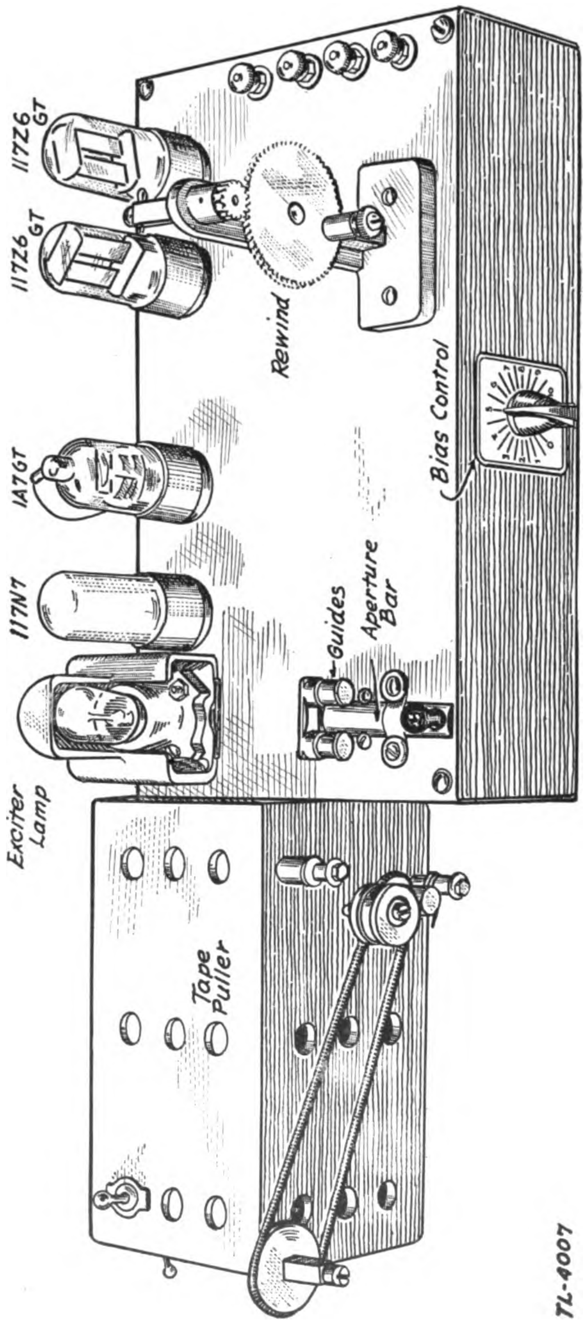
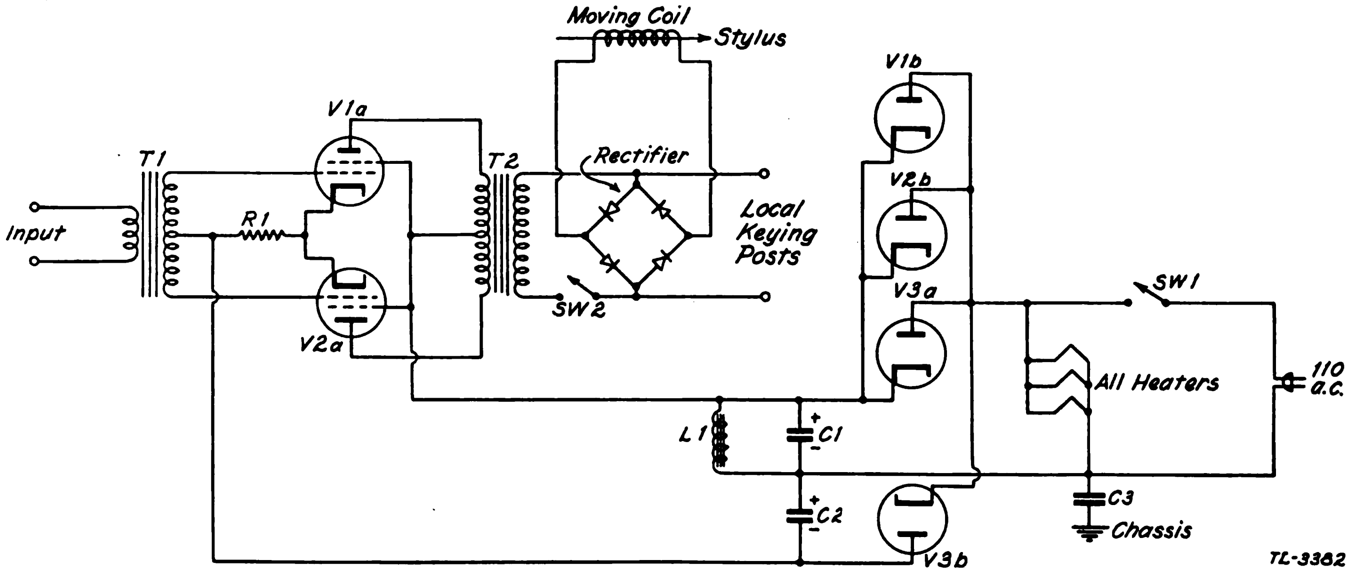


FIGURE 40.—McElroy automatic keyer, model G-813 modified, with associated tape puller. (Exciter lamp is shown in raised position.)

43. Recorder, McElroy model RRD–900 or R–900.—*a. Functioning of circuit.*—Figure 41 shows the complete schematic diagram of the instrument. The tetrode sections of the type 117N7GT tubes, marked V1a and V2a, are connected to form a conventional push-pull amplifier stage. Plate voltage is furnished by a voltage-doubler system similar to that employed in the McElroy automatic keyers. The diode sections of the type 117N7GT tubes, marked V1b and V2b, are part of this power circuit. V3a and V3b are the two diode sections of the type 117Z6GT tube.

The keyed tone signal to be recorded is led into the amplifier at the input posts. The amplified output of T2 is rectified by a full-wave, dry-disk rectifier, and the pulsating direct current from the latter actuates the moving coil element. The latter corresponds to the voice coil of a loudspeaker. To it is attached the ink-bearing stylus, which moves down and across the paper tape in accordance with the keying and the constant pull of the take-up motor.

b. Maintenance and repair.—Practically the only routine maintenance on this unit consists in maintaining a smooth, even flow of ink to the recording stylus. A cleaner wire for the stylus and inkwell outlet accompanies each unit as does a replacement ink hose. The stylus should be left solidly against the tape when the recorder is not in use, and the inkwell should be set in its lowest position. After inoperative periods of an hour or longer, the stylus may require cleaning as indicated in paragraph 32. Once a week, the inkwell and ink hose should be removed from the unit and thoroughly cleaned with water. Infrequently, an overnight soaking of the hose is desirable. A gentle milking action will force water through the hose. Frequent dusting of this unit is necessary, as the blank tape in feeding through it leaves an accumulation of paper lint. Two views of the recorder are shown in figures 42 and 43.



V1, V2	Type 117N7GT tube.	C2	20-μf, 25-v capacitor.	L1	Field coil of recorder unit.
V3	Type 117Z6GT tube.	C3	0.05-μf, 200-v capacitor.	SW1	Line switch.
R1	500-ohm, 10-w resistor.	T1	Input transformer.	SW2	Change-over switch.
C1	40-μf, 200-v capacitor.	T2	Output transformer.		

FIGURE 41.—Schematic diagram of McElroy recorder, model RRD–900 or R–900.

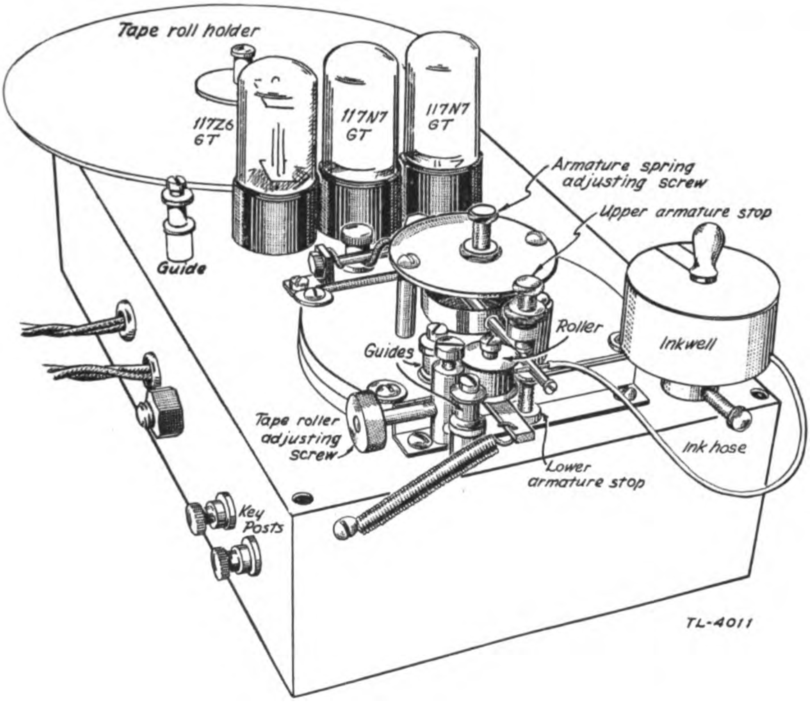


FIGURE 42.—Close-up end view of McElroy recorder. (Once various adjustments have been made, unit will operate for long periods without requiring attention.)

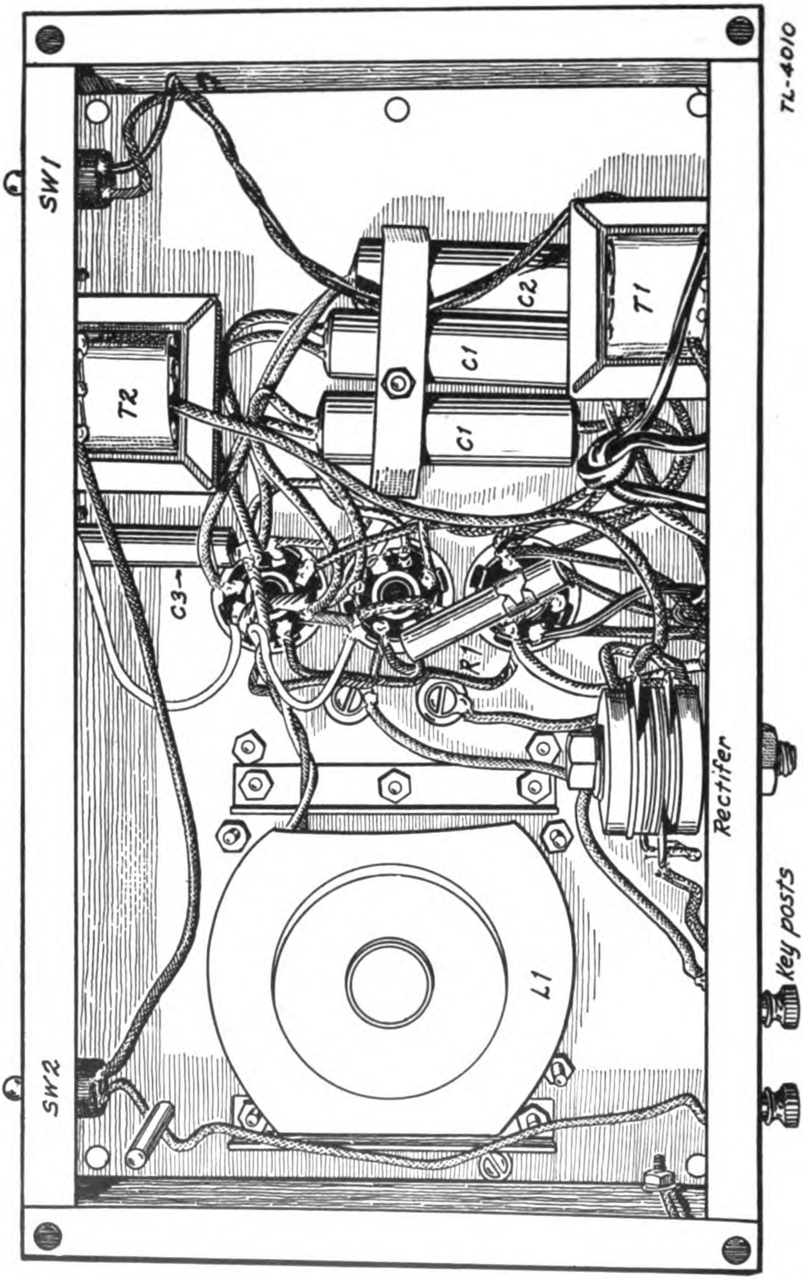
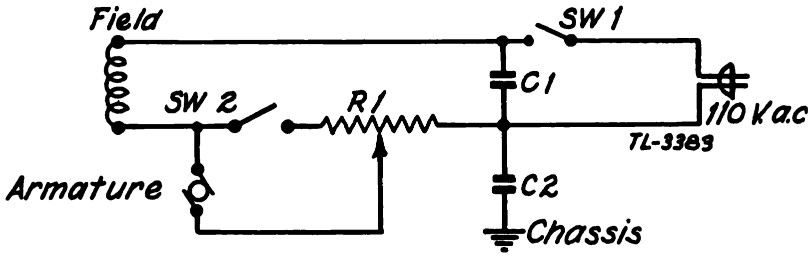


FIGURE 43.—Underview of chassis of recorder. (Parts are marked to correspond with schematic diagram, fig. 41.)

44. Tape puller, McElroy model CTP-1300.—*a. Functioning of circuit.*—The connections of the tape puller are very simple and are given in figure 44.



SW1	Line switch.
SW2	Speed-control switch.
C1, C2	0.05-μf, 200-v capacitors.
R1	300-ohm, 50-w potentiometer.

FIGURE 44.—Wiring of McElroy tape puller.

Not all models of this tape puller have the speed control switch SW2. In units in which it is not used, the circuit is equivalent to one with the switch closed. The motor operates as a hybrid shunt type with the armature excitation depending on the voltage drop between the arm of the potentiometer and the junction point of the armature and the field. When switch SW2 is open (corresponding to the forward position mentioned in paragraph 28*b*(2)) the motor operates as a conventional series type, and R1 acts merely as a series rheostat.

b. Maintenance and repair.—Once a day place 1 drop of light machine oil in the oil hole on the take-up spindle and in the oil duct leading to the puller wheel bearing. The entrance to the latter duct is located on top of the unit directly above the puller wheel.

45. Switchboard BD-57.—*a. Functioning of circuit.*—The circuit diagram of the switchboard BD-57, which is part of code practice equipment EE-81, appears as figure 45. A front view of the board with the cords exposed is given as figure 46.

The motor alternator mounted in the switchboard is not used in modern installations of code practice equipment. If the board is employed as issued, the master key terminals are short-circuited, and keyed or steady tone from an external source is fed to the terminals marked AUXILIARY. When the auxiliary plug (red cord) is inserted in the jack marked AUXILIARY, this tone signal goes through the primaries of the twenty-one individual transformers, which are connected in series. The secondary of each transformer is isolated by means of a plug. Tracing out the circuit at any trans-

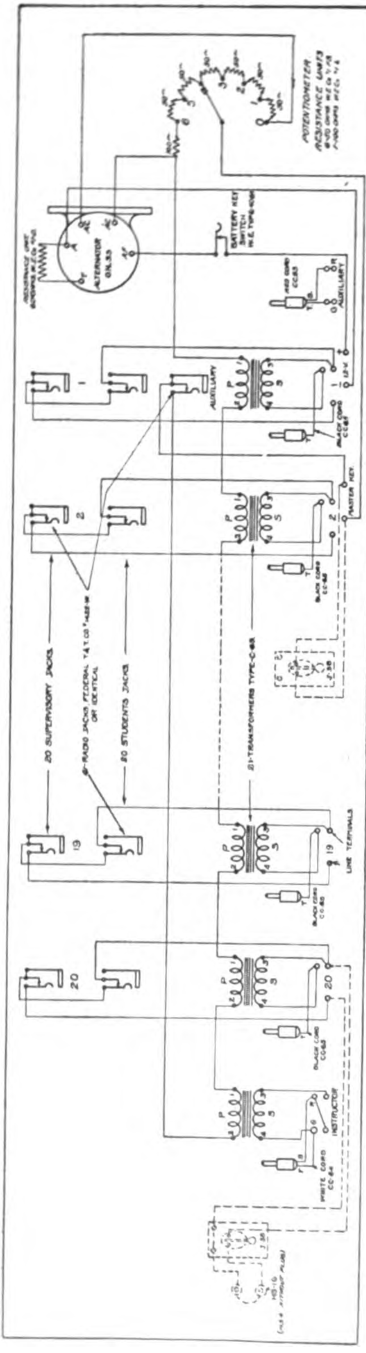


FIGURE 45.—Complete circuit diagram of switchboard BD–57.

former, it will be seen that secondary terminal 4 is connected to the *tip only* of the plug. Therefore, it is necessary to insert the plug into the corresponding "student" jack directly above it, in order

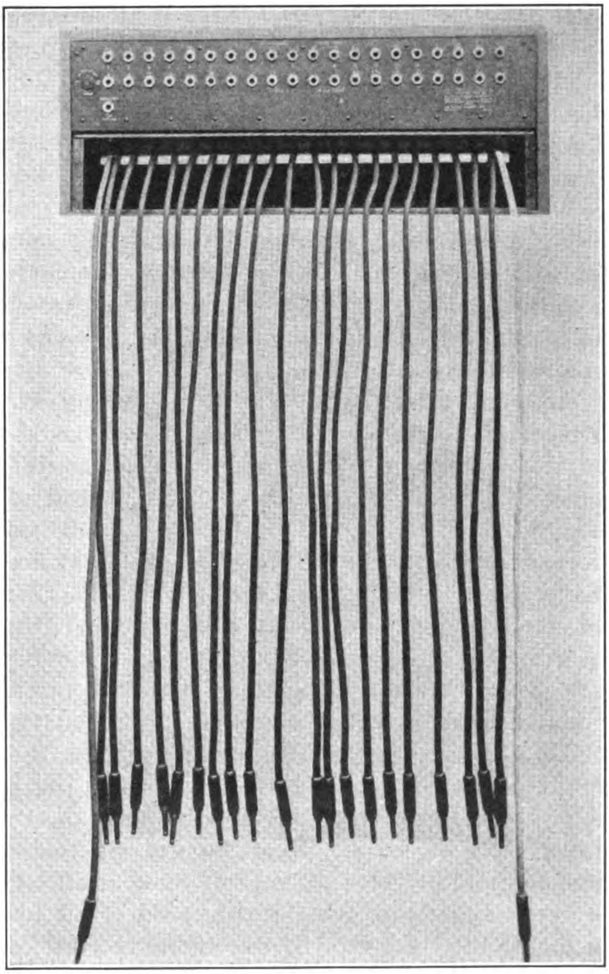


FIGURE 46.—Switchboard BD-57 set up for operation with cords exposed.

for the tone signal to appear in the earphones of the connected student position. If the tone is keyed, the student keeps his key closed. If the tone is steady, the student can open his key and practice sending to himself. The instructor can listen in by plugging the "instructor" plug (white cord) into any of the "supervisory" jacks along the top of the board, at the same time closing the switch on his key. Each of these jacks is in series with the "student" jack under it. When steady tone is supplied, simulated nets can be set up for groups of students by interchanging their black cords, exactly in the manner described for the BD-57-A. With any type of operation, the potentiometer continues to act as a volume control on the input signals.

b. Maintenance and repair.—Very little trouble develops with this board, as the parts are rugged and are subjected to very little strain, either mechanical or electrical. Cords and plugs may wear out after long service but are readily repaired or replaced. The main items to watch are the transformers. Because of their series connection, the entire board will go dead if only one primary becomes open. The faulty unit can be identified quickly with the aid of an ohmmeter or a simple continuity tester consisting of a headset in series with a dry cell and a pair of test prods.

46. Switchboard BD-57-A.—*a. Functioning of circuit.*—The complete schematic diagram of this board is shown as figure 47. Comparison of this diagram with figure 46 reveals several important improvements. There are three rows of jacks instead of two, permitting much greater flexibility of student circuit arrangement. The transformer primaries are still in series, but they are connected only to steady tone (through the AUX SWBD TONE posts) for purposes of hand keying by students and simulated net operation. This tone is available at all student positions when the plugs are *not* in any of the jacks. Tracing through the circuit of any transformer and its associated jacks, it will be seen that the secondary terminal 3 goes to one side of the student position through the tip and inner contacts of the bottom jack, which are closed when the jack is idle. Terminal 4 goes back to the other side of the student position through the two upper jacks in series. Note particularly that the frames of the bottom and middle jacks are not connected at all. One student can be fed keyed signals of any desired speed if his black cord is inserted in his middle jack, and if the auxiliary cord connected to the proper keyer is inserted in the top jack. The resultant circuit is a simple series one, with the transformer entirely out of action. Students can be connected in series for keyed signals by cross-connecting plugs in the middle jacks, just as they can be cross-connected for local net operation by means of the plugs and the lower jacks.

b. Maintenance and repair.—See paragraph 45*b*.

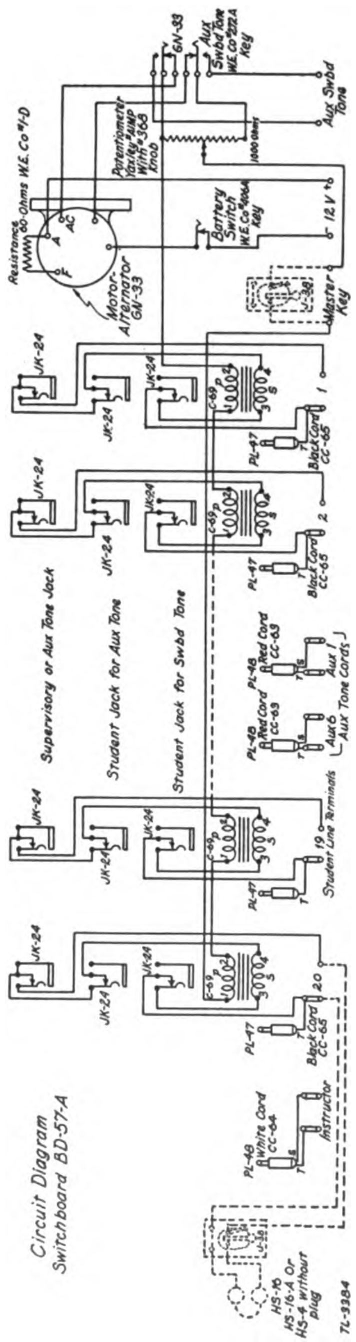
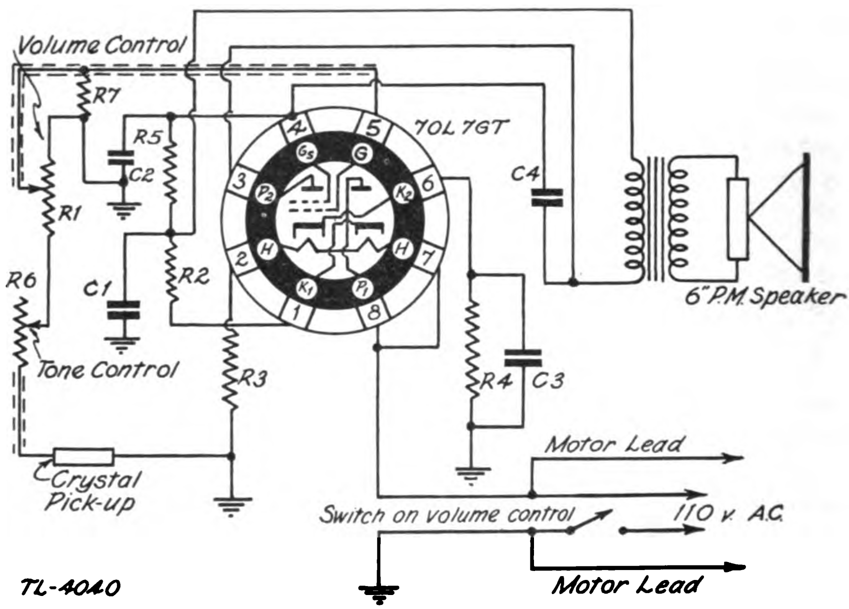


FIGURE 47.—Circuit diagram of switchboard BD-57-A.

47. Record player, Columbia model P.—*a. Functioning of circuit.*—This record player is a very simple unit, consisting merely of a turntable, a crystal pickup, a one-tube amplifier, and a 6-inch permanent magnet loudspeaker. The circuit is shown in figure 48.



R1	2-megohm potentiometer.	R6	2-megohm potentiometer.
R2	100-ohm, 3-w resistor.	R7	1-megohm, ¼-w resistor.
R3	300-ohm, 10-w resistor.	C1	30-μf capacitor.
R4	160-ohm, 1-w resistor.	C2, C3	20-μf capacitor.
R5	2,000-ohm, ¼-w resistor.	C4	0.005-μf capacitor.

FIGURE 48.—Circuit diagram of record player, Columbia model P.

The 70L7GT tube is a combination diode-tetrode, the diode section functioning as a half-wave rectifier to furnish plate and screen voltage for the tetrode amplifier.

b. Maintenance and repair.—The simplicity of this unit makes it practically foolproof. About the only part likely to require replacement is the tube. This is mounted on a small subpanel under the turntable deck. Access to it is had by removing the Phillips head screws that hold the latter in position. The motor is of the self-starting type. It requires no lubrication.

Appendix I

CHANGES IN SWITCHBOARDS BD-57 AND BD-57-A

1. **Improving switchboard BD-57.**—As mentioned in paragraph 17*b*, the switchboard BD-57, as issued, does not meet the requirements of modern installations of code practice equipment. However, if training or other funds are available for the purchase of 20 inexpensive single closed circuit telephone jacks, the board can be made the equivalent of the newer BD-57-A by a competent radio repairman. The extra jacks are added in a row under the present row marked STUDENT JACKS, and the wiring is changed to conform to that of the switchboard BD-57-A, as given in figure 47. To allow the connection of more than one keyer, the single red AUXILIARY cord can be supplemented by extra cords fitted with two-connection plugs. If regular patching cords are not available, standard radio plugs and ordinary flexible lamp cord will be found perfectly satisfactory. Extra terminals should be provided on the back of the board for these cords to facilitate connection to the automatic keyers. An alternative arrangement is the use of a separate patching board, described in the following paragraph.

2. **Patching board for switchboard BD-57-A.**—Code practice equipment set up as indicated in figures 5 and 9 will operate quite satisfactorily. However, the use of an extra patching board, containing volume controls for each keying circuit, has been found very convenient. As shown in figure 49, the outputs from the various keyers terminate across the ends of 1,000-ohm potentiometers, instead of at the auxiliary tone cords of the switchboard itself. A single open circuit jack is connected across the arm and one end of each potentiometer. Patching cords, consisting of short lengths of flexible wire with a two-connector phone plug at each end, provide a quick means of transferring the tone signals at any particular keyer jack to any student position. The potentiometers serve a double purpose:

a. They allow the signal volume in the students headsets to be adjusted to a comfortable level, or to a low level to simulate poor receiving conditions.

b. With the entire resistance connected permanently to the keyer output circuits, a constant load is maintained on the keyers, and the signals in one switchboard circuit will not change noticeably if changes are made in another switchboard to which the same signals are being piped. With this set-up, the six auxiliary tone cords on the BD-57-A

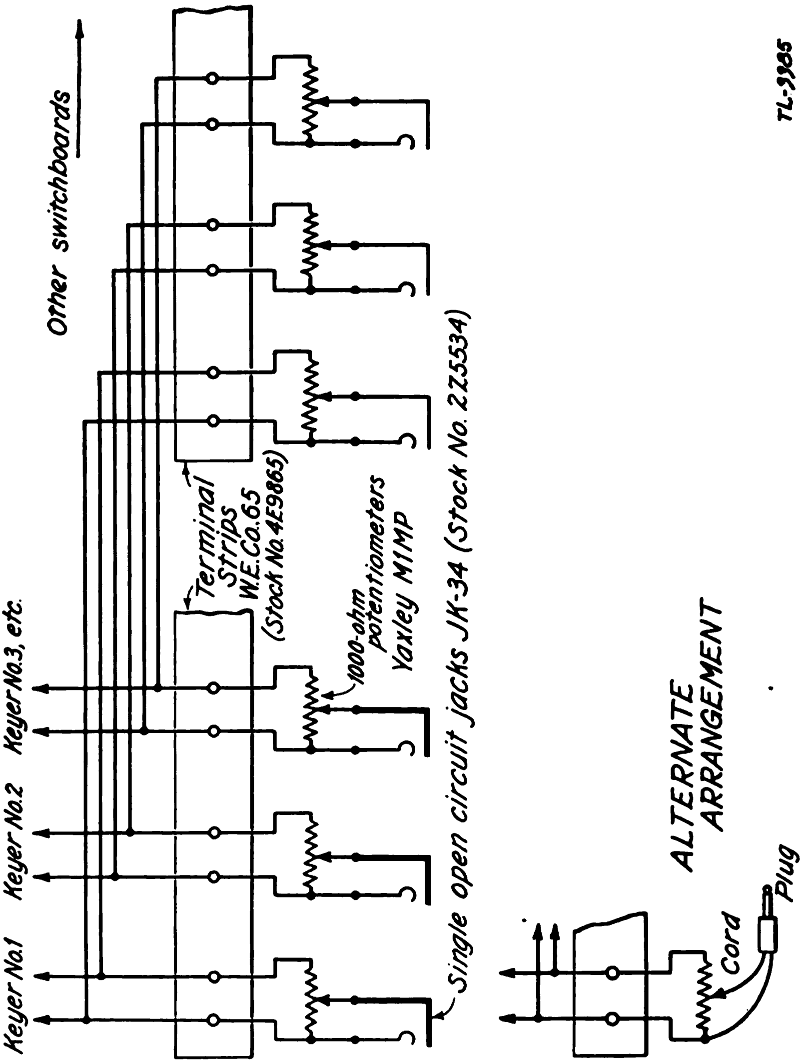


FIGURE 49.—Method of connecting potentiometers and jacks of auxiliary patching board for switchboard BD-57 or BD-57-A.

are not required; in fact, if these cords are removed and the remaining free ends fitted with phone plugs, they make excellent patching cords. Another arrangement is the direct connection of the auxiliary cords to the arm and one end of each potentiometer. While this set-up is not quite as flexible as the use of full patching cords, it is adequate for small installations where the number of available keyers is limited. The number of jacks and potentiometers to be provided on the patching board will depend on the size of the school. Figure 50 shows a

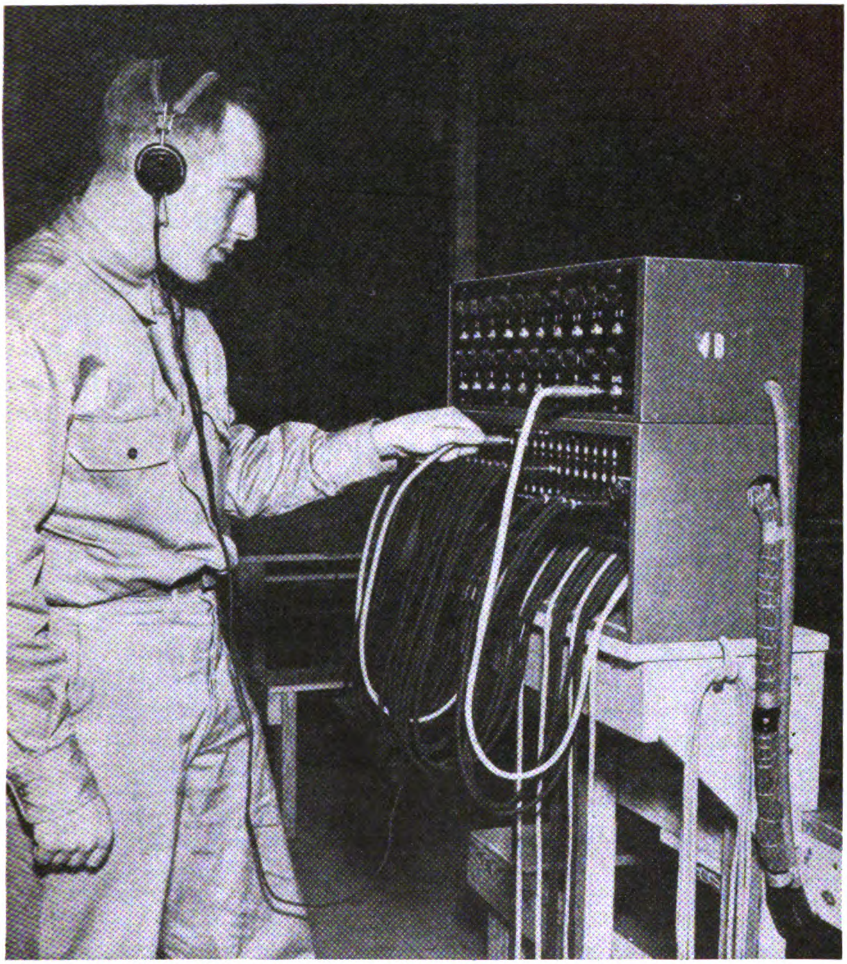


FIGURE 50.—Switchboard BD–57–A with patching board on top.

20-position board mounted on top of a BD–57–A in a large school. This provides outlets for all 15 of the master tapes supplied for the automatic keyers, the fixed tone source for local keying, and for signals from several radio receivers. An average of 12 positions is sufficient for most schools. It will be seen from figure 50 that the patching board has been made to match the switchboard in width and depth and general appearance. The front panel may be bakelite, hard rubber, any of the "pressed wood" boards, or even plywood, as insulation is not particularly a problem. The box is made from scrap shelving. This illustration also shows how the cabled leads are brought into the boards. A hook for the patching cords is provided on the right end of the mounting bracket.

3. **Monitoring board.**—Another convenience in a school using a large number of automatic keyers is a monitoring board. As shown in figure 51, this consists simply of several rows of single open circuit jacks. Each jack is connected to the output terminals of a keyer, paralleling the leads that go to the switchboard or the patching board. The monitoring operator is thus able to check the output of all the keyers from one position in a very short time. Directly above the monitoring board shown in figure 52 are two small permanent magnet loudspeakers, mounted in the wall. These have cords and plugs attached, and either can be left plugged into the jack representing any keyer when the operator wants to make a continuous check on a tape, while he is doing other work around the keyer room. As in the case of the patching board, this monitoring board can use bakelite, hard rubber, pressed wood or plywood for its panel.

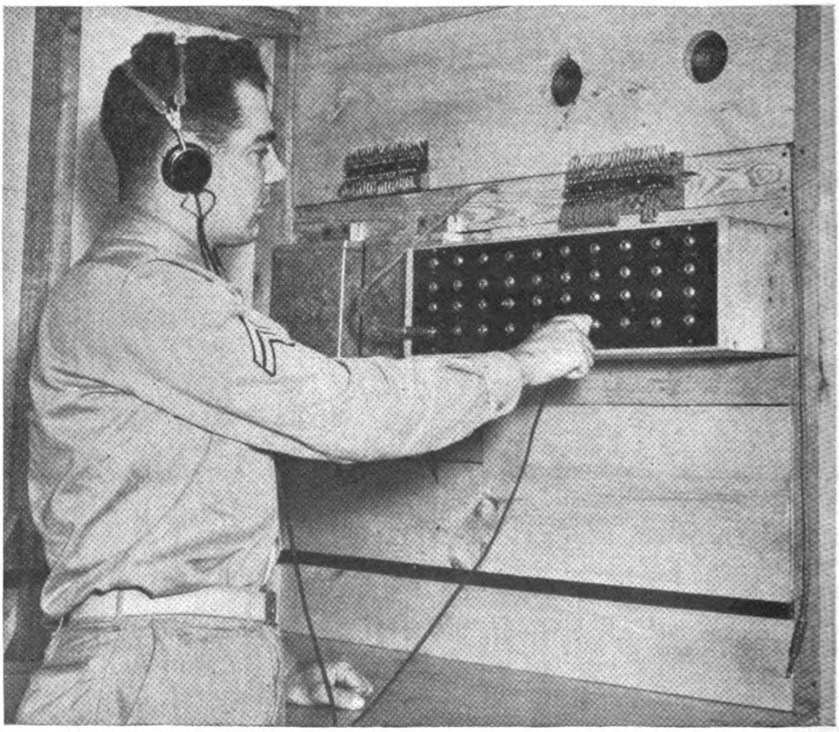


FIGURE 51.—Monitoring board used in connection with automatic keyers.

APPENDIX II

MATERIAL CARRIED ON MASTER TAPES

The material carried on the 15 master tapes furnished for the code practice equipment described in this manual is published herewith as an aid to instructors. It should be noted that random errors may occur in the tapes.

Tape No. 1—20 characters per minute

(Receiving lesson I, TM 11-454)

F	F	F	F	F	G	G	G	G	G	H	H	H	H	H	M	M	M	M	M
J	J	J	J	J	R	R	R	R	R	U	U	U	U	U	F	F	F	F	F
G	G	G	G	G	H	H	H	H	H	M	M	M	M	M	J	J	J	J	J
R	R	R	R	R	U	U	U	U	U	F	F	F	F	F	G	G	G	G	G
H	H	H	H	H	M	M	M	M	M	J	J	J	J	J	R	R	R	R	R
U	U	U	U	U	F	H	U	R	G	H	M	J	R	U	F	G	M	J	H
F	G	M	H	M	J	H	R	U	F	J	R	J	G	U	M	F	H	R	U
U	F	M	G	H	M	R	H	F	R	R	J	U	G	U	J	H	F	M	J
R	M	F	R	U	G	M	H	F	H	G	R	U	J	J	H	U	F	J	M
R	R	J	F	M	U	M	H	G	J	J	G	H	F	U	R	F	M	H	U
G	J	R	J	F	H	R	G	U	M	H	G	F	U	J	F	H	U	M	R
J	H	R	M	G	F	J	H	H	R	U	M	U	H	F	J	R	M	F	U
J	M	G	J	R	H	F	U	U	J	R	H	H	M	G	M	F	R	F	U
H	R	M	H	G	J	R	F	J	M	U	G	H	U	M	F	G	J	G	F
G	H	M	R	U	M	R	J	F	H	M	J	H	G	R	U	J	F	U	F
H	M	G	R	M	J	H	R	M	F	R	G	J	H	J	U	F	U	F	U
H	M	J	R	H	G	R	H	G	R	F	H	M	J	U	F	U	J	F	U
H	M	H	J	H	U	G	R	J	G	R	F	U	J	M	R	F	F	M	U
J	G	J	R	U	M	M	H	F	J	H	U	F	R	G	R	F	U	H	M
J	R	G	U	J	F	U	M	H	R	J	M	R	F	M	F	H	G	H	U
M	F	U	G	U	H	J	M	J	R	J	R	G	F	F	H	M	H	R	U
M	H	R	U	F	R	R	U	G	U	F	M	H	J	J	F	G	J	H	M
G	F	H	U	J	G	J	M	H	M	G	R	U	H	F	M	F	R	J	U
F	G	J	F	M	H	J	G	M	G	H	J	M	F	U	R	H	F	R	U
M	G	F	J	H	F	G	J	M	U	R	G	M	H	U	F	H	F	U	R
J	M	H	G	F	R	J	U	J	M	G	M	G	J	H	U	F	H	F	R
J	H	R	G	H	U	M	F	J	G	M	H	M	J	F	G	U	F	R	U
J	G	H	R	U	H	U	J	G	M	F	M	H	M	F	R	J	G	U	F
H	G	J	U	R	H	G	J	M	F	H	M	R	F	M	U	F	J	G	U
G	F	U	H	G	H	R	J	H	R	M	F	J	M	U	J	F	G	U	M
G	F	G	H	U	H	H	R	M	F	J	M	F	R	J	M	G	U	F	U
F	F	F	F	F	G	G	G	G	G	H	H	H	H	H	M	M	M	M	M
J	J	J	J	J	R	R	R	R	R	U	U	U	U	U	F	F	F	F	F
G	G	G	G	G	H	H	H	H	H	M	M	M	M	M	J	J	J	J	J
R	R	R	R	R	U	U	U	U	U	F	F	F	F	F	G	G	G	G	G
H	H	H	H	H	M	M	M	M	M	J	J	J	J	J	R	R	R	R	R

Tape No. 1—Continued

U	U	U	U	U	F	U	R	R	G	J	J	H	G	H	H	H	J	J	M
M	G	F	M	J	J	J	H	G	G	G	F	M	R	J	H	M	R	H	M
M	M	G	R	F	H	F	G	G	M	H	G	G	F	F	M	M	F	J	R
R	G	M	M	G	J	H	J	G	U	R	H	J	F	H	R	H	J	U	G
H	G	R	F	J	M	J	H	R	R	R	J	R	U	G	U	U	F	J	G
G	R	U	H	H	M	H	U	M	F	G	R	G	U	M	H	H	U	J	U
F	J	M	H	F	H	U	R	G	U	F	J	M	G	U	H	F	H	J	M
J	G	U	M	F	H	R	G	H	F	R	U	H	H	H	H	H	H	R	M
M	R	J	F	R	R	H	R	G	M	U	J	R	J	J	G	J	M	U	G
R	H	U	R	H	H	H	G	H	U	F	J	R	H	R	H	M	M	U	M
G	J	U	F	J	J	J	R	R	U	F	F	G	U	H	U	J	F	M	G
J	F	H	J	G	H	M	M	J	J	G	M	H	M	G	F	R	H	J	M
R	J	M	H	F	R	G	J	R	R	U	M	G	U	M	G	M	F	R	F
H	J	R	G	J	H	U	R	U	M	R	F	R	H	J	J	F	G	H	R
G	M	F	H	M	J	M	R	J	R	G	G	M	H	G	J	G	M	F	U
M	R	M	R	J	G	M	H	M	M	F	M	J	J	U	U	H	F	U	H
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G	J	F	U	H	M	U	G	H	J	J	R	F	F	J	H	F	H	J	J
M	F	M	R	U	U	U	J	U	J	F	G	M	R	J	U	M	G	M	F
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F	H	R	F	G	J	F	U	F	F	H	M	G	F	H	H	F	U	J	F
F	G	M	H	F	F	M	U	M	R	J	F	U	J	F	U	G	H	J	R
F	F	H	F	G	J	G	U	J	R	M	J	H	M	F	F	G	U	F	F
M	H	H	R	H	J	R	U	F	R	U	G	U	F	H	U	J	M	U	R
U	U	F	F	U	U	U	M	U	U	M	U	U	R	R	U	F	U	M	U

Tape No. 2—20 characters per minute

(Receiving lesson II, TM 11–454)

B	B	B	B	B	D	D	D	D	D	K	K	K	K	K	N	N	N	N	N
T	T	T	T	T	V	V	V	V	V	Y	Y	Y	Y	Y	B	B	B	B	B
D	D	D	D	D	K	K	K	K	K	N	N	N	N	N	T	T	T	T	T
V	V	V	V	V	Y	Y	Y	Y	Y	B	B	B	B	B	D	D	D	D	D
K	K	K	K	K	N	N	N	N	N	T	T	T	T	T	V	V	V	V	V
Y	Y	Y	Y	Y	B	F	U	T	V	M	N	H	Y	N	M	T	G	D	H
B	Y	G	F	V	R	D	B	G	Y	J	T	K	V	H	J	G	V	V	F
F	K	H	G	Y	F	M	K	R	B	F	D	V	U	T	F	Y	T	R	Y
J	G	U	M	J	B	G	Y	N	D	B	Y	D	Y	D	N	F	N	V	K
B	J	H	B	R	D	V	H	Y	T	K	V	U	N	B	K	G	N	T	K
D	U	D	M	R	K	M	N	V	D	V	U	T	K	T	B	H	N	D	T
N	K	R	J	U	K	N	J	T	M	N	Y	N	T	D	B	V	B	K	T
K	R	N	B	N	U	V	D	T	R	K	K	T	N	Y	Y	J	Y	D	V
T	R	U	T	D	Y	K	G	R	V	V	N	D	D	V	K	F	T	B	Y
V	J	V	K	F	N	T	U	B	Y	D	T	B	B	G	V	D	Y	B	R
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K	H	T	V	F	K	H	D	T	V	D	B	R	K	N	T	D	M	B	J
B	N	Y	D	T	G	U	V	K	T	K	J	K	V	D	N	M	D	J	B

Tape No. 2—Continued

D	U	B	T	H	V	Y	N	R	B	M	T	Y	J	K	U	B	K	N	R
K	Y	F	M	R	K	J	B	D	H	R	V	Y	N	D	B	R	N	T	K
N	J	F	G	U	D	M	V	D	G	J	T	K	U	V	D	V	J	Y	T
T	G	M	H	Y	B	D	K	H	K	T	R	M	N	Y	F	B	B	Y	V
B	K	F	K	U	D	Y	R	N	F	V	U	K	J	B	T	M	D	B	M
V	N	T	D	G	D	B	V	J	G	Y	K	D	N	M	V	J	B	U	H
N	T	V	B	T	H	K	U	K	H	N	D	D	Y	R	H	T	B	D	G
N	V	T	N	K	M	N	J	Y	M	K	T	F	R	D	V	U	G	R	K
J	Y	K	N	K	T	K	V	D	G	J	N	T	M	Y	R	B	J	F	N
T	D	Y	N	V	M	Y	U	H	M	D	B	R	V	U	T	F	B	T	N
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T	Y	V	N	B	G	J	Y	B	K	B	H	V	B	U	Y	R	T	Y	D
F	Y	G	T	R	H	D	D	N	K	F	D	B	R	Y	U	N	K	Y	B
B	B	B	B	B	D	D	D	D	D	K	K	K	K	K	N	N	N	N	N
T	T	T	T	T	V	V	V	V	V	Y	Y	Y	Y	Y	B	B	B	B	B
D	D	D	D	D	K	K	K	K	K	N	N	N	N	N	T	T	T	T	T
V	V	V	V	V	Y	Y	Y	Y	Y	B	B	B	B	B	D	D	D	D	D
K	K	K	K	K	N	N	N	N	N	T	T	T	T	T	V	V	V	V	V
Y	Y	Y	Y	Y	B	F	J	B	D	N	K	T	V	Y	K	B	D	K	N
T	B	V	B	N	J	T	B	T	F	Y	K	G	J	U	K	R	R	J	M
H	N	U	Y	J	G	K	N	T	V	Y	D	V	Y	Y	G	H	U	H	D
R	N	U	V	N	T	Y	B	F	F	M	F	T	V	T	K	Y	T	V	G
F	G	M	B	M	J	B	T	K	Y	V	D	T	M	G	H	K	D	B	N
N	N	Y	N	T	V	Y	J	R	R	U	N	D	F	G	F	T	H	R	U
Y	U	G	T	K	K	V	H	B	R	B	R	F	B	D	K	K	U	Y	N
T	K	G	V	K	D	B	D	D	H	M	T	M	F	G	H	F	D	M	G
V	M	N	V	K	T	N	H	U	Y	J	M	D	Y	B	K	N	K	Y	N
J	D	U	B	K	Y	H	N	J	D	G	U	F	D	V	N	B	V	K	R
V	U	J	V	U	M	Y	D	T	G	R	N	Y	V	T	T	R	B	D	T
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M	J	F	B	K	V	N	K	V	D	T	D	K	M	R	J	T	V	Y	N
K	J	D	J	B	F	N	T	D	Y	V	U	Y	K	N	T	B	B	J	T
V	T	R	U	K	D	T	N	B	Y	H	D	H	K	V	D	U	T	N	T
D	B	B	R	K	Y	Y	K	M	K	D	D	F	T	R	U	V	B	Y	V
U	Y	N	K	T	N	D	B	N	K	V	J	N	U	N	J	N	Y	R	M
V	V	B	R	N	H	T	D	B	T	D	Y	V	G	V	N	D	K	D	V
Y	B	M	R	D	Y	U	G	U	Y	M	J	F	N	K	B	B	Y	K	V
U	T	N	U	B	D	F	T	V	H	V	R	T	T	Y	U	T	G	Y	F
G	H	V	J	F	D	H	D	M	B	R	V	B	M	J	T	U	B	F	D
R	N	G	V	T	N	N	N	B	Y	T	Y	M	M	D	K	N	J	B	D
B	B	G	J	B	V	T	K	D	V	R	V	T	D	K	D	B	B	K	B
J	N	T	Y	Y	B	U	D	R	F	T	K	Y	Y	H	F	Y	K	K	T
T	V	Y	R	Y	J	B	R	K	T	V	M	H	G	K	N	N	D	D	B

Tape No. 3—20 characters per minute

(Receiving lesson III, TM 11-454)

C	C	C	C	C	E	E	E	E	E	I	I	I	I	I	L	L	L	L	L
O	O	O	O	O	S	S	S	S	S	W	W	W	W	W	C	C	C	C	C
E	E	E	E	E	I	I	I	I	I	L	L	L	L	L	O	O	O	O	O
S	S	S	S	S	W	W	W	W	W	C	C	C	C	C	E	E	E	E	E
I	I	I	I	I	L	L	L	L	L	O	O	O	O	O	S	S	S	S	S
W	W	W	W	W	C	F	L	O	I	B	C	Y	W	E	C	L	O	W	C
C	E	S	C	I	G	E	W	S	D	E	W	L	V	C	O	L	S	B	E
I	C	Y	I	H	S	C	I	U	K	S	O	F	I	E	T	W	O	S	D
V	E	L	M	L	L	Y	R	N	O	S	C	G	I	L	S	U	K	W	O
E	O	J	I	S	O	W	V	L	W	L	E	H	L	O	N	W	C	F	L
S	I	O	R	Y	N	T	I	B	S	O	M	E	L	G	C	T	S	S	W
L	W	S	O	U	N	E	D	O	S	J	W	I	R	V	K	E	O	I	S
O	T	C	J	V	C	K	W	K	R	C	T	E	J	Y	I	L	B	D	L
S	M	I	E	W	N	E	D	U	C	E	M	W	E	L	C	O	E	N	T
H	S	W	T	I	V	D	B	E	I	C	I	C	O	B	I	F	C	I	O
W	N	V	I	W	L	Y	L	I	B	E	H	S	L	E	G	D	B	C	S
C	Y	T	C	S	K	O	L	D	O	E	W	G	O	S	H	W	I	K	E
I	E	L	N	O	K	W	S	L	C	I	L	O	F	M	E	S	L	F	W
W	S	I	O	I	L	O	E	W	B	Y	C	L	S	J	W	C	E	O	G
E	N	D	L	E	S	U	S	I	C	O	R	I	L	I	O	E	S	H	M
T	B	W	I	W	L	W	W	E	C	E	U	V	S	L	O	C	W	J	S
C	V	K	S	O	E	S	W	C	S	W	I	L	O	C	Y	I	S	W	R
C	L	O	K	F	U	I	W	B	V	U	O	N	S	H	W	L	J	O	S
H	E	W	G	B	D	G	C	T	L	C	K	W	Y	C	G	S	I	L	G
O	E	K	H	S	G	O	I	Y	W	E	S	W	E	W	O	I	O	I	S
L	I	F	T	S	L	E	F	C	S	D	Y	I	H	L	S	I	O	E	M
I	L	N	W	I	C	Y	E	R	C	I	L	L	I	M	E	L	C	C	L
O	W	K	M	E	T	J	I	O	N	O	L	E	S	J	I	V	U	M	H
C	S	J	C	D	B	M	L	K	L	C	O	R	W	F	W	J	C	L	R
E	R	W	C	W	B	D	O	S	G	I	N	S	T	U	E	R	C	R	W
U	V	M	I	E	H	S	W	F	K	S	V	E	W	Y	C	W	J	W	E
C	C	C	C	C	E	E	E	E	E	I	I	I	I	I	L	L	L	L	L
O	O	O	O	O	S	S	S	S	S	W	W	W	W	W	C	C	C	C	C
E	E	E	E	E	I	I	I	I	I	L	L	L	L	L	O	O	O	O	O
S	S	S	S	S	W	W	W	W	W	C	C	C	C	C	E	E	E	E	E
I	I	I	I	I	L	L	L	L	L	O	O	O	O	O	S	S	S	S	S
W	W	W	W	W	C	I	V	E	S	L	O	S	H	W	C	I	W	E	T
C	C	H	O	L	I	O	C	E	U	E	C	E	O	I	W	T	M	S	N
Y	E	S	N	B	V	L	E	E	I	L	W	S	R	V	S	Y	L	J	O
S	C	I	W	V	T	L	I	D	W	K	O	W	K	F	N	K	J	W	M
C	I	M	I	R	O	J	E	T	I	C	N	O	L	I	S	K	G	H	T
W	M	C	C	I	I	H	L	S	Y	U	V	W	I	W	S	O	I	E	W
O	F	B	S	S	I	E	D	W	E	C	G	S	L	O	N	N	C	N	V
L	K	K	L	S	L	E	U	D	G	L	C	T	B	B	H	F	E	C	Y
W	T	E	K	E	D	Y	O	W	O	U	W	S	I	G	O	E	Y	J	M
D	S	L	W	I	R	V	I	D	W	D	B	L	L	S	E	S	W	W	W
C	I	F	E	I	L	O	W	O	S	U	N	L	B	O	K	U	E	I	D

Tape No. 3—Continued

L	W	I	E	C	B	T	Y	C	R	O	K	S	F	I	D	K	O	W	S
S	R	C	I	B	O	C	B	C	C	S	V	L	W	S	C	N	L	G	K
B	E	S	S	L	O	J	C	E	C	E	E	I	Y	O	E	W	U	C	E
D	I	O	C	I	S	C	W	O	C	E	M	W	T	M	I	H	W	L	C
R	U	I	O	K	S	Y	L	L	O	N	V	Y	L	F	G	H	E	I	E
W	C	S	G	O	L	I	V	L	N	W	W	I	L	E	R	S	E	W	V
I	I	L	L	R	J	E	O	L	O	F	S	L	S	O	S	Y	E	H	I
S	W	T	W	E	C	E	L	O	G	V	Y	L	B	E	S	M	J	I	L
C	H	C	W	L	M	J	F	U	Y	C	O	T	S	N	C	K	I	C	I
G	H	E	W	O	O	Y	W	G	O	S	E	I	W	E	C	L	L	W	U
W	T	E	L	O	F	D	W	S	C	E	C	I	L	S	I	I	L	V	J
R	W	O	S	O	K	C	S	O	B	E	C	B	I	L	E	S	W	S	J
I	O	O	C	U	C	C	J	W	B	S	W	F	S	I	D	N	I	C	K
F	O	H	J	W	O	L	I	E	C	M	L	R	W	C	E	D	O	L	W
S	L	T	O	S	E	W	G	M	S	R	S	G	S	M	L	H	R	W	E

Tape No. 4—20 characters per minute

(Receiving lesson IV, TM 11–454)

A	A	A	A	A	P	P	P	P	P	Q	Q	Q	Q	Q	X	X	X	X	X
Z	Z	Z	Z	Z	4	4	4	4	4	5	5	5	5	5	A	A	A	A	A
P	P	P	P	P	Q	Q	Q	Q	Q	X	X	X	X	X	Z	Z	Z	Z	Z
4	4	4	4	4	5	5	5	5	5	A	A	A	A	A	P	P	P	P	P
Q	Q	Q	Q	Q	X	X	X	X	X	Z	Z	Z	Z	Z	4	4	4	4	4
5	5	5	5	5	A	Q	K	P	X	A	N	B	D	P	T	Q	A	X	Z
4	E	A	X	P	W	A	U	5	A	Z	4	F	L	5	Q	Z	T	4	Q
5	P	I	Q	A	S	5	M	R	K	P	4	V	G	K	A	N	Z	4	P
Q	Z	X	J	Z	Q	4	Z	Q	P	X	A	5	A	H	S	N	4	P	Z
X	C	Y	Z	P	X	4	K	A	Y	Q	4	O	P	Q	M	5	T	L	X
X	Q	A	Q	4	V	S	E	P	5	O	Q	Z	M	5	W	J	F	Q	Q
4	V	Z	W	N	5	X	I	Q	Z	I	S	4	F	M	5	H	R	X	P
D	X	H	5	T	U	A	Z	Q	M	E	Y	G	W	5	V	U	4	G	A
4	C	Y	V	4	P	F	P	D	B	X	Z	E	P	A	X	Q	Z	B	X
K	R	5	B	R	Z	A	H	5	Q	X	B	Q	4	Y	C	J	X	D	Z
P	D	5	B	X	E	L	K	G	X	P	X	A	5	U	I	Q	Z	5	H
Q	4	A	Q	C	X	4	O	G	N	Z	Q	5	A	X	4	J	W	R	A
X	5	P	5	Z	4	H	S	Z	T	P	4	I	P	Z	E	P	V	A	P
5	A	4	A	G	5	L	4	O	Z	4	P	5	A	P	C	A	O	Z	Q
P	J	Z	Q	Z	M	U	V	A	5	Q	F	L	A	Y	C	A	5	X	Q
U	P	5	R	X	X	4	P	A	X	D	I	4	O	P	A	Z	Q	P	P
4	A	N	J	W	Q	A	T	S	L	P	5	F	5	Z	Q	4	X	Z	5
F	A	Q	5	I	P	Z	Q	4	U	K	H	5	Z	A	X	A	5	4	U
A	G	4	A	Q	A	S	H	O	X	4	N	P	Z	Q	4	V	P	C	Y
P	Q	H	S	M	W	X	P	K	5	Z	Q	T	X	F	Q	E	Z	D	B
X	5	4	M	5	N	P	D	4	L	N	X	4	V	U	I	Z	G	Q	V
W	X	4	T	J	5	A	I	Z	N	T	5	Z	J	Y	C	O	X	R	K
L	Q	A	Z	Q	R	W	R	4	K	4	X	G	4	Z	P	X	4	V	U
S	Z	P	X	P	D	U	4	P	E	Z	5	L	F	S	4	R	Q	Y	C

432514°—42——6

Tape No. 4—Continued

O	A	J	Q	A	E	M	B	5	M	A	Q	X	G	5	J	P	4	Q	P
P	X	B	Z	C	Y	H	5	D	5	H	U	A	P	Z	A	F	X	5	A
A	A	A	A	A	P	P	P	P	P	Q	Q	Q	Q	Q	X	X	X	X	X
Z	Z	Z	Z	Z	4	4	4	4	4	5	5	5	5	5	A	A	A	A	A
P	P	P	P	P	Q	Q	Q	Q	Q	X	X	X	X	X	Z	Z	Z	Z	Z
4	4	4	4	4	5	5	5	5	5	A	A	A	A	A	P	P	P	P	P
Q	Q	Q	Q	Q	X	X	X	X	X	Z	Z	Z	Z	Z	4	4	4	4	4
5	5	5	5	5	4	5	Q	X	Z	4	D	4	K	P	Q	X	5	P	U
4	F	A	P	X	W	L	S	O	P	E	P	Z	C	Q	V	X	C	R	D
4	5	A	J	P	A	A	G	Q	5	X	Q	Z	A	X	A	I	X	Y	A
Z	H	Y	5	5	A	P	4	Z	5	N	Q	4	H	4	4	A	P	J	B
X	Q	J	Z	Q	W	5	V	B	B	Q	5	A	Q	R	J	5	A	S	M
T	Z	X	Q	Z	P	A	Z	P	4	N	T	4	R	X	C	Z	G	Z	X
W	I	Q	M	5	J	Q	P	A	C	A	W	S	Q	X	V	5	U	P	Z
E	X	4	5	M	X	Q	P	A	W	N	5	R	D	E	Y	Q	A	5	4
4	S	X	A	F	A	L	4	H	L	U	4	A	Z	S	X	P	A	W	U
M	H	K	U	M	Z	K	E	I	Z	P	H	K	O	S	4	V	P	T	Q
H	P	D	I	R	4	B	5	P	5	R	Q	A	P	Q	Q	D	5	G	G
Z	O	A	A	S	4	O	K	4	Z	4	P	5	D	X	A	K	P	Y	5
Z	M	B	Q	X	N	T	Z	5	X	L	U	X	5	L	N	K	E	M	5
A	Z	P	X	Q	O	I	E	X	X	P	Z	P	4	Q	D	P	K	4	Z
N	T	4	Z	A	H	N	4	4	A	4	Q	S	Y	Z	B	X	Q	4	P
F	I	5	H	N	Q	X	5	X	5	Q	U	B	F	V	5	O	Z	4	G
E	Q	A	5	I	5	L	4	F	5	P	T	4	Z	G	L	X	A	D	L
G	A	P	M	F	W	P	4	5	A	P	A	A	O	5	Z	Z	X	V	J
4	F	G	P	P	5	K	H	Q	5	M	5	A	Y	U	X	Z	P	Y	P
Z	A	Q	F	U	Y	Z	S	5	Z	T	Q	A	S	M	W	5	V	X	C
I	4	E	C	C	A	Q	X	4	Q	I	C	P	4	J	A	Q	Z	N	N
5	J	H	U	Q	J	Q	J	P	A	A	Z	4	A	V	E	Z	O	X	R
P	F	A	T	Z	4	T	F	R	4	Z	X	Z	W	V	O	5	Q	X	5
P	Z	G	X	4	Q	4	X	X	4	4	P	L	Q	X	G	B	D	5	R
A	Z	X	P	Z	4	C	D	Q	R	V	Y	Q	5	Z	Q	P	Z	X	Q
P	A	X	Z	H	A	P	Q	Q	P	5	U	Y	B	V	K	U	C	P	A

Tape No. 5—20 characters per minute

(Receiving lesson V, TM 11-454)

1	1	1	1	1	2	2	2	2	2	3	3	3	3	3	6	6	6	6	6
7	7	7	7	7	8	8	8	8	8	9	9	9	9	9	Ø	Ø	Ø	Ø	Ø
1	1	1	1	1	2	2	2	2	2	3	3	3	3	3	6	6	6	6	6
7	7	7	7	7	8	8	8	8	8	9	9	9	9	9	Ø	Ø	Ø	Ø	Ø
1	1	1	1	1	2	2	2	2	2	3	3	3	3	3	6	6	6	6	6
7	7	7	7	7	8	8	8	8	8	9	9	9	9	9	Ø	Ø	Ø	Ø	Ø
8	6	P	3	Z	7	M	8	E	9	J	O	Y	Z	1	3	O	1	L	9
T	1	L	9	A	Ø	Y	C	D	Ø	E	6	K	1	N	9	A	1	E	6
9	O	2	F	8	P	Ø	A	Ø	I	7	V	4	L	T	Z	U	8	I	Ø
S	1	M	3	G	7	Y	S	8	L	Ø	2	W	1	O	3	5	6	R	9
2	Z	7	A	6	B	X	H	5	7	E	S	7	C	Z	W	4	V	7	Z
8	W	3	Q	Z	7	6	1	J	I	7	O	P	6	R	3	X	8	Z	3

Tape No. 5—Continued

2	X	B	9	D	6	8	5	H	6	R	4	Q	1	2	U	6	Y	C	9
3	M	Ø	7	6	L	U	9	B	6	G	O	B	D	1	N	1	7	4	2
7	Q	1	K	I	8	G	5	Ø	P	7	S	2	C	3	T	Ø	Z	8	6
2	J	9	E	6	N	3	E	9	K	8	1	V	9	Y	1	W	I	R	3
9	3	C	Ø	F	L	T	8	U	2	Y	3	T	8	Q	6	Ø	U	1	2
6	8	2	9	1	R	7	V	2	6	1	N	9	1	8	F	Ø	2	8	5
Ø	7	2	3	H	6	B	1	J	4	V	5	H	2	K	5	H	3	9	1
X	B	Ø	7	3	A	8	3	Ø	6	2	W	1	J	6	B	3	Y	7	8
Q	9	7	K	E	Ø	9	3	7	2	B	F	G	Z	J	Z	S	2	A	R
Z	A	8	G	6	Z	D	6	I	6	F	1	H	3	D	6	A	3	B	1
O	3	H	6	9	7	Ø	P	7	B	7	6	L	8	N	L	R	6	A	9
P	3	Z	6	L	6	P	5	R	E	M	Y	Ø	Y	X	Z	8	U	G	3
T	7	B	8	6	3	N	7	I	7	Q	Z	W	9	1	8	C	A	S	H
1	5	9	5	F	8	V	1	3	9	F	2	G	8	X	1	D	3	U	J
E	D	Ø	8	5	J	H	B	Ø	9	U	2	J	Ø	G	7	F	9	Z	9
P	8	J	7	8	9	Ø	I	L	7	I	6	6	P	K	2	6	4	6	8
K	Ø	E	Q	Y	9	D	1	W	C	J	E	7	Ø	E	7	R	G	7	8
Y	1	V	2	Q	1	C	1	1	6	2	Ø	L	1	7	Ø	6	V	2	S
O	4	O	S	1	3	N	5	W	Ø	N	4	M	2	Ø	3	T	O	S	X
Y	K	4	W	7	P	Q	B	2	V	T	9	H	1	K	9	V	8	K	3
K	Z	8	4	B	Z	1	L	1	C	6	1	D	C	9	8	1	2	J	7
F	5	1	9	G	6	N	2	V	6	3	9	2	3	W	3	U	N	T	1
6	F	5	B	6	D	H	7	Q	Ø	F	7	T	8	M	3	9	2	3	W
3	U	N	T	1	6	F	5	B	6	D	7	W	7	N	9	M	8	Y	9
O	A	U	S	4	X	6	1	Ø	W	Ø	Ø	H	3	8	3	T	Z	X	8
Y	Ø	U	9	R	1	1	8	6	V	8	Y	7	Z	7	U	2	3	Y	2
G	6	A	3	Ø	I	D	9	P	Ø	L	E	I	R	7	Z	C	4	8	R
1	9	9	7	X	1	S	8	Z	6	8	7	6	H	7	9	6	Ø	9	Z
3	9	2	6	3	2	5	1	8	3	7	9	4	7	2	9	8	7	5	6
9	8	Z	2	D	9	6	9	G	8	Q	Ø	K	7	M	6	8	2	X	3
Ø	7	1	B	6	P	3	F	7	K	1	N	9	F	8	D	3	G	1	7
9	K	1	F	A	3	N	2	F	Ø	C	4	V	5	H	7	T	6	8	9
6	B	2	G	3	Z	7	G	9	E	1	M	8	1	7	W	2	A	8	4
3	8	7	2	B	6	1	8	Z	Q	1	2	K	9	Q	7	X	3	Z	7
9	V	3	J	1	L	7	X	9	Y	6	Ø	3	G	Ø	N	8	Ø	6	2
2	1	C	Z	O	6	Q	1	P	9	2	3	K	6	F	9	Y	I	8	9
3	E	Ø	S	3	P	Z	D	8	D	Ø	T	2	N	7	M	Ø	D	7	8
O	3	L	2	H	5	W	3	J	1	L	O	8	2	T	8	U	9	6	7
6	U	1	A	6	R	9	U	7	W	1	S	4	V	8	Y	9	P	H	5
3	I	1	R	9	E	1	J	8	C	7	X	B	6	M	9	R	Ø	7	6
1	1	1	1	1	2	2	2	2	2	3	3	3	3	3	6	6	6	6	6
7	7	7	7	7	8	8	8	8	8	9	9	9	9	9	Ø	Ø	Ø	Ø	Ø
1	1	1	1	1	2	2	2	2	2	3	3	3	3	3	6	6	6	6	6
7	7	7	7	7	8	8	8	8	8	9	9	9	9	9	Ø	Ø	Ø	Ø	Ø
1	1	1	1	1	2	2	2	2	2	3	3	3	3	3	6	6	6	6	6
7	7	7	7	7	8	8	8	8	8	9	9	9	9	9	Ø	Ø	Ø	Ø	Ø
8	T	9	S	2	8	2	3	7	2	9	6	Ø	X	9	Ø	9	6	3	9
2	3	O	6	3	6	1	O	1	Z	W	X	M	Q	J	3	8	7	B	8
7	K	B	8	V	1	E	3	U	I	P	L	2	M	7	3	B	Ø	1	9
C	2	2	Ø	Z	1	1	2	7	3	C	Ø	L	1	1	3	9	F	3	A

Tape No. 6—25 characters per minute

(All letters and numbers in random order, 5 words per minute)

A S D F 1 A P L K J 2 P Q E N G E Q X I 4 H 6 X Z
O B R 7 Z 4 W T U 8 4 5 C Y M 9 5 A S D F Ø A V H
N H 7 D Q D Y U 6 S S M U R D N Y N G F V Z H T N
G E C Q D H R N 4 D C K F K S A Y B J V 5 X U D H
Ø W E F N J O M H W R U M L 4 D F F 2 R X N H U 1
R H Y J M Ø P B K R H V Z C U N M V V A I F G 4 F
X I U G Y Z L O H F W I G V B H 7 W X C F J J Z 5
N V F 5 P 5 I M H Z X P U V H 4 A Z G Y M 9 G A Y
D M X 5 5 N V U J T S T Y U R D Q U B U 1 Z A J V
G Z B Z O R J 8 A D L N G K Q I E F F 2 4 Y H M M
8 C Q E N R B Q P G B J I P A N H U D 4 P B M R L
Y 9 S R M H 4 V B V G I Y A G Y F E B H H U U Q J
Z D K H Ø Q O H D R K X Q C D U D T 4 J B U 9 H F
H H G 4 L Z R B F O 5 W H D U V W Z U R H B 4 X C
F U Ø S Y C B H G Q V E J J D Z S Y R H 6 4 P K J
F Y C O K Y J S Q 5 B H J C A N U N F Q S A H J H
U Q G I M F O S U W T M A X 4 G H J S Z J G D H R
E H I D J I 5 O K U U H L T H M H C Z P Y D U K A
H R F G D J Q O V M Q 4 X U V H 3 Y S J R F Q L U
W M U 9 G D C D M W 4 D G B H G 5 U I U M R A 4 V
J H D S X Y J H 9 Z T W N M 2 C A J K R T F M O J
U J W J E H G K S B U B F 9 T D K V U X X 5 R V R
W O 4 K H U G P P C J R U W 4 W U U W P D B D G 5
F P Y D H 3 A X S X U U Q V F M M Ø 5 Z K N U N Q
P V U F W W V J V U Ø M Y W J H Y T X N Y F 7 S G
F F M C E 4 W B U I P P R B U A U 4 S F H 5 Y A C
R U W D Q J K R S M C L H J F L X W M M 6 5 X C V
J J 5 O G T H 7 4 D C G U Ø X G V B J T J Q N V U
7 X D C N G 1 X S R V J P 5 4 E F G N Q A J H U V
D A G R U D F Q N D U 4 4 5 Y N U Ø W Z U H G Z U
4 S D M 5 P W I N U 9 P V U U U U U J H K U 6 R 5
D J F 4 5 V R H M S P P F D U 4 B G C M R C Y O G
V U Q H X I K R I L U F N U 9 X 5 W T M A V A D B
J G J P H D F 3 Z W C T U 8 Z 5 E V U Ø Z P V D F
Q Z 4 S M H Q S X E T H I 4 B L Y M I Z U B D U 5
P F Y B H 2 V 4 U H H O Z 4 H N F K A C W D J W P
I Y B H 7 H T B N J Y X W D F M J 4 R F B H 7 W 5
F F F O L P K K H U A J R D H D 4 Z W J H 5 O P V
G U W U N U V F S 5 S H J U Y W A O H M Ø 4 T S K
U C A M K H J A F S B G R Z C A Y J G T Z R V V F
D B V R B H C V C W V H W Q F O J M B Q M E J G J
S S I D F Ø Y 5 U B J Z H D G U M O 4 X S R F 8 I
U R N U F P L J H M P J P I U J C H U J B H B S X
U J M 9 5 A C H G Ø S T R R H X 5 V Y J U A A W K
T R O V F D J H E Z Z U B T S P I N D U 9 J X S K
R U P L G T H D A M B B J Y P P C A D 1 S F A D 1
P K 2 L J P K 2 Q N 3 E G Q N 3 X V 6 I H X V 6 Z
B 7 O R Z B 7 4 T 8 W U 4 T 8 5 Y 9 C M 5 Y 9 A D

Tape No. 6—Continued

Ø	S	F	A	D	Ø	V	V	9	I	H	4	H	8	Q	G	X	C	U	A	R	Y	S	M	Q
H	R	T	W	I	Y	H	4	H	F	S	D	S	H	Y	Q	L	G	5	D	7	Q	F	7	R
R	A	F	Ø	D	F	J	I	F	4	V	G	A	J	5	B	J	N	H	1	X	B	4	B	H
Q	B	C	E	B	8	I	J	A	G	D	H	B	D	G	U	5	B	I	4	J	T	H	F	P
Y	D	X	D	Q	R	U	X	T	3	H	M	W	R	M	U	U	9	B	J	Q	T	H	V	B
4	C	K	S	U	M	A	B	Ø	A	V	D	Y	G	U	H	Ø	X	M	G	W	G	D	R	1
L	G	J	G	F	A	B	K	G	J	E	T	H	4	J	R	X	D	Y	D	J	4	K	Z	5
U	P	C	F	Q	V	C	5	H	T	W	H	Q	H	9	P	B	X	U	H	W	K	A	T	6
S	M	X	U	8	A	D	C	K	M	R	D	Ø	5	J	P	C	U	N	M	D	S	U	N	R
U	X	V	F	Q	F	L	W	U	X	J	V	A	D	Ø	K	G	X	T	7	Z	Y	U	H	J
U	K	9	D	B	7	N	G	4	V	T	I	G	Y	D	F	Z	J	M	Y	V	A	F	M	4
U	S	Q	J	4	T	R	L	T	S	P	R	V	U	J	J	J	R	A	G	9	D	U	Q	

Tape No. 7—35 characters per minute

(All letters and numbers in random order, 7 words per minute)

A	D	1	S	F	A	D	1	P	K	2	L	J	P	K	2	Q	N	3	E
G	Q	N	3	X	V	6	I	H	X	V	6	Z	B	7	O	R	Z	B	7
4	T	8	W	U	4	T	8	5	Y	9	C	M	5	Y	9	A	D	Ø	S
F	A	D	Ø	5	B	2	O	G	Z	D	6	X	K	Ø	O	M	P	K	Y
X	V	2	O	H	T	D	Ø	Z	D	6	G	U	Q	Y	O	4	N	9	U
M	P	N	2	X	K	N	L	F	4	T	M	P	T	6	I	R	I	V	3
Z	Y	6	W	R	4	T	8	Q	D	3	S	H	H	J	B	Z	T	2	W
H	O	K	7	X	K	3	V	G	A	Y	2	4	B	7	I	J	U	B	1
4	N	8	C	H	5	Y	V	N	V	7	W	R	4	H	6	5	H	7	L
M	Q	U	8	Q	Y	8	R	J	P	B	S	Z	F	8	W	J	A	J	1
4	G	7	W	H	Q	B	2	5	V	6	L	U	Z	N	8	5	Y	6	O
F	Z	T	A	Q	V	W	S	J	4	R	Ø	Q	N	J	N	U	Q	K	1
4	V	3	L	H	5	T	9	Z	G	Ø	O	H	4	V	7	5	Y	Ø	I
M	B	M	2	X	H	7	J	U	X	Y	8	A	K	Ø	O	H	P	Y	Ø
U	D	9	I	M	X	B	Ø	R	T	8	H	G	I	U	9	4	B	3	E
F	A	H	9	Q	K	9	O	G	4	B	9	A	K	2	J	H	A	G	7
A	J	8	I	H	M	N	9	Q	D	3	N	J	Q	B	1	K	N	8	T
H	E	N	1	X	T	9	S	G	4	T	3	5	B	7	W	F	Z	D	Z
T	Y	2	O	G	X	N	Ø	P	N	D	S	M	Q	B	7	H	V	4	C
G	4	B	Q	A	K	8	E	M	O	K	6	Z	Y	P	R	M	C	V	2
X	B	8	U	H	F	T	7	4	Y	8	O	H	P	D	O	X	B	9	L
M	Q	F	6	X	U	2	O	R	Q	V	2	N	V	6	M	H	R	M	Ø
5	T	6	I	H	A	Y	2	Q	V	6	E	J	Z	B	9	A	Y	8	L
H	X	M	7	P	N	7	I	M	4	K	M	4	F	M	E	H	X	U	Ø
5	B	7	L	H	5	T	Ø	E	B	9	J	M	Q	Y	9	V	B	9	S
G	Q	V	3	S	V	Ø	I	M	4	N	6	A	V	2	S	G	5	B	3
4	T	R	C	J	Q	U	J	Z	D	6	O	G	4	D	A	A	B	K	I
H	4	K	1	Z	B	3	E	H	Z	B	6	L	K	1	L	J	4	T	7
Q	K	2	O	H	P	K	7	O	N	1	O	G	P	G	1	A	N	2	W
H	U	K	6	1	J	1	C	U	R	R	2	T	F	7	I	H	Q	T	5
A	B	1	D	H	A	V	Ø	5	N	7	K	H	5	D	Ø	4	D	2	E
H	Q	D	N	Q	N	3	L	U	Z	Y	6	4	B	3	S	H	Z	J	C
H	B	Ø	O	G	X	K	Ø	N	Y	7	S	H	Z	K	Z	4	H	8	S

Tape No. 7—Continued

G	Q	N	8	F	K	3	O	H	A	V	6	X	D	3	L	U	X	V	8
Q	V	T	O	U	Q	H	1	Q	K	2	I	M	E	T	8	A	K	Ø	L
H	W	T	G	4	N	6	I	U	5	Y	J	4	K	P	S	H	4	B	7
P	Y	H	G	R	X	T	O	A	N	S	E	U	X	J	Ø	M	Y	8	E
J	L	D	7	Q	D	B	L	R	4	K	B	Z	N	Ø	Y	H	X	D	3
Z	V	1	W	M	A	V	2	4	B	8	O	M	Z	T	2	4	N	1	S
H	P	F	8	V	B	I	W	H	Q	Y	E	5	N	Ø	L	U	X	D	1
5	B	1	W	F	Z	H	Ø	X	V	8	T	H	R	D	1	5	N	7	L
F	G	K	2	4	U	S	C	M	N	K	Ø	P	Y	9	C	U	A	N	2
5	T	2	W	J	Q	Y	9	4	K	B	F	U	E	Y	9	4	B	2	C
R	4	U	1	5	V	K	C	G	A	N	8	C	N	3	W	H	A	B	6
5	N	6	E	M	S	U	6	4	V	S	J	H	A	K	8	V	N	1	O
U	Z	F	Ø	T	F	1	F	J	Q	B	B	P	R	9	E	R	X	T	7
A	D	7	B	G	X	T	8	O	B	Ø	G	R	L	T	8	Q	K	9	K
H	5	Y	6	Z	Y	2	I	J	Y	V	9	R	N	6	U	H	I	H	7
P	D	X	C	H	D	B	7	X	N	1	C	M	Z	G	8	P	K	1	L
A	J	5	B	J	N	H	1	X	B	4	B	H	Q	B	C	E	B	8	I
J	A	G	D	H	B	D	G	U	5	B	I	4	J	T	H	F	P	Y	D
X	D	Q	R	U	X	T	3	H	M	W	R	M	U	U	9	B	J	Q	T
H	V	B	R	C	K	S	U	M	A	B	Ø	A	V	D	Y	G	U	H	Ø
X	M	G	W	G	D	R	1	L	G	J	G	F	A	B	K	G	J	E	T
H	4	J	R	X	D	Y	D	J	4	K	Z	5	U	P	C	F	Q	V	C
5	H	T	W	H	Q	H	9	P	B	X	U	H	W	K	A	Z	T	6	S
M	X	U	8	A	D	C	K	M	R	D	Ø	5	J	P	C	U	N	M	D
S	U	N	R	U	X	V	F	Q	F	L	W	U	X	J	V	A	D	Ø	K
G	X	T	7	Z	Y	U	H	J	U	K	9	D	B	7	N	G	4	V	T
I	G	Y	D	F	Z	J	M	Y	V	A	F	M	4	U	S	Q	J	4	T
R	L	T	S	P	R	V	U	J	J	J	4	A	G	9	D	U	Q	V	D
P	D	Q	C	R	C	B	V	9	B	M	N	M	M	K	M	V	V	4	V
G	J	N	L	A	D	3	N	F	F	G	S	H	J	B	Y	U	X	B	C
Z	F	U	K	H	E	B	X	O	Y	1	I	R	X	N	2	Q	H	Q	W
U	W	N	4	4	K	E	N	U	V	F	W	F	V	U	B	G	5	U	T
Z	V	H	N	F	R	T	C	W	Y	2	V	U	5	H	F	X	K	9	R
H	I	T	7	X	U	X	H	U	X	G	2	Y	M	J	W	H	4	D	8
V	V	Z	E	J	P	K	R	S	H	Q	E	H	5	H	5	P	T	J	C
F	Z	D	U	O	V	Z	H	J	M	B	1	5	V	B	T	J	Z	R	B
N	V	4	N	F	D	D	Ø	A	J	J	C	H	Q	B	G	G	K	9	V
F	4	G	7	U	M	3	W	M	X	D	S	4	B	Ø	H	J	P	U	2
J	B	B	F	H	W	N	Ø	G	H	E	V	J	X	H	S	O	B	4	G
U	W	G	W	T	J	N	C	H	S	H	Q	P	T	1	J	U	B	N	6
H	B	R	W	G	5	J	7	Q	N	M	S	M	X	H	M	X	U	5	C
H	V	F	7	S	T	N	G	F	P	B	Y	U	V	A	F	U	Q	G	4
D	N	5	H	M	A	H	B	D	H	U	T	H	B	J	V	U	F	L	P
M	H	K	Ø	4	D	T	K	H	H	T	W	X	V	6	E	H	X	D	S
T	G	E	F	M	X	R	V	A	V	S	R	R	W	F	S	M	M	U	Y
U	A	V	6	J	D	8	D	G	Q	J	D	B	K	J	T	F	V	F	Ø
D	D	9	C	U	Z	N	5	5	R	4	H	R	5	D	4	4	F	U	G
U	U	U	N	P	V	M	T	R	P	B	5	4	B	4	O	U	H	T	5
D	V	C	W	G	S	G	X	P	U	X	O	H	H	T	9	X	H	W	I

Tape No. 7—Continued

U P B S V R V U M O V P Z Y 4 H U 5 R C
P M 5 Y F U J 2 V H R G U 4 K A Y V Z C
H 5 H S X B 2 V F G U U G J I R M A B 5
4 N 6 E U D J B P H D I U Y N 5 4 V O C
H Q B N A J S B U Z D 3 Q V E N R R J Z
C T 2 K J Q N Ø X Y C E M U D B X G Q K
J X B V O H M D H Z J 2 D B C J U P V V
G J D W J Z U O 1 Q Y H K U 4 H 8 D R S
G H G C S T B C J A Y Y 4 J U F G T J 3
A H 2 I U 4 K J A M F H U B B Z Q T A V
U 5 B W 5 J X T U B U L Z H V C G Q H I
4 J C W M S G B W H D S U J R 6 V M D R
U M B O J Y 7 L U S Y T 5 D 6 N F A T N
V G 8 S M Z J Q P V 2 N U D N W G H Y H
R A J 5 O V 2 Y U 4 G U X D P L R S D F
U B D U U Q R O 5 V 1 R M Q U H A F C H
J W M X P K 9 K F Q Y Ø W B K B U Q V J
5 J M W U V V X P G C I F B D L 4 R 2 F
H D K Ø X V D I H H D G B B Q V M Q H U
U G Z W U S R L F M C O H X G 2 5 D 9 4
H A K X 4 F Ø F F J Y W C J T J J D J 5
I U D B H E M T T H 4 B J U D Ø W T 6 J
M S G E R R Y H H Q Y V 5 V Ø L F E D X
P B V H H X J V J N J W H J H Q Z R G G
H 4 K B P V 4 C U 4 H K N T 4 S F Y U 6
S D 7 U U H B 6 A Y N G M Q V S T B 2 L
U X M 9 M D C W J 5 U 4 S J 3 H R G Y R
A M F D G G H U R H D V F A A T V K 7 C
H 5 J M C R 2 K H B Y D F H H B M 5 F Ø
M V S J G X G 9 S D K F F H B J 5 U R C
J U D 8 D Y 3 C M J B G X D 4 D F Z G I
U J 6 W U O H L L J 6 W M A N T P M 9 F
J D B U U V 2 Y H H V D X D W T M Q H 6
A F Z E G N N 7 T H N R H C U 5 V H U T
U M V 3 W V W V R A Y V F V J D H X G M
A H K F U 4 B J I Y Ø 1 U P H 4 X U Q B
R 4 V 1 L M L F H Z J P M G V E J O N D

Tape No. 8—50 characters per minute

(Groups of five letters and numbers, 10 words per minute)

ALTHR	POMTR	DLSMT	WOESX	THBUW	ZOXIC	TUELX	QPSIX	ZTRMN	BPQIR	MSIWL
ALCIT	TUZRO	13597	ZAIQB	PRIWS	ZIVBC	OPQIV	MIROW	NONES	AIMES	GKPQZ
ICUTY	VISLX	NIOWZ	QPSOT	EIPQZ	IRVEX	PZXBN	MNPOQ	RVEMP	TYRIE	PXIZO
WQRVP	XIALE	ASCMY	87651	IRYQO	PZXGI	MPNOS	ZRATP	YAMSO	QPWXM	YRUAV
IRABU	BEZXB	MIOQR	VDXSG	GHRMP	PQXET	EMIEZ	PTWPZ	AXCRQ	GUMOU	EUIRY
13579	IHYGM	NBMVI	ISLXI	QPZXY	IYHGM	NURIZ	PQRVE	CIMPL	YMAXZ	TYEXP
AWQHG	HRMLV	TPOVM	RVQPO	6472Ø	IMXQP	WXONA	PXINE	WHYAR	TYEXP	AWQHG
HRMLV	TPOVM	RVQPO	6472Ø	IMXPQ	QWXON	NIXPE	YAWHR	YCOMN	CRACT	IYWOX
ZTQPZ	AXIFE	QPOWI	ERYTA	LSKDJ	FHGZM	MXNCQ	RASTP	UTONG	HORMO	PQRWS
TYZXL	LMHYU	UMNOG	QOXIX	ZAZIE	FORMD	Ø1932	WHIXZ	ARPHU	GUHIL	WZXGA
ILLXT	YEISL	XIXLW	PQOSL	IELMS	NXIOQ	EOWLX	TEQUM	WHGIW	SOXLA	YSOEL
HGUEI	NSIWL	ZHXOC	COIES	ANDIH	THROG	EMPUS	ZIPIS	RPSIX	SOGHU	ELNSI
WLZHX	OXCOE	ESAND	INTRO	GIMPU	ZAEPI	SRPSI	ZALTH	HRPOM	TROLS	MTWOE
SXTHS	UWZOX	ICXRS	LXQPS	IXZRT	MNBPQ	IRNSI	WLAAI	TUZRO	17362	ZAIPR
IWSZV	BCPPQ	IVMRO	WNONW	SAIME	QSPQX	UTYVI	SLXNI	OWZQP	SOTIE	PQZIR
HTXPZ	XBNMO	PQRVE	NPTYR	IETXZ	YAMPQ	WXMYR	UAVIR	ABUBE	ZXVMI	OQRVD
XSGHR	MOPQR	WSTYZ	XLMHY	UMNOG	QPZAF	ORMWH	PUGHI	LWZXG	AISLX	YEISZ
67325	YOSHG	ELUNS	IWZZH	XOCAN	DIHTR	OGIMB	USZEP	ISREZ	SOGEL	HUNSI
WLZHX	PMOTR	LDSMT	WOSEX	THRXZ	VBOCP	QVIRM	OWNSI	IRQSP	ZWSTX	YMTPQ
12Ø89	XLSNI	OXQYX	PMIYW	UAZOX	MPTPQ	ODHCT	NMWXU	QPOSA	YEISD	IYZPN
TWSYH	GZCOT	QWMNO	RWPQX	LUQXF	NUGWH	WIGSO	ZLAYS	APDWT	ZOTQB	47361
ITBQW	RWLUM	WGZAD	TWEXD	URGNL	ZHMOR	LDXWH	VQMRZ	BOART	PLWQR	STCCY
AROYX	PQIES	BIYQP	IEQZX	ISXLW	IUWEH	GRSRP	ZAMBA	PQOWK	LHMGO	PURMZ
QEPWZ	ARMQY	OARQW	BVNMR	AIWQP	APXCB	ZBAIP	EXYUW	Ø9873	RQPTD	OEKAS
ZXSTO	CEUIP	ZHNOV	URWPQ	ABWLU	PATBN	RSYPI	SOUQP	LUGML	NOUXZ	XRTMP
GAHYW	PIQZR	LRPWW	BBZZX	PRWIB	ULQGH	XRMOL	SRHNP	WBZZX	BCOIU	IAGVY
YHWQP	LMNPO	562Ø9	PZBAM	EROLK	KPYOU	METOL	ZCPOK	HNMWX	PLWTV	ZPXIY
SPIRT	WBTLZ	NKEID	NKIWL	HDURH	SUHYF	KORDS	CITHD	LAOTY	NAEWQ	PUDJR

GREOV JDEWQ NASIT JEIGZ FOPTS BOVRI MASPL JDYRU BDZAJ KTREU KDHRU

URYTE OJGRD XIYRA VOURS CJLOD ZKUWR QUTRX MURSA 7643Ø UITYR LIHQW

KFGDT SLPEX NKLRU VJIDR XTHFS NSEOG SIHIS EEWQP JUTRS 91538 DTRSA

MLPDY TWEIV TVVDE CYPLD BALSA WVVPY QGZAP WNAUR ELUMS RXUQV TYXZJ

YSAOI UVXTF IDWKL OFERL PASDQ LTDQP KNTRX JDTRE HAWQE GVIYW FMWPI

DCOIT SAWQL AWERT ZSTVP XFBIE CDERT ØØ917 VBLAS BTUII XWNMT NJILQ

MHGRX WSDGK FJCBF MLIOS NTHIY EREHT HDRBB CHIDX RAMPV NELDQ BURPA

GOOLX NUTCA 74531 LOUIE BGETY NSIGA VGKIS HZAPT GAPSE JUSEW APWER

HITZA XWQPL FRIXW FMCIH LNAEQ GROUD FPBRM FPYRU BKKRO CVCZQ 1539Ø

ULMSN VXNSE JDMTT CBSQG WERTY UTOPL KJHGF DSAZX CVBXN MWRMN EHCRN

BGNLB NVVGJ AHXFF LGFPV CUVJC WUKDC MEVNA ALCWN KKDUO 5739Ø ULMSN

VXNST JOMTT QTZSI LUMUU EDASD RXARW TXURS GSPSA YVEGA TRPVB JIFLL

WPXEE WITLT PERBT XVQAK AEYAS 619Ø8 TEWRA LWHQD MUOQN ETGYL XNNBN

JFBCA CMORS VIUDW SAYVL ETDTS DASKN LNAWW LSNDK NURLE JEBFJ NDJEN

OMDRH VHNLC ADWSJ HJXSN TGBCV 5Ø133 CNZXC LJQNB OAWGA CCATH NBMSW

QJAST GKUJW VURSR XTYWE WEBRV VNKCY HZADT WIXDS YBITA TANWH TCWKD

WASOW NNLSE RUVXA HNRZP DBJBM 11468 WOJXY TNOCP WGASA NVHET RXTDT

HWLEY TEBVF PVCLM AGXUY HLNEJ WWOJX TYCNJ WTNOC NTQVV RWGAS KTACU

NDWCV DWJOQ NOYWN ZLWDC 89753 XWFTN JEUID CIOSI JEUIZ SORWA OOEAK

VOUOL NEPZI LWQPV NMJIQ LTQZX OMOTA XYTMB AMATA AJRRW BNTRX VDPHW

SAVCL LZOJC PUCXZ TMNLQ OXSDM 1Ø937 QWXAS OJATI BYVFA PWDAN LINYM

BELLS YAWCL EAIST TVSPL VSDGR RSJYK YHATI VATMX TISYD ZQELF 1Ø828

OJJIE DOTJH SOUNA DIOQH SWMEW HARWD AYNOW DDPEJ QIDEO WCJOX VTEXN

QGNSV CLSRX SNLYL QRACV KFVAW LQMPV RRALN TJNDA DEXNL SIJXS TYWNB

XOVTW 74523 GDOWS NVJXT MPOAC QRMIN AAZIY ZARLQ CNSXD XMLMA IAWIN

NVKTY QNOFM RANWX HASSR NTNWC PATXD RUMBA DELXV CYKWS MIARQ CLXZP

MITFK MPRPS DELCO OTLOS 9971Ø RIQPB NMRTZ XISPQ XLEUT CIXOZ WUBHT

WSEOW TMSLD RMOPT RHTLA SENON TMRIM VIQPO CBVIZ SWIRP OQIAZ 76541

PRZUT IICLA LWISN OPPNM NBXZP XEWRI XQHIE TOSPQ ZWOIN XLSIV YTUCU

AQPOG SLMIA SONPM IGXZP OQYRI 15578 YMCSA ELAIX PVRPQ OXIXT EIDTT

PMEVE TEXQP PMHRG GSXDV RQOIM VXZEB URZRI FVURY MXWPQ OSAMY PTARZ

DTCZQ ISLXI IVMBN MGYHA TRIGH UOMUG UAVXZ ZPWTQ XEIME OPQVR MVOPT

NOTE.—On tapes Nos. 9 to 12, inclusive, some of the recordings terminate before the end of the material given herein. The material on the tape is continuous as given herein to the point where the tape ends.

Tape No. 9—60 characters per minute

(Tactical traffic, 12 words per minute)

WZ1 V WX3 NR1 P GR19 NINTH BT
NR1 CD MHNBT NJIUY MSHGT NNBGP QPIUY MNVXS WEIPT IPRTY
MNSXT TIWPQ MANTP MNTOC VCPQW PIQWX MNGPQ QPOWY 1Ø2P II II

WZ1 V WX3 NR2 GR21 NINTH BT
NR3 CD MPORT IOEQP MNOWL KNQPA STHGC DHGST IEMHS YMTOZ
MAXCV BCPQR ONTOZ MNTAS LDDAP SHIES OTILM BOMTE NATMA ZXMVY
1Ø5P II II

WZ1 V WX3 NR3 GR14 NINTH BT
NR5 CD MNTPE ALNDD KLKKL OPQWT SDHNG HKNSA SLTIO NEPAD
NORMD SNDPQ WIRSE 1Ø8P II II

WZ1 V WX3 NR4 Y P GR12 NINTH BT
INFANTRY TROOPS ENCAMPED ON OUR LEFT FLANK MACHINE GUNS NECESSARY
EXECUTE 11ØP II II

WZ1 V WX3 NR5 II WZ1 V XL7 GR21 NINTH BT
NR6 DFCT1 NHTY MEOE MAME KJHT HJNH HNMK ZXSE REQP
MNIP QWEC XZVG HUIN QWPY UNRY MNQP EXCV MNPY SHIE
115P II II

WZ1 V WX3 NR6 P GR24 NINTH BT
NR8 CD MNTOP SOPRT EIPAT PQIRE PTIAT XCPTY UIMNP QPRIY
MAOEC VCOPT QPRUM XCZBV PUWYT MEPTO QPEIT MANTI AUTIK DLKRB
MATNA EMTYU CVZXS 118P II II

WZ1 V WX3 NR7 NITE GR18 NINTH BT
NR1Ø CD SPRIT MENTI SHTIP NMJRU QWPOJ NBVER EIPQI METIP
NJTYU NHGZX ASWEP PONMO SSLKU OUTYE WPOWX 119P II II

WZ1 V WX3 NR8 Y P GR25 NINTH BT
NR12 CD OMERC WZAST MEOTO HGNBW QPOUN FHTYU KJMNT EINJT
MNZXE WTEQP QPZMA LAQPM MSKLD KNHGU NJGUT NGSER EIPTH HBNTO
NSOEP NAOEP QYURS TMATE 119P II II

WZI V WX3 NR9 Y P GR16 NINTH BT
NR15 CD MUTYE HGBNI WESDN HNXCE OJUIO MNHSW WRTYU NOQPU
MAPTD APRTM NQWUR MAPTE SDHEI 121P II II

WZ1 V WX3 NR1Ø GR2Ø NINTH BT
NR13 CD KNPQR MARST INEAU RYTUN AQWPO MNKIT TYHBG ZXSOP
NJPER NCXVB QWCVY EIMXT APKLD HGTYD TYDKR AIGHT NBVZX 12 5P II II

WZ1 V WX3 NR11 G Y O GR19 NINTH BT
NR15 CD MNOPQ QPLAN RYGHB QIJHX ZAQWE RTNGB EPQPE EIMBV
NQQRK KLTOX XOMTE MADVO DSSHS DDIRT NDITE QWURP 127P II II

WZ1 V WX3 NR12 P GR23 NINTH BT
NR16 CD MENTP EPEID NOWRS EIMVS OPWEP NCOSG SGOHT TMWTA
MAPRT ZXVYP SNDAL DIECT MXCVP PQMDT EIDMG QPODK AMDKP ASKPL
NDPQU URSPT 128P II II

WZ1 V WX3 NR13 II WZ1 V DO9 NITE GR14 NINTH BT
NR18 CD NRIOR DEOOU WPETA DSAPR SIVCP EIPET UEIMS NAPET
MANDO NAPRO NEOPQ 129P II II

WZ1 V WX3 NR14 G P GR7 NINTH BT
ENEMY CAVALRY ROUTED DRIVE SUCCESSFUL HERE 131P II II

WZ1 V WX3 NR15 P GR27 NINTH BT
NR19 CD MENTI AONER NAPRQ MTOPR GHTMH EOTPE PQIRT MEOTP
MNTZX WOTHD GHKLD AKDLS DNWOJ JKKLD DALSN EPMTU MSOLK GHTYR
MATIR MSOET XFHPQ SORMH DMSTK STAMX 134P II II

Tape No. 9—Continued

WZ1 WZ1 V WX3 WX3 NR16 NR16 F F GR21 GR21 NINTH NINTH BT BT
NR21 NR21 CD CD GIESS GIESS MSPRG MSPRG QPWEB QPWEB EIRMT EIRMT
OWDHT OWDHT WWMKJ WWMKJ SJLKT SJLKT APRJL APRJL NDEMT NDEMT
TMASS TMASS SLKER SLKER MTEMJ MTEMJ JKLQP JKLQP DMTRJ DMTRJ
KLSTS KLSTS ISLES ISLES NDJDK NDJDK SLTSE SLTSE 134P 134P VA VA
II II

WZ1 V WX3 NR17 NITE GR2Ø NINTH BT
NR22 CD EIGHT MSFKT SHBDK SGTIM SOEPE MAXNV OTOMD SOPEM
DMSTE SPETD KANEI SNDIT AJDKM DKTIO SMDKT SKDLS EIRYY 138P II II

WZ1 V WX3 NR18 T XD1 V WX3 G NITE GR31 NINTH BT
NR25 DFCT1 EIMG HOLD HARS DKMG DMSI EIHN SLNS SLPR
MSJD SPEI XNCX MSTO QPRM MAPE XMVN QWOP SLPN SPMN
NPEM DOWP WORU STON SNDP ASEN QPRY TSLT MADT PEEN
139P II II

WZ1 V WX3 NR19 GR2Ø NINTH BT
NR27 CD MSTOP NSORI NXPET SORMN VCIEI SMSOP NDOEN SPARN
MAPXG YUROG HJIPC VOTAL COMPT MSPTS SORIE SJHND DNOTC 142P II II

WZ1 V WX3 NR2Ø NITE GR18 NINTH BT
NR29 CD DOPSX SRIDH JRNXD LKSRW QPRYR UMONZ WOELX SIRNS
NDGEI ZDCIP DNIPD FESNP DNSIP EIGHN SITEM 145P II II

WZ1 WZ1 V WX3 WX3 NR21 NR21 F F GR19 GR19 NINTH NINTH BT BT
NR31 NR31 CD CD SPEUM SPEUM TIMSX TIMSX SIOXK SIOXK DKAPL DKAPL
SNDOP SNDOP QPRUR QPRUR THSMD THSMD MADND MADND MSNDL MSNDL
SNDIP SNDIP SMDKL SMDKL NDISL NDISL KYRUS KYRUS NSMHD NSMHD
SMDAL SMDAL DOPQU DOPQU 147P 147P VA VA II II

WZ1 V WX3 NR22 O GR12 NINTH BT
LOST HILL TWO SIX SUFFERING HEAVY LOSSES NEED SUPPLIES AND
AMMUNITION 151P II II

WZ1 V WX3 NR23 P GR23 NINTH BT
NR34 CD SNDIN SIPEI SMNDP XDCVC IDMSL MDTRC DPEIT MSTND
JGHTY DKJFU AKNCV AWERD MBNBJ HGFRT DTBCV EIHDK SLNDI XCZWE
DPEIT URYUN 153P II II

WZ1 V WX3 NR24 G NITE GR21 NINTH BT
NR25 CD SDDJK SNDKL EIMXL SBGHT NCMKW WOPKD NMLPA NVBEQ
MDNPE UOYJK LDGBV SMEMT YURST MXOMD QWADK LJUYR HDNBX TYUNB
155P II II

WZ1 V WX3 NR25 T XD5 V WX3 NITE GR29 NINTH BT
NR41 CD DKIEH MNHTI MNVKS EUTYH NBVFG RUIMK SIEHD SMDHX
MNDJH SMKDI TNDDS NDIEY MSJDH SJDIP UTYQV BDGKI 158P II II

WZ1 V WX3 NR26 Y P GR2Ø NINTH BT
NR43 CD MSJUT NSITY SMKSL DKITH SKSLK DNTIX SMDKT SKJNC
MSPEI QPEIR MSNBK SRTYU MSNEP EIMXL XCNDK DILET MSKSY 159P II II

WZ1 V WX3 NR27 GR15 NINTH BT
NR45 CD MSKLS KDIHT KDNSK DKUTH SKKID MIJTK SLITH XFKMC
MSITH SLPKP QURYT SKMDO 159P II II

WZ1 V WX3 NR28 P GR19 NINTH BT
NR49 DFCT1 EIMD SIMG NJDN DKPE MDJS NXOS IPQI MDMX
MDNS SMDP QPIE MSND MSKD MEKT IENT NJUT 2Ø2P II II

WZ1 WZ1 V WX3 WX3 NR29 NR29 F F NITE NITE GR22 GR22 NINTH NINTH BT BT
NR51 NR51 CD CD MSIRD MSIRD IPSJK IPSJK STHNB STHNB DISMD DISMD ISMDI ISMDI
TIMEL TIMEL SMXSP SMXSP MSOED MSOED MSNDX MSNDX VICEO VICEO SNXCP SNXCP
QURYT QURYT MXDKP MXDKP DMXPE DMXPE XHHZD XHHZD KLJEL KLJEL DISND DISND
ADJEP ADJEP DISXH DISXH 2Ø3P 2Ø3P VA VA II II

Tape No. 9—Continued

WZ1 V WX3 NR3Ø GR15 N I N T H   B T
NR53 CD U I K L O F W S D X Z A Q S W J F H G Y D H F G T C G F T R K F H G J
G G B C N E Y R T F W X A D S G T Y F H H V G S K 2Ø4P   I I   I I

Tape No. 10—60 characters per minute

(Tactical traffic, 12 words per minute)

F Q1 V XL7 NR1 G O GR18 E I G H T H   B T
NR11 CD O W Y R I U O N H V J K L S A N C E R T U B Z X S Q M N C B H L K D F N J O P Q
H A Y T G S P O I L N Y T G E Q U O E T G H K D A E R Y Q P H U I T S 112P   I I   I I

F Q1 V XL7 NR2 GR12 E I G H T H   B T
M O R A L E O F T H E M E N L O W E R E D C O N S I D E R A B L Y B Y E N E M Y A T T A C K S F R O M
A I R 114P   I I   I I

F Q1 V XL7 NR3 O GR25 E I G H T H   B T
NR21 CD Q A Z X C R F V B N U J M L P O K M N B Y G V C Z E S Z A Q W S X D R T G B H U
I J N H Y T F C D E W A Q W A R F T Y G U J K I O P L K J H Y G F D S Q A S D F Q W S D C R T G H B
M N H G R B V F D W A S C V T J U N H V 118P   I I   I I

F Q1 V XL7 NR4 P GR9 E I G H T H   B T
E N E M Y T A N K S T H I S S E C T I O N H A Z A R D O R O U S F O O T S O L D I E R S H E L P L E S S
A G A I N S T
119P   I I   I I

F Q1 V XL7 NR5 T FU1 V XL7 Y GR19 E I G H T H   B T
NR31 CD Q O W O W U N I K L U I R Y T S I E L V N V M Z K S I T U E S I Q P Y D J I T Y
M S I T L S L I T R S I T H D N B Y E I S L A P Q N G Y T J S L E Y T S K I T Y 121P   I I   I I

F Q1 V XL7 NR6 G GR22 E I G H T H   B T
NR41 CD D F H J U E I S L R K I O U Y B C H J K M K T R E X S D V G B N F G H N M J U I
M B V D E Z X C V B H G F D S U I Y B V N T R E D M K J Y C V F D S I O P I U N M J B V C H Y D R C
V H J U T 125P   I I   I I

FQ1 V XL7 NR7 GR17 EIGHTH BT
NR51 CD INCJS IEOHG MOESZ OJGVC BFWAM OIUXS BRJKI MHTRD ZSTYN
MKLOI NJRFB BHYTG KIEXC NJWAS 127P II II

FQ1 V XL7 NR8 GR19 EIGHTH BT
NR61 CD NIEYT MCJAL CBNGS PZIET CIESL WHTRA VHAKL INTOT
KUYRS SDALE LITCK SCGBA NJHRT MJARY REWAA NINTP 129P II II

FQ1 V XL7 NR9 O GR16 EIGHTH BT
NR71 CD QPALZ MALQP IEURY RIOER NAITO EOTIE KELSB NUTHE
TOUTY HJDZN JSOTU SLIET NKELT 132P II II

FQ1 V XL7 NR1Ø GR25 EIGHTH BT
NR81 CD WORIO SKELT LROTU SOELT SLETU SLEIT ALSIE SLEIT
TIEKL EOTHR EILZX NNELE ELTIT DKFJG DLLSY KKEIT GHTUE DKWMZ
EEOUU JJAKE LELTI UTYRW 134P II II

FQ1 FQ1 V V XL7 XL7 NR11 NR11 F F NITE NITE GR19 GR19 EIGHTH EIGHTH BT
BT
NR91 NR91 CD CD OLIKU OLIKU JHYTG JHYTG FREDS FREDS WAQWA WAQWA
AZSXD AZXSD
CFVGB CFVGB HNJMK HNJMK LPOLP LPOLP QWEAS QWEAS RTYFD RTYFD
UIOHG UIOHG
OPLKJ OPLKJ ZXCFG ZXCFG VBNHJ VBNHJ MKLOP MKLOP YGUJH YGUJH 135P
135P
$\overline{VA}$ $\overline{VA}$

FQ1 V XL7 NR12 O GR17 EIGHTH BT
NR12 CD QWOET EILTO EOTJS IJNBH UHBVG TFCDR EDCFR OLIKJ
OPQWZ ITUEI KSMTU EOTUR KDLEN IIKEO 137P II II

FQ1 V XL7 NR19 G GR21 EIGHTH BT
NR72 OD UIEOE PPIOT OSITY RONCL ZSLAO OLEHI ROQIR APZOD
SOTYF LKIYT SOTLD ELUTY SITYQ LSITY OTOWI SLPRY TUQPE GHSKL
155P II II

Tape No. 10—Continued

FQ1 V XL7 NR2Ø T PQ9 V XL7 P GR16 EIGHTH BT
NR82 CD RURIR SLEIT TUIPQ ISUTY EOUTN FHALD SLEIY EILSI
NTURP ELUTL IEOTQ SKELY 2Ø2P II II

FQ1 V XL7 NR21 GR16 EIGHTH BT
NR92 CD ITYHE UTHAL ENOTP ISQPR ALZNC SLIQQ UTYRA EITYQ
UTHLC MALRY SIELT ALTYQ ALITY 2Ø4P II II

FQ1 V XL7 NR22 Y GR21 EIGHTH BT
NR13 CD TOQPW SLTUR SIELT LEIAL NELZL ENGLS ZELAI TNALE
NALDI ELTUA NKEFD SLENF NSKEL NEUTY SMALL UTALE EJALI HURYT
2Ø6P II II

FQ1 V XL7 NR23 G P GR19 EIGHTH BT
NR23 CD NVLSK ALIRT NSLZL MAIEL MENTL SITYE ZLCXN SLEIP
UQOSP TYSLX CMXLZ SLEIT NSITY MAOPR EOTYH MEIGH 2Ø8P II II

FQ1 V XL7 NR24 Y NITE GR14 EIGHTH BT
NR33 CD AEIOU EOITH LEITH MAITY HLEIT MELTI SLEIQ
YSLPQ MEPRD FGHAL EMTHA 21ØP II II

FQ1 V XL7 NR25 Y O GR5 EIGHTH BT
FO2 NR7 FIFTEENTH 1145P 21ØP II II

FQ1 FQ1 V XL7 XL7 NR26 NR26 F F GR26 GR26 EIGHTH EIGHTH BT BT
NR43 NR43 DFCT1 DFCT1 QPWO QPWO EIRU EIRU TYGH TYGH FJDK FJDK SLAP
SLAP
ZIMX ZIMX JFUR JFUR LAUT LAUT ZWXE ZWXE CRVT CRVT BYNU BYNU MIKO MIKO
LPJI LPJI BNTR BNTR DEWQ DEWQ XDSA XDSA ZGRY ZGRY KUOY KUOY QPNC QPNC
ZXCV ZXCV JKLO JKLO UIOP UIOP QAZS QAZS 214P 214P VA VA II II

FQ1 V XL7 NR27 P GR17 EIGHTH BT
NR53 CD MCJKD LEITS MELTY SIELT SLEIT EIOPT TOSIE NEUTL
MAUTY ENKTU SLEIT LSIEH NEITB NNUTH 21 5P II II

FQ1 V XL7 NR28 O GR19 EIGHTH BT
NR63 CD EIORY EOMEI SKALU LEIAY DKEIA NCKEL ETCHE EELIS
QPPAO EOTUN EILTI TIELT SLEIU EITLS MAUGJ ELITY 217P II II

FQ1 V XL7 NR29 Y NITE GR22 EIGHTH BT
NR73 CD QPOEI ITUEJ SLEIT LIUTY EITAY ZLHNV LEITE HHALE
LEIAL TMEKT THIEL TMEIT FIEKT MMEIT AAZXC SOOKX MEITH NELTY
ALLOK 218P II II

FQ1 V XL7 NR3Ø II FQ1 V K9P G GR16 EIGHTH BT
NR83 CD ABFUX NAMMA ELTIE POIUR SLEIT NNELT LSITY MEKTL
UXNDK DKELU TIELA MEKTL QPSOI 219P II II

Tape No. 11—60 characters per minute

(Tactical traffic, 12 words per minute)

FU1 V FZ2 NR1 P GR16 TENTH BT
NR1Ø CD JHNYT BNHGT BGFRE BGFDE CVFTY VGYUI NHTRE KLFRE
WUYRE BGUWE BZXCQ INHYT NGBDR 112P II

FU1 V FZ2 NR2 GR18 TENTH BT
NR11 CD NHGTR VGFCX CDEWQ ZXCEW DSUTN HGTRW NMHGI NVCZY
PGZIW NBFXA CXEYH MNBGR FVDEW BXCDT BGFRE 113P II

FU1 V FZ2 NR3 T WZ1 V FZ2 GR18 TENTH BT
NR12 CD MNBVZ CDYUI BGFEW CVDFG HGTRE DCBGT MKJLU OTYBG
MJNFB GVDSZ XDWAS RDFTY BHFGR BMNDT BVDWQ 114P II

FU1 V FZ2 NR4 G Y O GR22 TENTH BT
NR13 CD XZSDE FGVCR HGBVT GHYUI MNKJY HGBJI LKMHN KMDFW
OUIJN BHGTR FDEWS ZXSDR VGFBH NJKMG JNBFV CGRFE VGHYT UIOPL
MVGED 115P II

Tape No. 11—Continued

FU1 V FZ2 NR5 P GR17 TENTH BT
NR14 CD OJKYH BGFTR VDFRE BVFGR HGCXZ MHJKY MNEIP VDXZW
PIOUT YIURT VSWWQ ASDFR SDFGT KJHGR 116P II

FU1 V FZ2 NR6 Y NITE GR15 TENTH BT
NR15 CD MNBHG BVFDS XCFGT HBFVC VFDES XCDFT VGFRY BGHFR
MNHGB BVFDC CDSAX IUHGT 118P II

FU1 V FZ2 NR7 G P GR17 TENTH BT
NR16 CD MNHHG HYTGF GFRTE FDREW KMNGH BVFDC VCFDE MHNTI
DLCMF ANSHD BVGFR VDUJT BHGRE OISHE 119P II

FU1 V FZ2 NR8 G NITE GR19 TENTH BT
NR17 CD MNBVG JHGFT HGFDR MKLJI KJHUY JHGYT HJGNB BVGFR
MNJHK JHGUT NBHGY HGYTR BGHFT MNBJR FSCXD ZXCES 111P II

FU1 V FZ2 NR9 T XU1 V FZ2 Y GR18 TENTH BT
NR18 DFCT1 NJNH NJYT BVGF BVGF VCRE ZXPO NJHU GYTR
MKLI KJIU JHUY HRTF GFRE BCFE DWSA 12ØP II

FU1 V FZ2 NR1Ø GR17 TENTH BT
NR19 CD NMJKI HJTYU FGERT CVXZD CFDRE FGYTR MNKLJ BFYSZ
PIOUJ JKLYU JGYTR VDGHR VCXZS NMJLU 121P II

FU1 V FZ2 NR11 Y P GR19 TENTH BT
NR2Ø CD IUHJK JGYTR ZXCSD SADEW SREDF FDTGR SQWEA ZCXDR
IJKHY NBGHR BGFVR CFDEW SDTRF BVGFT HGUYJ LKIOU 122P II

FU1 V FZ2 NR120 GR24 TENTH BT
NR21 CD IUJHY NBHGT FXZEC FDEWA BVGFT KFNBH CVDRZ SDWAZ
NBHGF VFCDX CFDTR GYTHB NMJKO KLJUY HJNBG GTRFD FREDW FDRWS
NBVGU BFDCI VCXSA 123P II

FU1 V FZ2 NR13 Y GR15 TENTH BT
NR22 CD IJKGT XSDEW ZXSRE VGFDZ CVBNJ MNHUY KLYHU BFGRS
LJMNT GVFRW CSFDR VCGRU 124P II

FU1 V FZ2 NR14 NITE GR18 TENTH BT
NR23 CD MNJGY HVFTR VGDFE BVHGU IOJUY HGYRT GVFDC CDSXA
MKLGY BNJHU JHYTG HGFRE DFRTE NBHGR XZCSW II

FU1 V FZ2 NR15 T WZ1 V FZ2 G Y NITE GR17 TENTH BT
NR24 CD XZESD FDREF GFTRY BGHYT GFRED CFDXA ZXDVC BGHJU
MVBFR FGDCF VCFDE SXDZX VBCVF HFGDR 126P II

FU1 FU1 V FZ2 FZ2 NR16 NR16 F F P P GR23 GR23 TENTH TENTH BT BT
NR25 NR25 CD CD MNKJU MNKJU KJHYT KJHYT GHTRF GHTRF VBGFT VBGFT
FDRED FDRED CXDSZ CXDSZ ZXASZ ZXASZ BVPXT BVPXT MNJKT MNJKT GHVBR
GHVBR FVCDT FVCDT VGBFC VGBFC CVDWS CVDWS VCFDT VCFDT GYUIO GYUIO
PKLIJ PKLIJ KJUYT KJUYT BHGRX BHGRX BVGFR BVGFR FVCEQ FVCEQ 127P
127P VA VA II II

FU1 V FZ2 NR17 G P GR17 TENTH BT
NR26 CD NHJGY BCVXZ XSDRE GFVTR GFVCD FUYTG BHGIU JNVDC
NVBFD CVFDE CXZSD CFVRE VGHBN NJHMB 129P II

FU1 V FZ2 NR18 GR2Ø TENTH BT
ENEMY ADVANCING ON ALL SIDES PLEASE LET US KNOW BY PIGEON
WHETHER YOU CAN SUPPORT US AT THIS TIME 13ØP II

FU1 V FZ2 NR19 Y O GR17 TENTH BT
NR28 CD NHJYG HGBFT GFRDE BGHVF DCFIO MKJUY HJUYT BGFEW
MKLDC VCFRE FDCYU BGHTW CXDSE JKRTQ 131P II

FU1 V FZ2 NR2Ø P GR16 TENTH BT
NR29 CD MNHDR VCDWA SREFT BCXZE QWEDS FGDRE BVGFT MNKYI
POIUH JKLOI NBVGF VCFDS BVCXZ 132P II

Tape No. 11—Continued

FU1 V FZ2 NR21 NITE GR18 TENTH BT
NR3Ø CD PILKO KJIUY JHUYT NBHJU JHGYT HGBVF VBGFT VCFXZ
BVGFR FDCSE SCDFT GFVBH YTRFG NBJHU XDSZA 133P II

FU1 V FZ2 NR22 P GR16 TENTH BT
NR31 CD NBVGF GFVFR GHYRF BVGHY NBJHU HGYTH BVFDS CXDSE
MNJHY HGBVF GVFDR CVFDE DSXCA 134P II

FU1 FU1 V FZ2 FZ2 NR23 NR23 F F O O GR17 GR17 TENTH TENTH BT BT
NR32 NR32 CD CD BVCFR BVCFR FVCDE FVCDE CFDTG CFDTG BHGYT BHGYT
NJHUI NJHUI MNJUY MNJUY HGTYB HGTYB CXZSW CXZSW KEYVX KEYVX
BVGFT BVGFT FHGUK FHGUK LHKGE LHKGE VSYTN VSYTN NBGHR NBGHR
135P 135P VA VA II II

FU1 V FZ2 NR24 T LC1 V FZ2 P GR18 TENTH BT
NR33 CD BVCXZ ASDFG HYTGR FDTRE BVGFW XZSAW DSFRD FDGTR
MJBFC AXFVH NGYRF VCFDR SDEWA BVGSX BSAZX 136P II

FU1 FU1 V FZ2 FZ2 NR25 NR25 F F GR19 GR19 TENTH TENTH BT BT
NR34 NR34 DFCT1 DFCT1 JHUT JHUT BVGR BVGR CFDE CFDE CVFG CVFG
BHGY BHGY MNUY MNUY SXHG SXHG GFVT GFVT TRFG TRFG HYTG HYTG
NJHU NJHU YGTF YGTF VBDF VBDF CXZS CXZS SXCZ SXCZ GWSA GWSA
138P 138P VA VA II II

FU1 V FZ2 HR26 T LC2 V FQ1 Y GR22 TENTH BT
NR35 CD TFGTE VCDFE DSXAZ CXDFG GFHJK HJKLO IUJKL BSKFJ
MNBHJ HGYRT GFVBH GVCDE XCSEQ BVGFR GFDET GYGUT UIOPJ MNHJK
CFDET 139P II

FU1 V FZ2 NR27 P GR16 TENTH BT
NR36 CD XZCVG VCFDR YTGHU NHJUY HBGER DFTVD CVEGY HJUOI
LKMJU NHUTG NHGFR BVFED VFCXZ 14ØP II

FU1 V FZ2 NR28 Y GR17 TENTH BT
NR37 CD NBHGF VCFDE CDFEW BVGHY JNBHG BHGYT GFTRE BVGFR
NJHGY BVGFR CVFDE DXCSA ZXSEW LMNJY 141P II

FU1 V FZ2 MR29 GR18 TENTH BT
NR38 CD MNJUT ZXCVB OIJKU BHGTR FDEWQ ASZXD PQALG BVFDE
JHYTF VCFED CGVHB NBHFR DSXAW BVGFR FDCXS 142P II

FU1 V FZ2 NR3Ø P GR17 TENTH BT
NR39 CD FGRDF FDESW FDTYR BHGFT JHUIO KJIUY PLKIU KJYHT
JHGTR ZXCDS CXDFR GFTRE BVHGT NBHJY 143P II

Tape No. 12—75 characters per minute

(Tactical traffic, 15 words per minute)

KX7 V KZ3 NR1 P GR1Ø FOURTH BT
NR5 CD TYRSD GHOIY MKLRO BHTRY OPYCG NMURG LIJHK 11ØØA II II

KX7 V KZ3 NR2 P GR15 FOURTH BT
NR8 CD MKIOP MKLSH IPYTS BSHDT ISPHS MOPGD KLPYQ MNVXS
UISDG MJOIY SETYD FOOEY 1ØØA II II

KX7 V KZ3 NR3 GR2Ø FOURTH BT
NR19 CD MOIJH PUYTQ MJKHD PETYD LFLFL OMOIN TYQWI PKLJH
UDFTS MNBCX YQUQY MKNLI PUYES MJHGF ASDFG LFJKD OIURS 1144P IIBII

KX7 V KZ3 NR4 NITE GR9 FOURTH BT
NR13 CD TYREW NGFTW PUYTV VBHSF OUAAL MPOWS 8ØØA II II

KX7 V KZ3 NR5 P GR19 FOURTH BT
NR15 CD LFHJI EABCD MNHST GRTOP GOOTY MKLFG BNGER PITYQ
HSDRT BVGFL QYUIT LPRST KJLHG EPTRS ADGKP MOIYT 745P II II

Tape No. 12—Continued

KX7 V KZ3 NR6 GR21 FOURTH BT
NR19 CD LOIUY JHTRS KHBGD MLFGH PIOYT DWTRP MDGFS QYTUE
TYREW GHSDE SSHST MABVC PUTYE MKLFH OYTHR CGFTS ABCDF THOPR
95Ø II II

KX7 V KZ3 NR7 O GR26 FOURTH BT
NR22 CD TRSRE MNBVC CYOIT PLKUT EDFRS MJHGT WDMNX ZMOIP
BHGFI OMPQW MBVCZ JYTHW PUYTS DETRS LKJHG DGFSA ABVCM ABWSU
RWQOP GHDES BNCXZ GHROY LHGJD 855P II II

KX7 V KZ3 NR8 GR21 FOURTH BT
NR25 CD TYPIU DEPHL MHGTW EDFRT PUMNB VDBFG QRWTE MHGFT
BVCFG MKLTY ERTYU QWERT GHTYP MHYTR EFLGH QYRTS MERTS GHRTA
855A II II

KX7 V KZ3 NR9 Y GR27 FOURTH BT
NR27 CD KODZS OPYHG MNBVC TYREW SDFHK PUYWQ MGTWS PIUYT
VHGFD KDLJG PUYEW BVCHD PYGWS SEGHF ITERS HSPYT MGHFT BHGTP
GHRYS PIUHR SHETR MFGHL LFITE GHBNC 111P II II

KX7 V KZ3 NR1Ø P GR22 FOURTH BT
NR19 CD TYPRE MHSDG FLKJH REWQY YQRTS PIOYT MENKL ERTYU
AFGRQ MGHTY SHIPE MNHKE THYRE GHTYW WDFHG KJHFG MEPIE MNSLG
MNHGT 625A II II

KX7 V KZ3 NR11 G P GR27 FOURTH BT
NR19 CD TYPRE MHSDF FLKJH RRWQY YQTRS PIOYT MENKL ERTYU
AFGRQ MGHTY SHIPE MNHKI THYRE GHTYW WDFHG TYERS LKJHO EIGHY
GHRYS PIUHR SHETR MFGHL LFITE GHBNC 111P II II

KX7 V KZ3 NR12 P GR23 FOURTH BT
NR46 CD FGHJY QWRTY QUIOE GHTYR HNGTQ QYPIT MEFGT PTYRS
MAHSG MNVGF PTYWQ AMSNL MERTY RTYWE MGHTP BHGJS DCVBF BVDRH
OITYR TYQWE 11ØØP II II

KX7 V KZ3 NR13 O GR18 FOURTH BT
NR4 CD FGHJK BETRS METRS GHBNT PTYUE MASDF GHSDF METGH
QWERT TYUIO DFGER MASTY METYU GHRWA ADSFD 835A II II

KX7 V KZ3 NR14 Y GR7 FOURTH BT
NR7 ATTACK AT DAWN REINFORCEMENTS FOLLOW 1Ø5ØA II II

KX7 V KZ3 NR15 Y GR17 FOURTH BT
NR12 CD GHRES METYU UDJKP GHRET MQOPE NEKLS ADFKL MENIP
NRGHU IERPO MELSE MENZX ZYRTX NTHRY 1Ø1ØP II II

KX7 V KZ3 NR16 P GR24 FOURTH BT
NR34 CD RETYS ZCXVB SLPIT FGTKL TNPOZ ZFGTY MLSKJ GHREW
ALPEX MLDKJ DEOIF MSLPE MANLT MENPE DEZCY MLSQI MLPYJ QTRYU
ANKEP IOKJE MEPYI 9ØØA II II

KX7 V KZ3 NR17 GR2Ø FOURTH BT
NR15 DFCT1 THIE SPIL NEKL THIP MLKJ MKLS QRTS MLSH
NOIU QERT MLHK MGHT MLHJ RSTY GHTU WERS MPOR 455P II II

KX7 V KZ3 NR18 GR21 FOURTH BT
NR14 CD TPOIG CVBNM ANMLE THIUY QYFGL ALFGJ MKLST MLSHR
NOIKP MNDKS ADHKL NMLKJ MNYAN THOIS SHIEP MLKHP ERTYG MLAPW
1Ø12P II II

KX7 V KZ3 NR19 GR8 FOURTH BT
NR8 MACHINE GUN NEST CAPTURED NO LOSSES 125P II II

KX7 V KZ3 NR2Ø GR24 FOURTH BT
NR11 CD KLIOQ NKLQW MANYD GHTYU ARETZ XCVBN MNALE QRTYU
NKLAE TPOIW NKLST MEITY QPOIS NOIUR SDFGH HSIET MLPAR IOSHE
RTYUI QWRTS NKLSE 95ØA II II

KX7 V KZ3 NR21 GR21 FOURTH BT
NR5 CD THOPS IOZYU MJKHT SLSER MFLFK TYQWD DOIPA MLKPW
NATGH HYRES TRYUP QWYPO OMKOU NAFGH ALPRY CMLAR POITY CVBNV
1Ø1ØA II II

Tape No. 12—Continued

KX7 V KZ3 NR22 O GR24 FOURTH BT
NR67 CD QWUIT FOOME SPOET GHDVB ASDHG POIEN LKASD THGSR
QWTYU UDFGH AILNK QRYVH VVDUI GHWEY YQTSD MPONT MLSKJ
QTYUP VCDVD GHTVB SHOPE 1245A II II

KX7 V KZ3 NR23 P GR7 FOURTH BT
NR1Ø OBJECTIVE REACHED AWAIT FURTHER ORDERS 25ØA II II

KX7 V KZ3 NR24 G GR17 FOURTH BT
NR25 CD THIOP ERGTS NOIRT NGHTW WDFGH QPOTU QYTFL NHBGJ
THYER FHTOP OMOJM SOTHW WWGHT BVVFE 145P II II

KX7 V KZ3 NR25 GR21 FOURTH BT
NR25 DFCT1 MOMO THYR WEDT MNBV VDFT WDRT GHRY VBMN
QWRT TOMT JOMJ RTHY AMLE GHRE WSHI ALOP PHOM SLOT
255P II II

KX7 V KZ3 NR26 G GR25 FOURTH BT
NR23 CD GOIUY SDFGH APOET GNMVB BBBTB RTRRW CYCTI APOID
ABHVF PIOUY WTRFG HSIEG METRY YQWYR REDGF FLDGH POOPO GHURD
ANHVT TETYT TTOIT GHCDC 1ØØP II II

KX7 V KZ3 NR27 O GR21 FOURTH BT
NR13 CD VBNMS RTYUI FHVBE ALPER VBETR ISOIT MLALF ENTRE
NOETD DDDKD NLSLF GOETD NODKD NOPER MLARE EPTIZ ZZNKZ WRTYS
91ØA II II

KX7 V KZ3 NR28 P GR8 FOURTH BT
NR5Ø ADVANCED TEN KILOMETERS SEND SUPPLIES REINFORCEMENTS
2ØØP II II

KX7 V KZ3 NR29 GR19 FOURTH BT
NR45 CD GHIUR QWRDF FLASK GHINT SLPEO ALSKT MENTH RETYA
NALRT TREWY SNKLD GHTYI WNLET GHBNV FVTYV WETVB 755A II II

KX7 V KZ3 NR3Ø GR22 FOURTH BT
NR22 CD GHTYU WRETF FLFLE EGHRF FTYHG QWRTU AMLST MKOTE
NLORT WEFGH SETRS NLETD DODOD NKLWE FGHLT MERET NKLPS THYRS
NSDSI 7ØØA II II

KX7 V KZ3 NR31 GR2Ø FOURTH BT
NR24 CD TOTPO METUJ JEPET BNHGT WESWT MDGTY MELPR SDFGH
NPEOR TRESO EIMLP NLKET SLSLS METRY SLPOE MSLTE NOIET 11ØØP II II

KX7 V KZ3 NR32 O GR8 FOURTH BT
NR78 BARBED WIRE ENTANGLEMENTS HOLDING OUR ADVANCE 836A II II

KX7 V KZ3 NR33 G O GR21 FOURTH BT
NR77 CD BHGRE MPOEN SLKEK GHWER RETTR NLPOO MOTOE NKLSE
NKLSE EITZS ZYEQT MLSPE MALSG NKSTZ XXDIX NLTEX AZAGZ NPETO
756P II II

KX7 V KZ3 NR34 G P GR17 FOURTH BT
NR42 DFCT1 INGR TRKA DHUT NCNX AGHI YEWS OPYT
REDX EWPU NHKL RESA FTOP NRPU YHVZ 849P II II

KX7 V KZ3 NR35 NITE GR22 FOURTH BT
NR53 CD YRQNP JITWC THEMA NGKLA NOPIT JKLAS ASFUX MKHFS
EQPMZ ZITBV OAFSL LHSGH NOVAM RIYHA JLDAN MRQYW TQPMZ FHSLA
RQINX 853P II II

Tape No. 13—75 characters per minute

(Tactical traffic, 15 words per minute)

FL2 V FQ3 NR1 GR16 FIRST BT
NR6 CD XEIRT PITUR NFWOV QITGB CIPXS ORHAM QINHF PNVAD
PRWYL KFJOS YROMS TOMKE TPVNH 831A II II

Tape No. 13—Continued

FL2 FQ3 NR2 GR14 FIRST BT
PROCEED ON ROAD ROUTE R4 AT A SPEED OF TWENTY MILES PER HOUR 120A
II II

FL2 V FQ3 NR3 GR21 FIRST BT
NR28 CD MLUVF VFGUT HGDAL VTNUM VFEXP OLESO NJTRC NYIOE
SDCVT BHGRZ TEUBR AIRFC HUTGB RIPVA QYETC TPMHA FBXRH NJSKL
844A II II

FL2 V FQ3 NR4 GR17 FIRST BT
NR37 CD HETDA NITCM HGNKA RQOPA NHRE J MFDCZ TNKSL HLOPT
GADWN RPQNB VCDGJ URYWA EBSOH QOPRD 848A II II

FL2 V FQ3 NR5 P GR18 FIRST BT
NR42 DFCT1 INGR TRKA DHUT MCCX AGHI YEWS OPYT BGJI
REDX EWPU NHKL RESA FTOP NRPU YHVZ 849A II II

FL2 V FQ3 NR6 G GR22 FIRST BT
NR53 CD YRPQN JITWC THEMA NGLKA NOPIT KJLAS ASFUX MKHFS
EQPMZ ZITBV OAFSL LHSGH NOVAM RIYHA JLDAN MRQYW TQPMZ FHSLA
RQINX 903A II II

FL2 V FQ3 NR7 O GR16 FIRST BT
NR29 CD JREPQ TRNKS LEKAD TADCK QOOTD TNALD RNIAP RDKAL
TOAKS EOCBN ZIRPQ NHGSD NAOTA 907A II II

FL2 V FQ3 NR8 GR23 FIRST BT
NR18 DFCT1 PQRX DTLL FOPU HIJK AXDD HBNM GEIT IENN
NBVJ WERZ MERL IBTX LIXJ KIOP POPP TELE PONK MLPE
VTNU MITF 910A II II

FL2 V FQ3 NR9 NITE GR19 FIRST BT
NR43 CD HREPQ QWENF HAKLE TCXMA ZMXNC XNCBF TROPQ FKLAG
QMPZY NORDC HRIRT GEIMP WNOXG UMRXA YTHFS JKLAS 917A II II

FL2 V FQ3 NR10 GR12 FIRST BT
MUSTARD GAS DEPOSITS IN THIS AREA THICK ADVISE
DISPOSITION OF SUPPLIES 255P II II

FL2 V FQ3 NR11 P GR25 FIRST BT
NR74 CD QNZSE PLMKO QUAZP TROPE NOITA NKLED HMBAX ROPAN
NAUTD KLAHN IEATP SUSPA NUMTD KJASL SLTYP NPETZ HAJHS ZXASW
POKLM ANSIE NAKEL TMEIS 925A II II

FL2 V FQ3 NR12 GR17 FIRST BT
NR29 DFCT7 QPZM OWNX FOEO TAIS TIAL KFEL AIRE FHJK
FHLA SJDK ROAO ISSM THAK KAND 929A II II

FL2 V FQ3 NR13 P GR18 FIRST BT
NR37 CD PQIOT NORKS TOAIG NAITE MAIRT SKLEG ALTJD DJAHF
MAOPE NUTYQ MEFPT ANOYH MLKAS NTAGS NRAPK 932P II II

FL2 V FQ3 NR14 O GR20 FIRST BT
NR28 CD TRAIO MEPER SLEAL MATIY PQMZH AILTA MOTNH PAHSL
MJAKL LEAIT MATYD NJTIQ JKEQR YPQMZ XNVAC ORYUW NAKTU 936A II II

FL2 V FQ3 NR15 GR15 FIRST BT
NR49 CD WQPRT YAPER MITBZ SHALF ALEIT PQALS MAITY RAIGH
MATHA JANGD FCVZS MJNKL 937A II II

FL2 V FQ3 NR16 Y GR24 FIRST BT
NR12 DFCT1 TRAY NJKL RITH TWDC AIRO SIEL AIEP MAIT
AGSF ALDK QPWO RQIP THRT MZNX BAJD HARI QMPZ KALG
QMZP WONV CPAT 942A II II

FL2 V FQ3 NR17 P GR17 FIRST BT
NR13 CD TOPER NAITJ AMTOP KLAGJ ELAIT APTQC MAPTB NAKLR
ATITY AMTAP NAPTE EOPTW QPNMC TRWYP 946A II II

Tape No. 13—Continued

FL2 V FQ3 NR18 GR19 FIRST BT
NR14 CD UIPTH JAPRY MAPEN TWPZM JKLAD FALKE MPQUT RPWNV
HAKLS LEPTE PQLTY YQPYQ HAPGL RPQUT ALTIR MNCXZ 948A II II

FL2 V FQ3 NR19 G GR18 FIRST BT
NR15 CD PQIOT AITPR JALKE EMTIP TOAPE AIOPR TOPQV TPAIK
TAPRU AORPQ AMPTU MNVZX APCVN AIMNZ APTXM 951A II II

FL2 V FQ3 NR20 P GR15 FIRST BT
NR16 DFCT1 TPQE APET HYTB YHAP IRPM PBVZ XNJG KLHF
APRI OQMZ HAKT LAPT 955A II II

FL2 V FQ3 NR21 O GR17 FIRST BT
NR17 CD ASDFV LKJHB QPWOE LKJHY TREWS UIOPH WERTG OUUYG
MNBVF ZXCVG IFNBG RFVGH UHBVF BHUIO 1004A II II

FL2 V FQ3 NR22 P GR18 FIRST BT
NR18 CD QWERF OKMNH IJNBG UHBVF YGVCD TFCXS RDXZA QAZXD
WSXCF EDCVG RFVBH UQHBV YWGVC IJNMK OKMLP 1006A II II

FL2 V FQ3 NR23 G GR24 FIRST BT
NR19 CD REWSD TYUHG UIOKJ LKJNU KJHBY HGFRC QPOWY HJKUY
REDFV JIONM CDERT BGTYU NJIOP MJUYT VFREW QWEDC YUJMN IJMKU
HYFRD HUBTQ ZCBML 1008A II II
FL2 V FQ3 NR24 Y GR18 FIRST BT
NR2 CD UIYTR KJHGF HJKLO IJNDL LIGTD WDYBH IYTBV NOPQR
PQYTR NJIOK HNUIR PTNKY MAORT NAHVJ NIPQT 1009A II II

FL2 V FQ3 NR25 Y GR21 FIRST BT
NR3 DFCT1 QPWC EIRU TYGH ALSK DJFH EICN MEIX NOQM
ZMXN AONV ASHJ EIOT MOTY QPMC NRYT QPTO MIKL HJGF
1012A II II

FL2 V FQ3 NR26 P GR14 FIRST BT
FOUR REPLACEMENTS DUE YOUR COMMAND POST THIS AFTERNOON RADIO
TIME OF THEIR ARRIVAL 1015A II II

FL2 V FQ3 NR27 GR18 FIRST BT
NR4 CD ETUPQ PAITM AOUTL NUBYR HBOUT MAUYT JALKE MJHBV
JAMCH CVZNA HQPQY MAITY QYRWP HJKLA HFGTE 1017A II II

FL2 V FQ3 NR28 O GR25 FIRST BT
NR6 CD WROUY APRTJ MAIYR HLKDA KPQMN XAORP TURAE MAPRY
HALFK AMELS EKLAO ALEPE HEPTE AOEYT QPTYR AMOTY APRVB CZLAM
RQPUT YAHGS AMOEP NVBCZ 1018A II II

FL2 V FQ3 NR29 GR17 FIRST BT
NR8 CD RTPOY AORPE RIQNC MAOTR HGJKL LKAIE AKEIT EKATY
MAPTY HGNVB NVKDL LKHSD ZXMAT TORPD 1019A II II

FL2 V FQ3 NR30 GR23 FIRST BT
NR32 DFCT1 RTEY UITP MITY AORP RYAL HDLF NJEO MEPE
NAIT GHJD KELE LEIT AOTP ALEP MAUT YTLS LEIT KJDH
EPQW QWXZ 1021A II II

FL2 V FQ3 NR31 GR16 FIRST BT
NR41 CD QPWOE NAITY MEOPE NITYH MAITY NEJKL CNALD THOJF
WPOTM UNKJF CXZBN MAORY HSKDA 1023A II II

FL2 V FQ3 NR32 GR18 FIRST BT
NR5 CD REQYT AOTPE OPELT NJIUY BHYTR GVBHJ MKJNH BHGVF
VGBHY NURTY NAITY ZASXD CFDER VFGRT UQNZM 1025A II II

FL2 V FQ3 NR33 GR13 FIRST BT
RATIONS RUNNING LOW CUT OFF FROM DEPOT BY LINE OF
INFANTRY CAVALRY 1028A II II

Tape No. 13—Continued

FL2 V FQ3 NR34 GR24 FIRST BT
NR10 CD QPWOT YIROE JHDLF NAKDL NKTUI NUTYA CUITH SNUTB
MAOPR HJKLA MAKEL MACBZ NAITH MRTNH JNLAI NREQI AXSDF JAPRB
JRHTY CHUIT FANTE 1030A II II

FL2 V FQ3 NR35 GR19 FIRST BT
NR91 CD MARIT NAKFL RTAIF AKJHG HSLDK AKLEP MEITY HADSG
NAKRP AMEOI NAITU ROPEL MARUQ FNAJB HALRE TEGHU 1032A II II

Tape No. 14—100 characters per minute

(Tactical traffic, 20 words per minute)

LX1 V LX8 NR1 GR19 SEVENTH BT
NR2 CD KOXNT BHTRM NMGHT PEXXN HCVZM CBNET FOTZQ XEETO
NNEIU IHOIB BUOBE EBMOE IZCMX PXEXQ MEBIT NOTEQ 901A II II

LX1 V LX8 NR2 GR15 SEVENTH BT
NR3 CD DFCTJ IORYT OEXMT ERRSH EINMT DESCN BHNJO LOTYH
ZKIEP QPOGC YCEXN ZEXIN 902A II II

LX1 V LX8 NR3 P GR21 SEVENTH BT
NR4 CD NEISL INUTY XVFHG MNBYT KJIEX EXCBH MITHY EEDSA
ADIMA EXITN OPOOE EEDSA IMHTM ADOHO VIRCB EECEN NOTPH NENOM
903A II II

LX1 V LX8 NR4 GR22 SEVENTH BT
NR4 CD NKEME AEOEI AVENN QEWRT WERTY ERTYU RTYUI UIOPA
ASDFG SDFGH DFGHK AQWEX NOTES ENEQT FOXEN ZEXIN PMENT HQHPD II
II
MNBYT 904A

LX1 V LX8 NR5 GR19 SEVENTH BT
NR5 DFCT1 NRJH ERIS IENM THNI CSED JHEN KYOY YUHJ
BXZX SSIE SXXE QOPQ EIKZ ZXIT UIOK BENT 905A II II

LX1 V LX8 NR6 GR14 SEVENTH BT
REQUEST PLANES SENT ON HARRASSING DETAIL TO ENEMYS SOUTHERN LINES
GROUND STRAFING POSSIBLE 906A II II

LX1 V LX8 NR7 GR24 SEVENTH BT
NR56 CD FOPPN NUQES SIEMF FTMNV HFDCQ EPDKN KDBCL REWGX
FNSTH TFPDE PQNCK CGLXN NQRTY NESTP QWERT RUNJN NESTZ FEXNT
JELNT HQSPD NIXNT 906A II II

LX1 V LX8 NR8 GR25 SEVENTH BT
NR71 CD BNGFG KEUBV KEING KXEUA IERGH BOVWI ILKJN AVCRN
IEBGN XKEIT XEIEE CDXJN XKEOT AASNT EIMNT XNSIP EKFOT CNJMT
YZTGM BAYKE OJPAN RUIXT 907A II II

LX1 V LX8 NR9 GR17 SEVENTH BT
NR8 DFCT1 URGS IHIV EXCL YZTG BYAK OJPA OKKD RIUX
JANW NYIM NHIM USDT USDT IHTF 908A II II

LX1 V LX8 NR10 GR19 SEVENTH BT
NR9 DFCT1 ETBL AXMZ DYKV KUOG KOYA INIY YUKA OMGF
INIY YUKA OMGF OFRZ OVDG JUAC AWRT UHMG 906A

LX1 V LX8 NR11 GR20 SEVENTH BT
NR10 CD XORMO HDBAT SAARN XOVEN GOUKT SMANI IBTEN UILOR
ISOGN ICKYN FYDOT EMDZC IEIRN OLITP ETBNC HQHPD NIXTU 909A II II

LX1 V LX8 NR12 G O Y GR20 SEVENTH BT
NR69 CD NEOXT IMCEN IUDJH UODAN EIONT KSOAN CNDJW EOTNE
NITFO MNTON LWQNT WIEIT NOCIO PAKSK ALSLD DJGHK NOTUN 1010P II II

Tape No. 14—Continued

LX1 V LX8 NR13 GR22 SEVENTH BT
NR11 CD DFCTJ KUNHN HYVYO ZEZEQ WETNP FEXON FERTY INOPT
NYGDN NENTP FERTY EOTNK KPTON NERTY QUION WERNR HRNTH FERMN
IPINT 111OP II II

LX1 V LX8 NR14 GR23 SEVENTH BT
NR11O CD FINIT LOTNK ERTYN ESAYY NESTO FOFTE XEZEN NUTTY
NIXTN FOXET TSTNT EASNT TESTN FERTN QUINN WEPTN FIXFJ JIJSJ
LOJNT ASNSK 555P II II

LX1 V LX8 NR15 GR5 SEVENTH BT
KX8 NR41 SEVENTH 444P 449P II II

LX1 V LX8 NR16 GR25 SEVENTH BT
NR19 CD TITEN FEQTY POINM MOENE FERTP ZEXEN CMNGD HRNOW
EANTH FIFTP BEONT SHIEH FEINT ERORQ POTNT OITNQ ERTYJ JNRJN
VEMEN ZXCVM QWERJ FIISE 948P II II

LX1 V LX8 NR17 GR26 SEVENTH BT
NR21 CD ONATP QUIRT WERNJ FERTM ASSAN SASSN DIDQJ FOOFN
OISIO JJKMN BISNT ERTOY FEMTN NIXON FEMNT IOTNM XIXIN EMMNA
HQHPN HRNEW NTEMT QSTMN ZZANM 941A II II

LX1 V LX8 NR18 GR16 SEVENTH BT
NR121 DFCT1 WANT FINT POTN MANT EANT QRTY FIXN NOTM
SISN EAIJ JIKL LNTP MENT 749A II II

LX1 V LX8 NR19 GR17 SEVENTH BT
NR222 CD FINJY OOPEN FIMEN HQDHN ENETM FONTA WENTJ HRNEW
EOJOP FEMNT LPWNT ALSKN AJKNE NEMNT 933A II II

LX1 V LX8 NR20 GR22 SEVENTH BT
NR99 CD QUINT WERTP EASNT RUMPO TESNT YUMAN UNIET IOPNT
TNIMN POINT OMANT EFENT KEEIP IMNIO MENTL ZEJQN FENTP EASTM
QUIOP 333P II II

LX1 V LX8 NR21 GR15 SEVENTH BT
NR889 DFCT1 ENTY FINT POKY FEMN QUIT WEAN MEIT OLKN
EMNT PETY FERZ NIME 832P II II

LX1 V LX8 NR22 GR11 SEVENTH BT
TROOPS CONCENTRATION EAST OF RIVER PROVING EFFECTIVE FURTHER
DETAILS LATER 931A II II

LX1 V LX8 NR23 GR18 SEVENTH BT
NR44 DFCT1 QJJY WKKN EAET PENT SENK FINT LOSN MEQN
QPWO EORI RUTY ALSK KDFJ GHZM NIPT 335A II II

LX1 V LX8 NR24 GR19 SEVENTH BT
NR41 CD PEMNT HMAST EMNTY FISNT LOANT EMENT HIHEE EIIEN
LOTZE EANAT EMETP FINTH HIEEM MENTJ EMDJK LINTP 456P II II

LX1 V LX8 NR25 GR20 SEVENTH BT
NR100 CD NOWIT EMENT WIEMT POZON ZEMNT HUTEN MINIE GHLID
EMETO HIENT ESHET FINTP LITIE HEREQ JKHGN NITOP ZEXLN 649A II II

LX1 V LX8 NR26 P GR21 SEVENTH BT
NR13 CD FINTO LOTNT HIENT QPOTN MENTA KINTO HHNET LIENT
MESSE EASJY MINTO LINTP HENZQ LITME HEQNT EFITP HIEMT LPOIN
949A II II

LX1 V LX8 NR27 GR16 SEVENTH BT
NR922 CD HIMET LOPEN QITNT PEMTP HRIOP ZEMIT HIEMT LOANT
GUEJN JITNP EATOP SIXEN GEMET 848A II II

Tape No. 14—Continued

LX1 V LX8 NR28 GR25 SEVENTH BT
NR29 CD ENJUS IHHIT PEMTP EMNTO LIQNT FEMTZ HIENT LIOTN
MESSE ESSIS JUMNT HIQNT LOTAN JUMTN QUENT FIENT LOAJJ WJWMT
AWJAJ EISHT MONTA EEMTY 934A II II

LX1 V LX8 NR29 GR21 SEVENTH BT
NR31 DFCT1 EAMN EITN LOAN MENT FUNT LIAK EANT LUNT
HIST EANT FOEX LOAT MENT NOTA LOAT JFEN LQON LILA 847A II II

LX1 V LX8 NR30 O GR12 SEVENTH BT
THREE REPLACEMENTS THIS UNIT ARRIVED YESTERDAY AM ONE SERGANT
TWO CORPORALS 1039A II II

LX1 V LX8 NR31 GR22 SEVENTH BT
NR44 DFCT1 EMEM LOAT FINT EAST ENNW HETN LOAT MENT
EOAQ HIKN NITO POET METO MAST EATT HQNT MOTN FIXT
MEST 125A II II

LX1 V LX8 NR32 P GR17 SEVENTH BT
NR141 CD NETOL FINTO FITON LEASN SENTA MINTO HQHET FINTO
MYNTA KINLO QITON MESTO HANTO MENTA 847A II II

LX1 V LX8 NR33 GR17 SEVENTH BT
NR12 CD HENTA NINAS FERTY AUINT MENTA LIANT HETOP FERNT
ZENTO LAXTO MENTA MENTA EFNTA MANTA 846A II II

LX1 V LX8 NR34 GR19 SEVENTH BT
NR118 CD FENTO LASTO MENTA FERNT HASON MANTO KIKEN FENTA
MENTA FERMT LISTO PERTO HIEST MENTA FEROZ LLSTO 443A II II

LX1 V LX8 NR35 GR19 SEVENTH BT
NR119 CD QUINT FERTO LITON MENTA FERTO XERON ZELAT EMATO
PIOHN VNTTN MNXNT XZNTO WIPOT MENTO HISTO KEENT 441A II II

LX1 V LX8 NR36 GR23 SEVENTH BT
NR118 CD QITON FENTN LISTO MENTA NOTAL HISTO KENTA POTOL
MENTA MENTA FISON HERON NOTAP MENTA WIZIZ ZXVNO ZCNTO VNBBN
EPOJH GHJDN 223A II II

LX1 V LX8 NR37 GR27 SEVENTH BT
NR1 CD QUITO WESTO EASTN MENTA RUNTA YIYEN YIENT UOONN
EXONT MENTA MENTA LOSTN M NTAL ZCXNM ZSNYT LONTA MENTA PIOTA
MENTA METAL ZSILA VETZX WOTET EANTA 221P II II

LX1 V LX8 NR38 GR16 SEVENTH BT
NR333 DFCT1 EATM MENT MOTN QITO EANT FINT MOTN MENT
HOTN QOIT MENT HOTA IEAN 449P II II

LX1 V LX8 NR39 GR17 SEVENTH BT
NR190 CD MENTA FERTO LITIO QITAN SESON SASAN DGDHG HJKLA
LADPN NEEAT ZXCNM CNTOP MENTA EATOP 444P II II

LX1 V LX8 NR40 G O Y GR22 SEVENTH BT
NR2 CD ASNTA LOSTN MENTA MENTW EASTM FETTO OKOMN NOTAL
SESIS FERNT LOATN NOTAP HISTO JKGHN QJAST NOATO NATIO ALANT
ENDAN 758A II II

Tape No. 15—100 characters per minute

(Tactical traffic, 20 words per minute)

FR1 V FR3 NR1 G GR17 SECOND BT
NR11 CD SEXTA IRTOB JUGBC VOVYD CSJYE QUGYF CERXW WAICR
YZBIA HETEI ZIGUT GHTED MVOPL EFVJQ 112P II II

FR1 V FR3 NR2 T CD3 V BC2 G Y O GR20 SECOND BT
NR6 CD SIIVA JELLO DUGTN AMQIB UBIXZ NATSE FOKIA GRALB
EOPAN TOANC DOMTA IUPAM KWONG TYRWP LQBCD INGWQ OELNS 910A II II

Tape No. 15—Continued

FR1 V FR3 NR3 GR20 SECOND BT
NR7 CD OFGAL YTRAN WOBOX QUSON XAUNT ELENI JLAEO IOGNY
WPOTN THWON TONWQ THOWA VXARU XOAMI PWRAM LANGQ MAPMZ 921A II II

FR1 V FR3 NR4 G O GR23 SECOND BT
NR9 CD MUYRQ THOWQ MAYWQ AQISP WOTRN MEIGM JYTFW QPBZX
PWOAM WOAND ALENS DONWI EHTMA DWOSM THAPZ TNWTV ONLUD KAWLC
OXBUV MAORW 924A II II

FR1 V FR3 NR5 P GR19 SECOND BT
NR10 DFCT1 WOBO OLKO SYAP WOFK WUWE SYAP EZRS HAQY
WAHU MERI ZULP TAXA AHPY DEPD CYBE FENY 930A II II

FR1 V FR3 NR6 GR13 SECOND BT
ENEMY TANKS HAVE BEEN ROUTED WERE LAST SEEN IN VICINITY
OF ARNEYTOWN 823A II II

FR1 V FR3 NR7 GR25 SECOND BT
NR6 CD CYKMX JELAS EUYCA ERRAO CYYFT WAHYU AMQIF UMAHH
IGOHG CYMKX AHPHN YJMJK LANDK ONLYR ALPEM HOISW ALPZS KWACF
EMAQP NYTND MAOTR MAOFW 935A II II

FR1 V FR3 NR8 GR15 SECOND BT
NR8 CD KLYTR MAONF APMWY CIWHI HNBJK CYSTJ TUXGC WVAJK
EMZAL NUQWS KINDS QSUDK 921A II II

FR1 V FR3 NR9 P GR16 SECOND BT
NR19 CD HNBJK JMCIK LJOER VWZIL RTVER MKPFQ DQHKA BZCUO
GSLDM DOXGL FHMLT RSPHD UTHKJ 925A II II

FR1 V FR3 NR1Ø T CD3 V BC2 G Y O GR18 SECOND BT
NR22 CD JALNM LANKE ALSSM ALDNI ALDMS ALRWQ PNEWK MAOLQ
WPAMW OWACV PWTYE AMONE AMPEW UDXSZ IUPOQ 829A II II

FR1 V FR3 NR11 GR15 SECOND BT
NR37 CD YEPOT MAOND MAOWX AGNVB WEKJI GHDJA EUIKJ QESZX
MCHAU TUJVM OWEPM TPEWY 930A II II

FR1 V FR3 NR12 GR16 SECOND BT
MAIN BODY OF SUPPLIES LOCATED AT PUMPKINPATCH JUNCTION SEND BACK
GUARD TO MAINTAIN ORDERLY DISTRIBUTION 931A II II

FR1 V FR3 NR13 Y P GR14 SECOND BT
NR23 CD XMZJK JIMEF CUMLC YMOAE FIMVC MXDOF JKJWZ CMUTM
QMONE IRTYU PWRIU 1Ø1ØA II II

FR1 V FR3 NR14 GR15 SECOND BT
NR9 CD MJCHF NCJDH GDYEI DGERI LADWM ANOWE QPUOE MAOTD
MAOTE CXWQZ QPWMX WTEIV 947A II II

FR1 V FR3 NR15 P GR18 SECOND BT
NR34 DFCT1 NJUM YIUK WQED ASDE WERF ERTG RYTH YUIK
YCSZ BHTO OPKB MFKW KLIH CZXX JAWQ 948A II II

FR1 V FR3 NR16 P GR17 SECOND BT
NR2 CD XMJZK JINEF CMUCL YJOAE FIMVK XMCOF MQCEA CTUMN
AONES MAOWW VKMIF JISEQ XMFOC KQLWU 958A II II

FR1 V FR3 NR17 NITE GR19 SECOND BT
NR7 CD MAOEN TRPME OEMPS MEONA XQYRO PRWMN MWHTZ OMESW
ENSDX MWORN OTUTM TPWMO WQRSK MWOND OEZXY PWQVT 936A II II

FR1 V FR3 NR18 GR22 SECOND BT
NR38 CD MOWXZ NEOWN ETHWN OEWAM WYRND AJAWH ALIRN OWNAW
OWNAL OENIE QWEOP IUYTQ OISDG LKDHH HJKAS WBNCD AFDSG LJKDH
MNOVX 939A II II

FR1 V FR3 NR19 Y GR19 SECOND BT
NR39 CD LKJMN HGFCV IOPUY FDSER MJKHB FDREW JHBVC WFJUY
OUIYF HCBSR WUORU EJHDW QOEMC WKDNC QLSIE WJDNV 1Ø17A II II

Tape No. 15—Continued

FR1 V FR3 NR2Ø GR2Ø SECOND BT
NR4Ø CD WKSJD FUWCN WQDSG KDXZM ASZXM QPWJX RKSNC WKLDH
QODJV WHDCM QHASC WODNX DLKAM WHDOV ZSWGH WIOFJ KONES 1Ø18A II II

FR1 V FR3 NR21 GR16 SECOND BT
NR41 CD ALSKF WURVS WOFBZ QODNC DUWZX OENSV OENAL YSLCM
ONSAM ALEND MIEQD QPROX IEWQZ 1Ø2ØA II II

FR1 V FR3 NR22 P GR17 SECOND BT
NR43 CD WHDSV ALEHD OIEUT WPCXZ JFNMS OQEIU ZXMEY OPETD
UHFRW ETUOG MVBDU RGBJI OKNGF WSXCF 1Ø39A II II

FR1 V FR3 NR23 G GR18 SECOND BT
NR44 CD PLKJY IHYTR HGFRE HJNBV DTJVZ IEKAN QPSOC WIUHD
QKSJC BHDOP JIUYE JNXZC MKGEY LNMGH DFTES 1Ø39A II II

FR1 V FR3 NR24 G Y O GR24 SECOND BT
NR42 DFCT1 QOWI ALKD DNMC WIOR WJKC AHKJ WOXZ LKUI
LKYU GFTR EWSD JKSI ONSE REOP HGMK ALDJ EIOZ WDKJ
NFGD NKSJ OZXV 1Ø31A II II

FR1 V FR3 NR25 GR17 SECOND BT
NR43 CD MCCIK JINER OIOXD ONETY APEMC NOEAL QJLSF LOEAN
JAOEN SCXPE ALWON ZENCA PANEQ ZICQV 1Ø32A II II

FR1 V FR3 NR26 GR2Ø SECOND BT
NR44 CD NKJVS QACEM OANSW ZWQYT OENSL ETRIN ONEAN EATON
SHDRL UAITM APNEM WTEUY UITYE WORIY AJDHG SLDKG ZNCME 1Ø33A II II

FR1 V FR3 NR27 GR15 SECOND BT
NR45 CD WQIUC ALDNG AIEND AIEWQ QOEHC SLRLX WICNG WORND
QPALZ SHFKE EIFND WNXZV 1Ø34A II II

FR1 V FR3 NR28 NITE GR16 SECOND BT
NR47 CD NBHGF GHTYR JKHUY GFDSE CNVBG DKGJH WORJV KLHJF
JKUIY HGTRE DHGJL HBVFD HUYFE 1Ø35A II II

FR1 V FR3 NR29 P GR17 SECOND BT
NR49 CD MJKHG JHGFD IUYDR NGJHT FGKNB CXZSD SISEZ JDVCM
JSGCB WIOFG JFDHT DKCNG UYGRD HTFRS 1Ø37A 'II II

FR1 V FR3 NR3Ø GR19 SECOND BT
NR51 CD JHNGF HYRTD HJUOI SLFER ZXCDE GFTER IGREE GHKJL
JHGFC VBHRT WQAGO JHGDF QOFHT YFVBR EYRTD OHVDF 1Ø38A II II

FR1 V FR3 NR31 G GR18 SECOND BT
NR52 CD UYRFG IUHGF IHVZX REWQA GZXSE HGCVB FTESD OTFJH
OYHVF GJHFV WTYDF GHUTY FHGVX IYFOY GBDZX 1Ø39A II II

FR1 V FR3 NR32 GR24 SECOND BT
NR54 CD WJNBF HYRTD FGRYT HFGTS CXZSW BVGDF JGYHR FGJHD
FSXCV GFHJI HGTYR PDGHR WQADF HKJLG JGBNH JDHTY FWEZX FBGDF
KLJGH BFHGT CDEWS 1Ø24A II II

FR1 V FR3 NR33 P GR22 SECOND BT
NR55 CD JHGTY GHRTE FGRTD HJKLN BNHGE JKUIG JKHFT ERYTF
HBNGF DFHGJ BCVNM QWRET YRFGH BHGFR FHGJU HDFGR GKJBB ZCXVE
WASQR 1Ø25A II II

FR1 V FR3 NR34 GR17 SECOND BT
NR57 CD FGTRE FHGYT GHTYR GHDXZ ZXCVB JHGTY FGRTD WASQW
LJKHG GHKCV BVGFD GHTED BHFFT JKNMY 1Ø27A II II

FR1 V FR3 NR35 GR14 SECOND BT
ENEMY ADVANCING ON OUR LEFT FLANK MACHINE NOT EFFECTIVE SUFFERING
HEAVY LOSSES ADVISE 1Ø28A II II

FR1 V FR3 NR36 GR18 SECOND BT
NR59 CD JHFGT HGFDS DVDRE MJHJY HGTYF RDCXZ XWRED GHGTR
KLCEW XCVDI GTDKN IEUSH GHYDV JBHFT GJBXW 1Ø29A II II

Tape No. 15—Continued

FR1 V FR3 NR37 GR17 SECOND BT
NR6Ø CD HUSUI BFHRT GDVCE ZXCWE FHGFD FTEHM FHKBV XCBZV
BDTEJ GKHNF EUVDT AZXWW NZCWO IGBEF 1Ø3ØA II II

FR1 V FR3 NR38 GR18 SECOND BT
NR61 CD AFDSE DFRSW DCXVR NVGHR CHRTF GDFES LKIJM DXWOH
XSIHN GJFFR DGTVC SUTMR FCEJY CUFVE ZWQLB 1Ø32A II II

FR1 V FR3 NR39 GR19 SECOND BT
NR63 CD FDREW CGFDR BFXCU IUSTV VFTRE DHDTY JHBFG GHYTF
MBNGH FTUIO BVFGE GFRDW HKYUB BHJTY GJHRT IGXWP 1Ø33A II II

FR1 V FR3 NR4Ø P GR22 SECOND BT
NR64 CD JNHFG HFGRE FGTRD JUYIG KNMGR GFHYG BDGER FGHRT
JKYUI FXWRC NBVFG GFDEW ASWER DFRTG GHTYF GHYUM JHBNF XCDEW
ZERCX 1Ø32A II II

[A. G. 062.11 (11-19-41).]

BY ORDER OF THE SECRETARY OF WAR:

G. C. MARSHALL,
Chief of Staff.

OFFICIAL:

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The Adjutant General.

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(For explanation of symbols, see FM 21-6.)

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TM 11-433

WAR DEPARTMENT

TECHNICAL MANUAL

TIME INTERVAL APPARATUS EE-56, EE-85, EE-86-A
LINE CONNECTOR UNIT EE-87
TIME INTERVAL SIGNAL BE-65
AND BELL MC-153

August 17, 1942

TECHNICAL MANUAL No. 11-433

WAR DEPARTMENT,
WASHINGTON, August 17, 1942.

TIME INTERVAL APPARATUS EE-56, EE-85, EE-86-A, LINE CONNECTOR UNIT EE-87, TIME INTERVAL SIGNAL BE-65, AND BELL MC-153

SECTION I

GENERAL

1. **Purpose.**—*a.* Time interval apparatuses EE-56, EE-85, and EE-86-A* are designed to afford chronological coordination of all functions of fire control of the Coast Artillery Corps. The battery commander and personnel concerned with the several functions at observation posts, plotting rooms, and gun positions thus to a great extent are guided and their functions coordinated, by means of proper control of the time element, through accurate time interval programs.

b. Time interval apparatuses EE-56 and EE-86-A, with the associated bells MC-153, are designed for use in permanently installed fire-control systems of fixed seacoast artillery. Time interval apparatus EE-86-A is of later design and includes certain improvements and refinements.

c. Time interval apparatus EE-85, with the associated line connector unit EE-87 and time interval signal BE-65, is designed for use in fire-control systems of mobile seacoast artillery.

2. **Use.**—*a. General.*—(1) Seacoast artillery must be able to fire simultaneously on a number of relatively small, rapidly moving, armored targets; make necessary changes in types of projectiles or weights of propelling charges; and take full advantage of fleeting opportunities to deliver an intensive and accurate fire.

(2) Time interval equipment is, therefore, an integral part of fire-control communication systems of both fixed and mobile seacoast artillery.

b. Provision for time interval signals.—(1) In fixed seacoast artillery, either time interval apparatus EE-56 or time interval apparatus EE-86-A is used to provide the timing of time interval signals. Either is capable of providing time intervals suitable for any or all elements of armament controlled from one fire-control switchboard without requiring relays and local power supply in distant stations. A section of the regimental headquarters battery, except in the case of separate battalions, is responsible for operation and maintenance of the fire-control communication system, including the time interval system. Installations and major repair or replacement are the responsibility of the corps area signal officer.

(*a*) The EE-56 produces electrical signal impulses at 10-, 15-, 20-, and 30-second intervals concurrently. The time interval impulses are transmitted to bells MC-153 at observation posts, plotting rooms, battery commanders' rooms, and gun wells and platforms of gun emplacements. Additional auxiliary equipment is necessary for switching desired time interval signals to all batteries and distributing the signals to various locations within each firing battery. Switch-

*No production was ever made under the nomenclature "time interval apparatus EE-86," the first production having been designated "EE-86-A."

boards BD-15 (time interval switch-panel), BD-74, or BD-78, provide for switching any one of the four time intervals to each firing battery. Frame FM-5 provides for distributing the time interval signals in use in each battery to all bells employed within the battery time interval system.

(*b*) Time interval apparatus EE-86-A differs from the EE-56 in that it produces electrical signal impulses for 1-, 5-, 10-, 15-, 20-, 30-, 40-, and 60-second intervals and ordinarily would be used with either switchboard BD-74 or switchboard BD-78, both of which provide for switching and distribution.

(2) In mobile seacoast artillery, time interval apparatus EE-85, line connector unit EE-87, time interval signal BE-65, and batteries BB-50 are used to supply desired time interval signals. In mobile units, each battery is responsible for installation, operation, and maintenance of its own time interval equipment; each is supplied with one time interval apparatus EE-85, one line connector unit EE-87, five time interval signals BE-65, and two batteries BB-50 (12-volt storage).

(*a*) The EE-85 produces electrical signal impulses for 1-, 5-, 10-, 15-, 20-, 30- and 45-second intervals, or other specially desired intervals as explained in paragraph 3*c*(4)(*b*) and (*c*).

(*b*) Line connector unit EE-87 produces a 1,000-cycle tone which is superimposed on telephone lines in signal impulses as determined by time interval apparatus EE-85, to which it is connected.

(*c*) Time interval signals BE-65 are installed at gun positions and in the plotting room. The time interval signals BE-65 are connected directly to the time interval apparatus EE-85.

3. Description.—*a. Time interval apparatus EE-56.*—This apparatus is mounted on a hollow oak base and is provided with a protecting oak cover (fig. 1). A bakelite terminal strip with seven binding posts and a dial switch is mounted at the front of the base. The dial switch positions are designated OFF and ON. Two binding posts are marked 30 VOLTS d-c for connection to 30-volt direct-current power supply, and five binding posts are marked C, 10, 15, 20, and 30 for connection to the common connection and 10-, 15-, 20-, and 30-second connections respectively of the time interval program circuits. The motor, governor, cam arbor, and contactor assemblies are mounted on a bronze casting which is bolted to the oak base. Over-all dimensions of the complete unit are 13⅜ by 10½ by 14¼ inches and the net weight is 45 pounds.

(1) The motor is of series type, runs at 1,280 revolutions per minute with 30-volt direct-current power supply, and is equipped with ball bearings. The motor is mounted vertically on the front end of the

bronze frame, and the adjustable-speed centrifugal-type governor is mounted on an extension of the motor shaft. A 100-ohm resistor is in series with the motor circuit. The motor drives a cam arbor through a gear train consisting of two stages of speed reduction. One stage is at the worm gear cut on the extended motor shaft and the other is a set of spur gears, the larger of which is mounted with the cam arbor assembly as the driving gear. The smaller spur gear is cut on one end of the shaft on which the worm wheel is mounted.

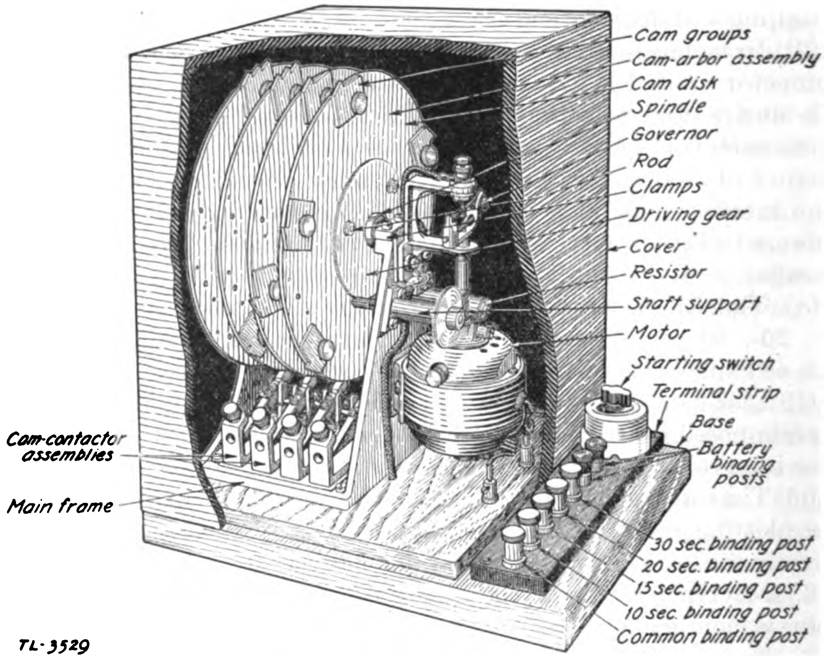


FIGURE 1.—Time interval apparatus EE-56.

(2) The cam-arbor assembly is mounted on a spindle carried by a stationary steel shaft clamped at front and rear by two brackets which form part of the frame casting. The spindle revolves about the stationary shaft on ball bearings, and is pinned to the driving gear at the front end. The driving gear and four cam disks and the bushings for separating them are mounted on the spindle and on three rods. The front ends of the rods are bolted to the driving gear at three equidistant points close to the periphery of the gear. The other ends of the rods are bolted to the fourth cam disk which is pinned to the arbor spindle to prevent lateral movement of the cam disks. All four cam disks are equipped with cam groups having projections which operate con-

tactors associated with the cam disks. Each cam group is fitted with two dowel pins and a knurled-head screw which fit into two drilled holes and one drilled and tapped hole close to the periphery of the cam disk, and secure the group in place. All four cam disks are drilled and tapped to receive cam groups necessary for any one of the four time intervals. All disks and cam groups are interchangeable.

NOTE: Time interval apparatus EE–56 is normally assembled when issued so that cam groups are arranged for 10-, 15-, 20-, and 30-second synchronized intervals on the first, second, third, and fourth disks from the front of the apparatus. The first disk has six three-projection cam groups equally spaced at 60°, each producing the firing signal and 1- and 2-second warning signals. The second disk has four three-projection cam groups equally spaced at 90°, and the third disk has three equally spaced at 120°. The fourth disk has two three-projection cam groups equally spaced at 180°, each producing the firing and warning signals, and two single-projection cams leading the other cam groups by 30°, each producing a 5-second warning signal. Each disk is drilled and tapped in the same manner so that if the cam groups are rearranged, any disk can produce any of the four intervals and also a 60-second interval to meet the needs of the particular harbor defense project. Several additional single-projection and three-projection cam groups are included so that various arrangements of preliminary, warning, firing, and observing signals are possible.

(3) Four cam-contactor assemblies are mounted on the base of the casting and are insulated from it by a bakelite strip. Each has screw adjustments for duration of contact closure and for operation of rubber bumpers which cushion the fall of the rocker arms.

b. Time interval apparatus EE–86–A.—This is constructed similarly to time interval apparatus EE–56 (fig. 2). Important changes are the use of mahogany instead of oak, addition of four cam disks to gain four more time intervals, increase of speed of the motor to 1,380 revolutions per minute, addition of a master timing contact (fig. 3), an improved type of motor governor, and inclusion of a stroboscopic tuning fork. Mounted on the terminal strip are a toggle switch and eleven binding posts to accommodate the four additional time interval program circuits. The positions of the switch and the battery and time interval binding posts are designated as are those of the EE–56. Over-all dimensions of the complete unit are 18 by 11 by $15\frac{1}{8}$ inches, and the net weight is 72 pounds.

(1) (*a*) The improved governor is more positive in its adjustment and operation. The governor gives constant motor shaft speed within ± 0.25 percent at 27 to 30 volts.

(*b*) The stroboscopic tuning fork is contained in a compartment in the rear of the base of the apparatus. It is used to regulate the motor speed, having a frequency such that when it indicates a stationary pattern of the governor the speed of the motor is 1,380 revolutions per minute (±0.05 percent). The fork is made of chromium steel alloy and the ends of the tines are each fitted with slotted brass pieces. The entire fork is fastened securely in a black metal case which has apertures to make it possible to look through the slots of the fork.

(2) A master 1-second timing-contact cam is driven through another worm gear by the same worm which drives the cam-arbor

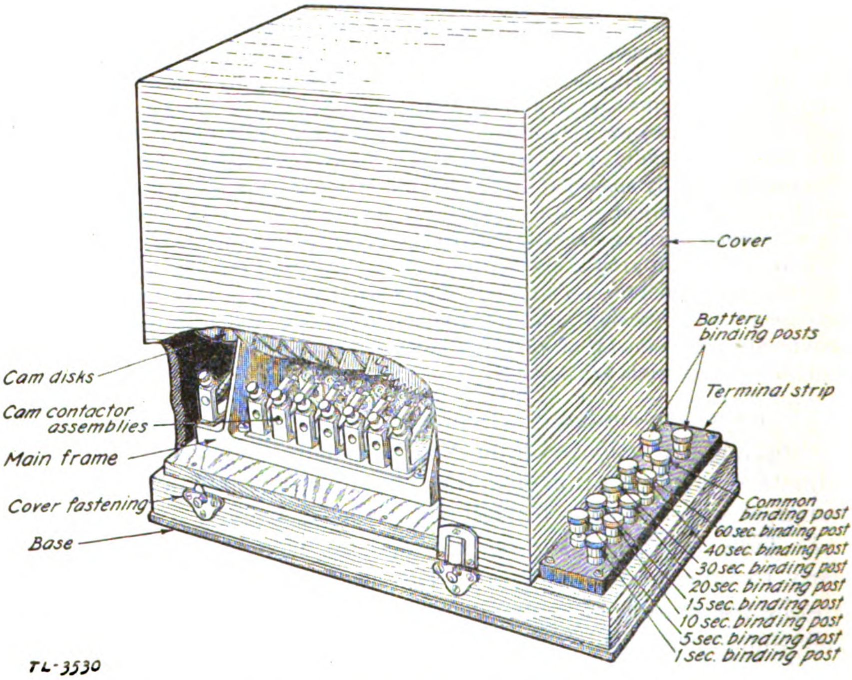


FIGURE 2.—Time interval apparatus EE–86–A.

worm gear. This cam operates the master timing contact which acts as the make contact of all time interval circuits.

(3) Additional disks and an improved method of spacing the drilled and tapped holes are used in the cam-arbor assembly of the EE–86–A. Seven disks are mounted in the same way as the four disks of the EE–56. The eighth cam disk is pinned to a secondary spindle mounted on an extension of the arbor shaft. This secondary spindle is driven from the forward spindle through a two-stage spur-gear train providing a step-up ratio of two to three, so that it rotates at 1½ revolutions per minute. The first cam disk is cut from one piece of steel to provide 60 projections equally spaced around its periphery. The next six cam disks are drilled and tapped to receive cam groups

at twelve equidistant points about their peripheries. The eighth cam disk, which is located on the 1½-revolutions-per-minute spindle, is drilled and tapped at eight equidistant points around its periphery. Cam groups of the eighth cam disk are not interchangeable with those of the other six drilled and tapped disks.

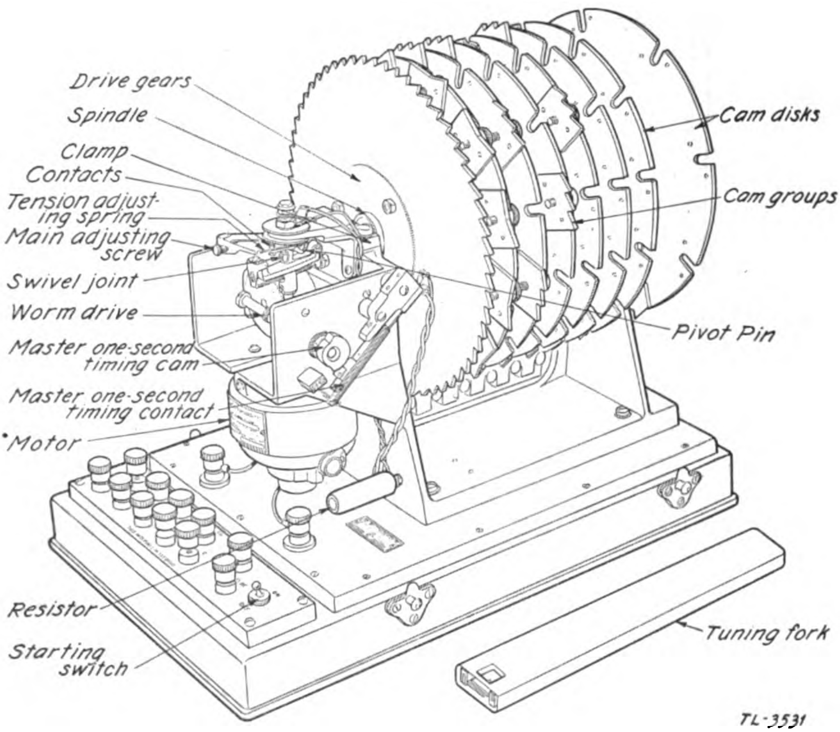


FIGURE 3.—Time interval apparatus EE–86–A—master 1-second timing contact and governor.

NOTE: Time interval apparatus EE–86–A is normally assembled so that cam groups are arranged for 1-, 5-, 10-, 15-, 20-, 30-, 40-, and 60-second synchronized intervals on successive disks from the front of the apparatus. The projections are cut into the periphery of the 1-second disk, and the 5-second disk has twelve single-projection cams equally spaced at 30°. The 10-second disk has six three-projection cam groups equally spaced at 60°, each producing the firing signal and 1- and 2-second warning signals. The 15-second disk has four three-projection cam groups equally spaced at 90°, the 20-second disk has three at 120°, the 30-second disk has two at 180°, the 40-second disk has one, and the 60-second disk has one. Because cam groups are interchangeable for all but the 1- and 40-second disks, any of the other six intervals may be produced on any of the six disks, if cam groups are rearranged to meet the needs of a particular harbor defense project. Additional single-projection and three-projection cam groups are provided so that various arrangements of preliminary, warning, firing, and observing signals are possible.

c. Time interval apparatus EE-85.—This apparatus is contained in a birch case with hinged cover and web carrying strap. A flush-hasp clasp holds the cover securely in place. A spring-hinged section on the left side of the cover provides entrance for field wire and battery

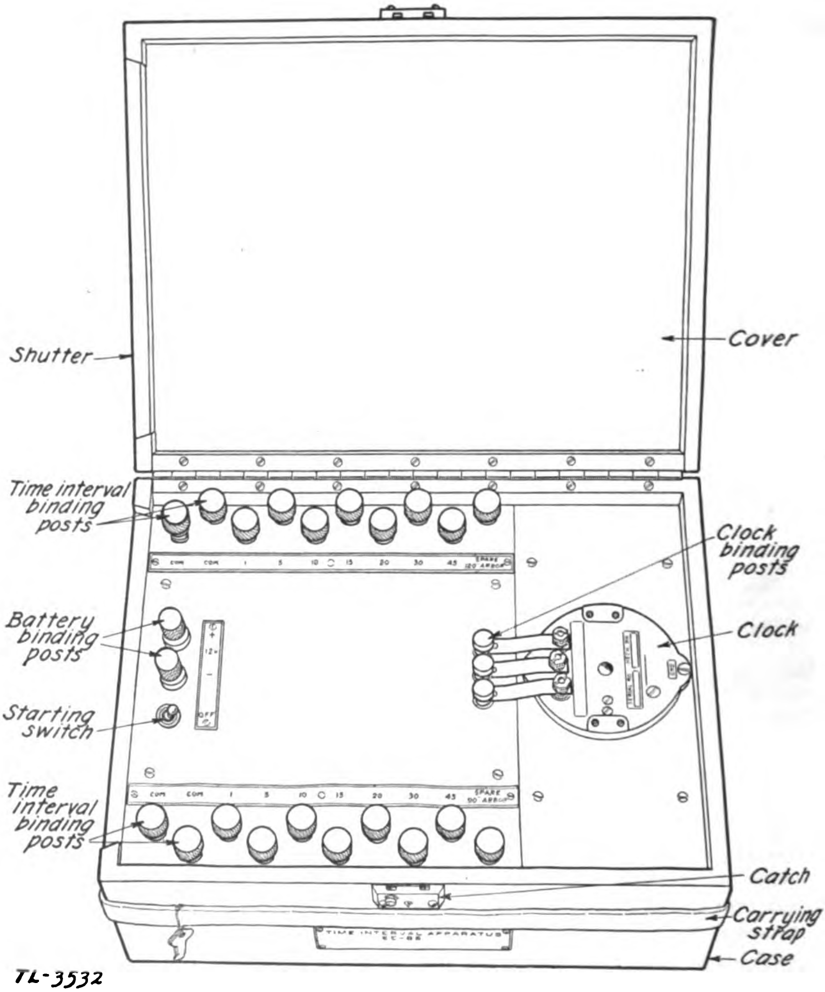


FIGURE 4.—Time interval apparatus EE-85.

leads. The case is 7 by 11¼ by 14½ inches, and the entire apparatus weighs 14 pounds.

(1) Two bakelite panels are mounted at the top of the case (fig. 4), one providing an opening for the clock and a means for holding it rigidly, and the other having switch SW-105 and 25 binding posts on

top and the interval-producing mechanism mounted on the under side (fig. 6). Only the OFF position of this two-position toggle switch is designated. Three binding posts TM-152, with no designation, are provided for the metal straps connecting the clock, and two binding posts TM-109 are designated + and −12 volts for battery connection.

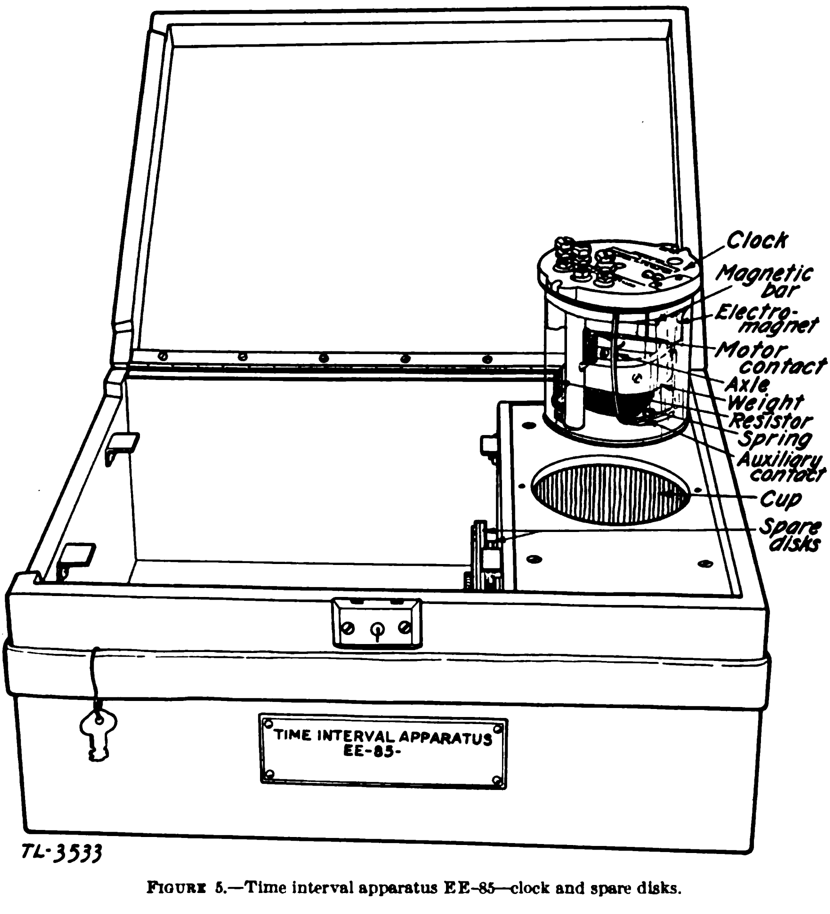


FIGURE 5.—Time interval apparatus EE-85—clock and spare disks.

Also, four binding posts TM-175 are provided for common connection, for any of the desired time intervals, two each for the 1-, 5-, 10-, 15-, 20-, 30-, and 45-second intervals, one for the spare contact on the 90-second arbor, and one for the spare contact on the 120-second arbor. The time interval contacts are designated COM., 1, 5, 10, 15, 20, 30, 45, SPARE 90″ ARBOR, and SPARE 120″ ARBOR respectively.

(2) The clock is resonance type, electromagnetically driven from the 12-volt battery supply (fig. 5). It consists of a center vertical

axle upon which is mounted a heavy cylindrical weight, a contact operating mechanism, and a magnetic bar suspended between the windings of an electromagnet. At the bottom of the axle is fastened a heavy spiral spring. The spring also is connected to a contact arm which closes a heavy auxiliary contact. The time of one complete oscillation of the clock is 1 second. A capacitor and a resistor in

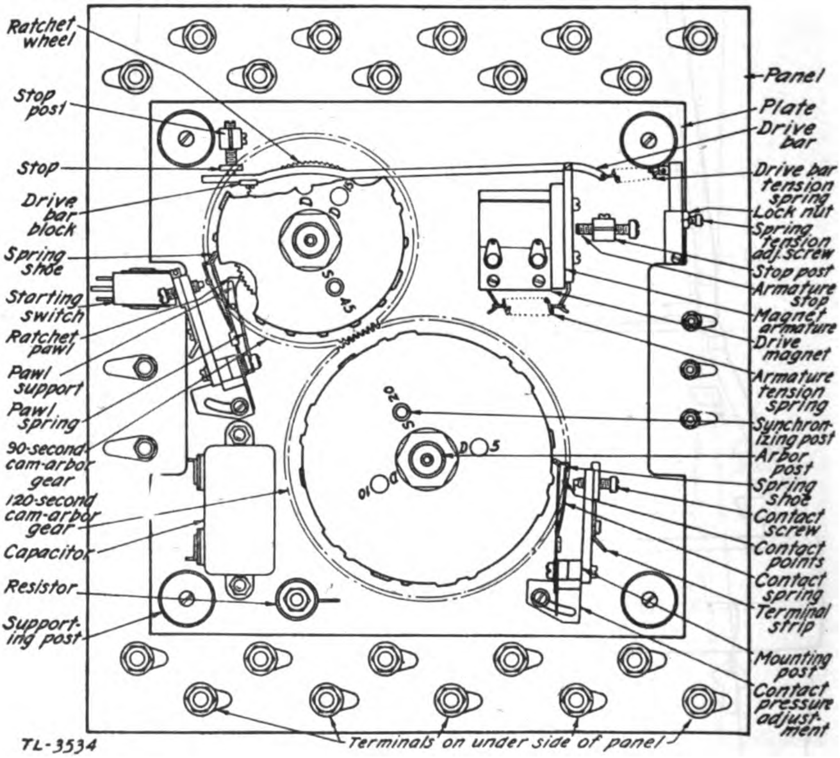


FIGURE 6.—Time interval apparatus EE-85—driving, interval-producing, and contact mechanisms.

series are bridged across the motor contact of the clock. Also, a 10-ohm resistor in series with two 0.5-microfarad capacitors in parallel is bridged across the auxiliary contact.

(3) The driving mechanism consists of a driving magnet which turns the 90-second arbor through a ratchet bar (fig. 6). The 120-second arbor is geared to the 90-second arbor and turned by it.

(4) The actual interval-producing mechanism consists of the 90-second and 120-second arbor pins, four bakelite disks mounted on each of them, and heavy wiping contacts operated by the disks (fig. 6).

(*a*) In addition to the main arbor pin of each arbor assembly, there is a synchronizing pin projecting from each of the two gears, parallel to the arbor. The bakelite disks are drilled to fit on both these pins, one hole being at the center for the main arbor pin and the other hole being off-center for the synchronizing pin. On each arbor assembly, the disks are separated from the gear and from each other by small spacers. They are held in place by a brass washer and nut on the main arbor pin, and may be removed easily.

(*b*) The 5-second-interval disk is mounted next to the gear on the 90-second arbor and has raised sections cut on its circumference to hold the corresponding contact closed 1 second of each 5 seconds. Next to this disk is the 15-second disk, having a raised section cut to hold its contact closed for the last 3 seconds of each 15-second interval. The third disk is the 45-second disk, cut to close its contact for the fortieth second and for the last 3 seconds of each 45-second interval. These three disks are synchronized so that the last second of each series of the 45-second interval coincides with that of the 5-second interval for two positions of the arbor, and the last second of each series of the 15-second interval coincides with that of the 5-second interval for six positions. It is the position of the holes for the synchronizing pin which affords synchronization, the holes being marked S5, S15, and S45, respectively. The fourth disk operates the contact connected to the binding post marked SPARE 90″ ARBOR, the disk furnished being a 45-second disk similar to the other except that there are three arbor-pin holes. To obtain delayed time interval programs instead of synchronized programs, holes are drilled at two positions other than the synchronized position on this fourth disk. The hole for the synchronized position is marked S45, and the others are marked D5 and D15 (fig. 6) to denote 5- and 15-second delays in the time intervals from the intervals of the synchronized position. To obtain the desired delayed program, the synchronizing-pin hole so marked is fitted over the synchronizing pin.

(*c*) On the 120-second arbor next to the gear is the 10-second disk, the raised sections of which hold the corresponding contact closed for the last 3 seconds of each 10-second interval. Next is the 20-second disk, cut to close its contact for the fifteenth second and for the last 3 seconds of each 20-second interval. Third is the 30-second disk, closing its contact for the twenty-fifth second and for the last 3 seconds of each interval. These three disks are synchronized by the location of their synchronizing-pin holes and are marked S10, S20, and S30, respectively. The fourth disk operates the contact connected to the binding post marked SPARE 120″ ARBOR. Either of two disks are available to be used as the fourth disk. They are furnished with synchronizing-pin holes marked S20, D5, and D10 for one, and S30, D10, and D15 for the other. These disks provide delayed 20- and 30-second intervals as indicated. One of these disks is carried on the

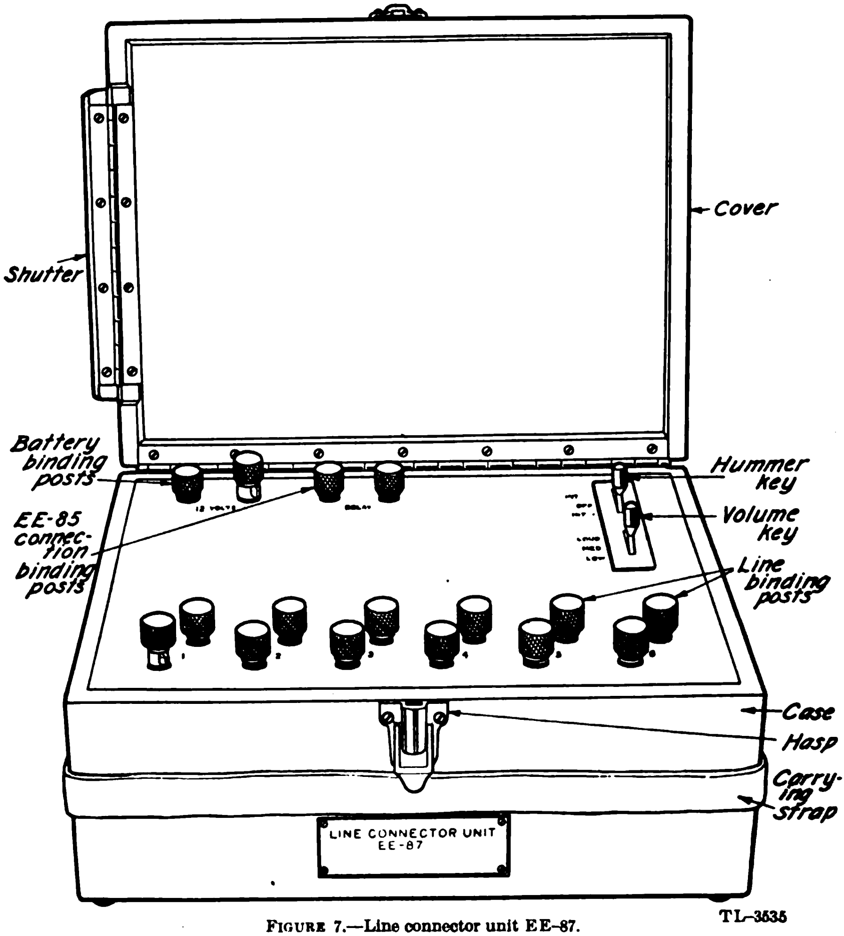


FIGURE 7.—Line connector unit EE-87. TL-3535

120-second arbor, and the other is mounted on a stud inside the case (fig. 5), with two blank 90-second and two blank 120-second disks which may be cut for any desired intervals within the scope of their respective arbors.

(*d*) The contact closed by the raised portions of each disk is in series with battery, switch, auxiliary contact of the clock, and corresponding interval binding post and common binding posts (fig. 20). Each contact consists of a light spring armature which rides on the disk, and a make-contact point which is in itself a screw adjustment.

d. Line connector unit EE–87.—The unit is contained in a birch case similar to that of the EE–85, and has a hinged cover and web carrying strap (fig. 7). A flush-hasp clasp holds the cover in place, a spring-hinged section on the side of the cover providing entrance for

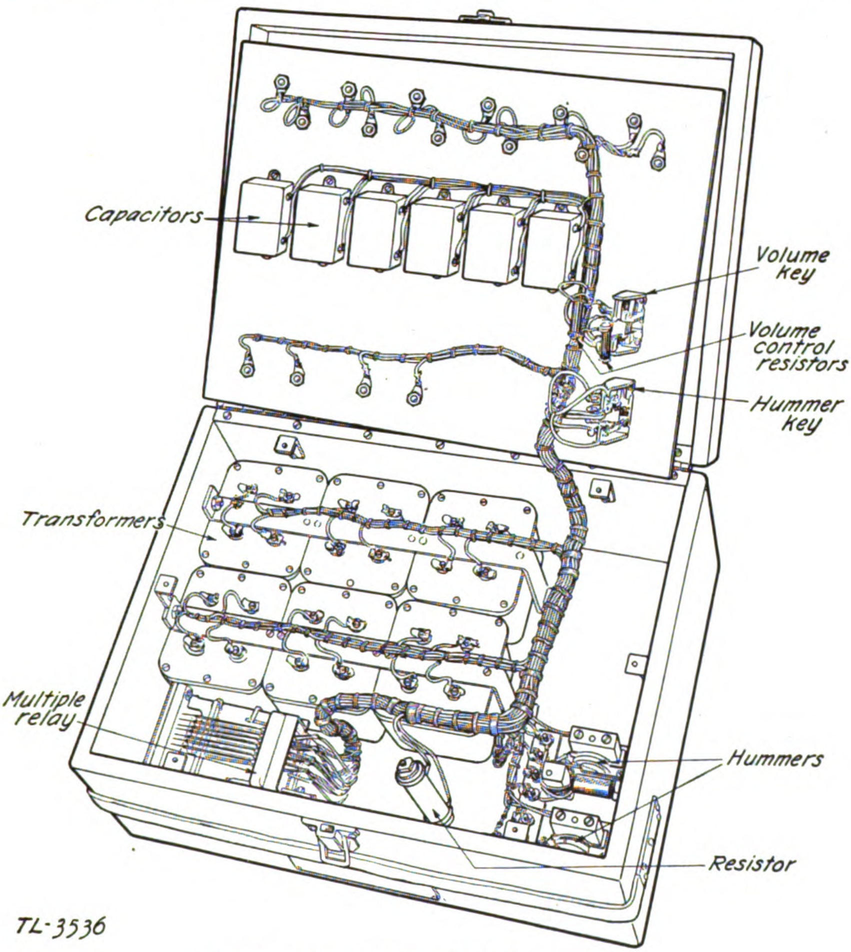


FIGURE 8.—Line connector unit EE–87—internal view.

field wire and battery leads. A bakelite panel, mounted at the top of the case, has sixteen binding posts TM–175 and two Western Electric 479–type key switches fitted on it. Inside the case are mounted six transformers, one North Electric Company multiple relay, two duplicate General Radio 572B microphone hummers, and six 0.1 μf capacitors (fig. 8). The case is 7 by 11 by 14½ inches, and the entire unit weighs 26½ pounds.

(1) Of the bakelite panel fittings, two binding posts are designated +12 VOLTS— for battery connection, two are designated RELAY for connection to common and desired time interval terminals of the time interval apparatus EE-85, and 12 are designated in pairs for connection to six telephone lines. One key switch, designated INT. 1, OFF, and INT. 2 for the three positions of the key lever, connects one or the other hummer to the circuit. The other key switch marked LOUD, MED., and LOW, controls the volume of the hummer tone.

(2) Six transformers C-231, wired as shown in figure 21, induce the voltage output of either hummer on the telephone line terminals. Transformer C-231 has 350 turns on the coil connected to terminals numbered 1 and 2, and 850 turns on the coil connected to those numbered 3 and 4.

(3) The multiple-contact relay (fig. 8) has seven knife contacts. The moving contacts are mounted on flat springs. One contact completes the circuit to the hummer coil primaries, and the other six contacts complete the six circuits to the telephone line terminals.

(4) Each microphone hummer (fig. 8) produces 1,000-cycle tone. The hummer is a push-pull arrangement of a carbon-microphone transmitter button opposing a vibrator-type receiver. A small transformer is a part of each hummer.

(5) A 0.1-microfarad capacitor CA-166 is placed in series in each telephone line circuit (fig. 21).

e. Time interval signal BE-65.—This is a local battery howler housed in a heavy, crackled black metal case with carrying handle. A heavy screen grille on the front (fig. 9) covers a resonator chamber and heavy, blast-proof diaphragm. The back cover is hinged at the bottom and held in place by two knurled-head screws at the top. There is a heavy waterproof gasket around the inside edge of the cover and at the opening provided for entrance of the line wires. Inside the case are a relay, a heavy vibrator acting on a diaphragm, a bakelite terminal panel, and a battery compartment for two batteries BA-23 (fig. 10).

(1) The small bakelite terminal panel has four binding posts mounted on it. Two binding posts TM-152 are designated +3 VOLTS— and two binding posts TM-195 are designated LINE.

(2) The battery compartment consists of a metal slide held in place when the cover is closed, upon which two batteries BA-23 are clamped in wooden cradles by means of metal straps and thumbscrews. Leads are provided for connecting the dry batteries in series and to binding posts on the terminal panel.

(3) The relay is of great sensitivity, having a large number of turns on the coil; the resistance of which is 1,950 ohms. The moving contact point is mounted on the pivoted armature, at the end away from the coil. Stops for motion of armature both backward and forward, a return tension spring, and a coil spring bumper are parts of

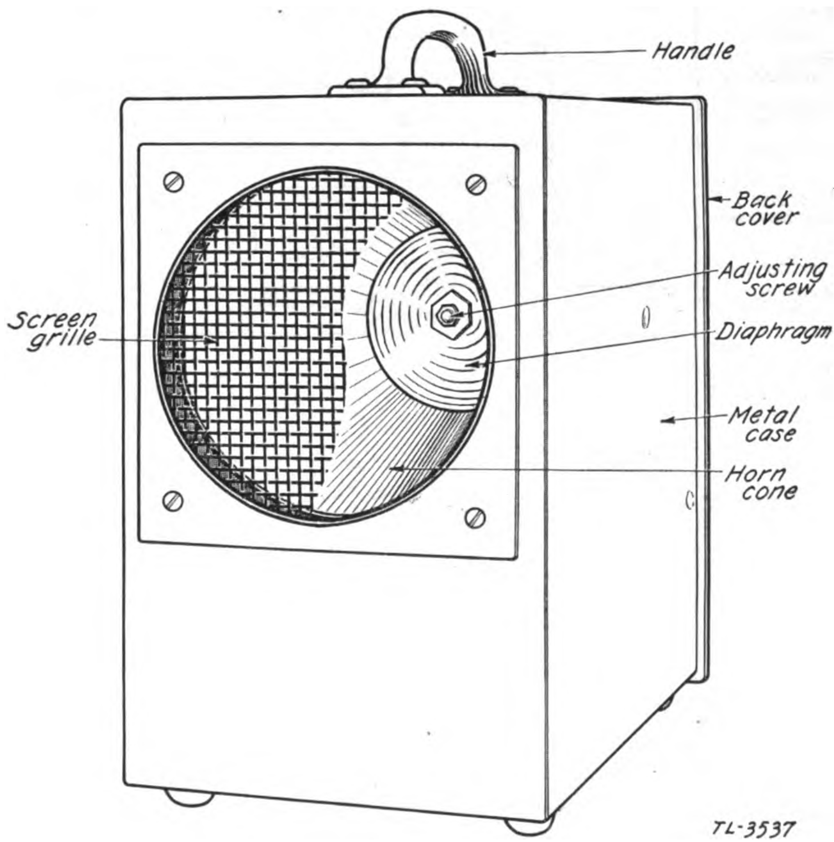


FIGURE 9.—Time interval signal BE-65—front view.

the relay, the entire mechanism being mounted on an insulating plate· The relay coil is connected to the terminals of the binding posts marked LINE and the contact which it operates is in the horn magnet circuit.

(4) The vibrator-diaphragm-resonator assembly, or horn assembly, is of extremely rugged construction (fig. 11). There is a strong U-shaped electromagnet of only 0.1-ohm coil resistance. A diaphragm

is fastened to the armature of this magnet. A post is fastened to the diaphragm and passes back through the magnet to the magnet contact

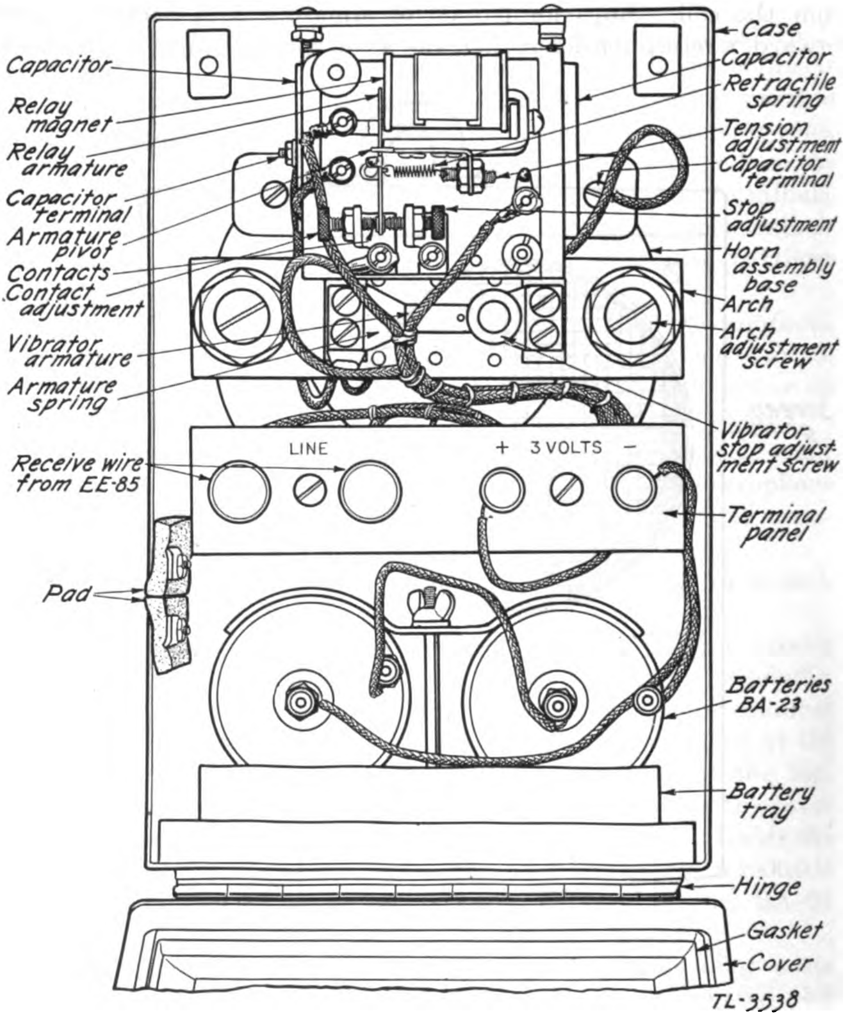


FIGURE 10.—Time interval signal BE-65—back with cover open.

assembly, or vibrator contact assembly. A 6-microfarad capacitor is connected in parallel across the vibrator contact, as part of the vibrator circuit. A cone-shaped resonator is mounted in front of the diaphragm.

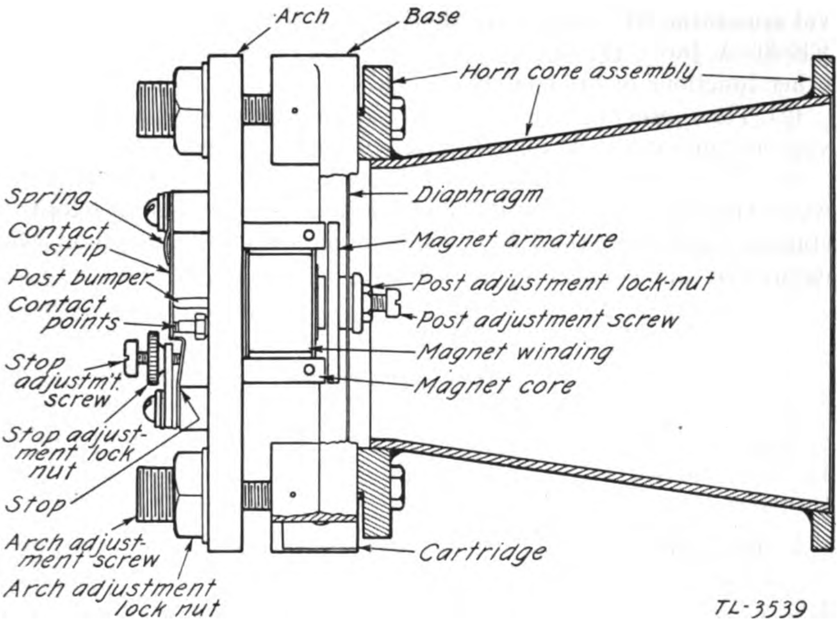


FIGURE 11.—Time interval signal BE-65—horn assembly.

4. Capabilities.—*a. Fixed seacoast artillery time interval equipment.*—(1) Accuracy of the motor governor, controlling factor of accuracy of time intervals, of time interval apparatus EE–86–A is well within the limits of accuracy of other functions of fire control and their corresponding equipment. Accuracy of the motor governor of time interval apparatus EE–56 is lower, but is commensurate with accuracy of the other parts. It is necessary that personnel whose functions are directed by time intervals be trained to react instantly upon hearing the bell, so that no lack of uniformity in time of observation or time of firing results.

(2) In providing 1-, 5-, 10-, 15-, 20-, 30-, 40-, and 60-second intervals, time interval apparatus EE–86–A provides all time intervals necessary for observation, for firing of all calibers of guns, and for all methods of placing fire on the target. Though fewer time intervals are provided by time interval apparatus EE–56, proper use of available intervals results in almost equal flexibility.

(3) If bells MC–153 are connected properly (par. 5*a*(3)(*d*)), either time interval apparatus EE–86–A or time interval apparatus EE–56 will provide signals at all stations at which bells are located.

b. Mobile seacoast artillery time interval equipment.—(1) Accuracy of the clock, controlling factor of accuracy of time intervals, of time interval apparatus EE-85 is lower than that of the motor governor of the EE-86-A, but is greater than the combined accuracy of equipment of other functions of fire control effected.

(2) Time interval apparatus EE-85 and associated equipment provide all time intervals necessary for observation and firing.

(3) Time interval apparatus EE-85 will provide signals at all places where time interval signals BE-65 are to be located and at all telephone stations which have the 1,000-cycle tone signals superimposed on their circuits by line connector unit EE-87.

Section II

EMPLOYMENT

5. Installation.—*a. Fixed seacoast artillery time interval systems.*—(1) *Responsibility.*—Installation of time interval apparatus EE-56 and EE-86-A in permanent coast artillery fire-control communication systems is under technical control of the corps area signal officer. Also, any major repair to the time interval system which is beyond the capacity of local coast artillery troops is referred to the corps area signal officer.

(2) *Location.*—Either the EE-56 or EE-86-A is installed in the fire-control switchboard room, as it is required that time interval apparatus provide time intervals for any or all elements of armament controlled from one fire-control switchboard, without relays and local power supply in distant stations. Whether connected directly to bells or through switching equipment, time interval apparatus is located conveniently to the fire-control switchboard and other switching equipment and where it is free from vibration and extreme temperature change.

(3) *Connection.*—(*a*) It is recommended that both time interval apparatus EE-56 and EE-86-A be used with switching equipment in providing signals at the bells of all stations. For the installation of either time interval apparatus, the binding posts marked 30-VOLT d-c are connected across the 30-volt switchboard battery supply bus by running two lines directly to switchboard BD-65 (power panel). When time interval apparatus EE-56 is used with switchboard BD-15 (switching panel) and frame FM-5 (fig. 12), each time interval binding post 10, 15, 20, and 30 is connected to the corresponding time interval bus 10, 15, 20, or 30 of the BD-15, and the common binding post C is

connected through the 30-volt switchboard battery supply bus (at the BD-65) to the common bus C of the BD-15. Switchboard BD-15 provides the desired time interval for any gun battery and frame FM-5 distributes the time interval to all bells within the battery. In effect, time interval apparatus program circuit, battery, switchboard, frame, and bell are connected in series.

(*b*) Either time interval apparatus EE-56 or EE-86-A is used with switchboard BD-74 or BD-78. Both switchboards have a double row of jacks in each section, an upper row of line jacks and a lower row of tie jacks, as shown in figure 13. The common binding post C of the EE-86-A is connected through the 30-volt switchboard battery supply bus (at the BD-65) to the tip terminals T1 of all tie jacks and the tip terminals T of all line jacks of the BD-74 or BD-78 which are used to furnish any of the eight time intervals. Each time

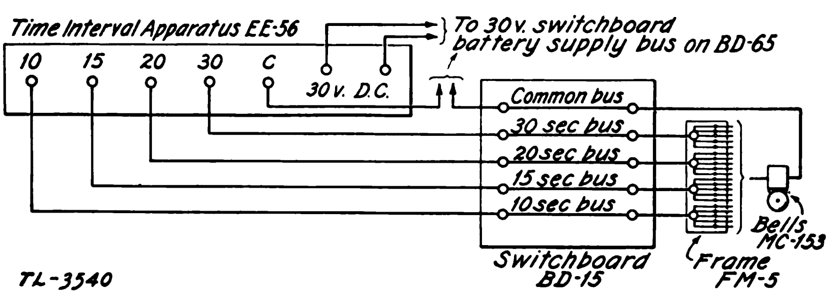


FIGURE 12.—Time interval apparatus EE-56—connection through switching equipment.

interval binding post (1, 5, 10, 15, 20, 30, 40, and 60) is connected to the sleeve terminals R1 of the tie jacks and the sleeve terminals R of the line jacks which are designated as furnishing that particular time interval. The line which runs to the bells of each battery is connected to the tip terminal T and the sleeve terminal R of one of the tie jacks which furnishes that time interval which is customarily used by that battery. Careful examination of figure 13 shows that when no plug is in the tie jack to which the line of the particular battery is connected, the customary time interval is connected directly to that battery. If another time interval is desired, a patching cord is plugged into a line jack designated as furnishing the newly desired time interval and into the tie jack to which the line of that battery is connected. Plugging into the tie jack disconnects the formerly desired time interval circuit at the tie jack and applies the presently desired time interval supplied by the patching cord. Thus each battery receives its customary time interval without the use of patching cords and their use is resorted to only under unusual circumstances requiring a different time interval, which then is available at a selected number of line jacks. In effect, time interval apparatus EE–86–A, 30-volt battery supply, switchboard BD–74 or BD–78, and bells MC–153 complete a series circuit. Very few EE–86–A have been procured and at the time of writing none of them have been installed. All switchboards BD–74 and BD–78 in use are connected to time interval apparatus EE–56. The connections are similar to those described above except that only 10-, 15-, 20- and 30-second intervals are available.

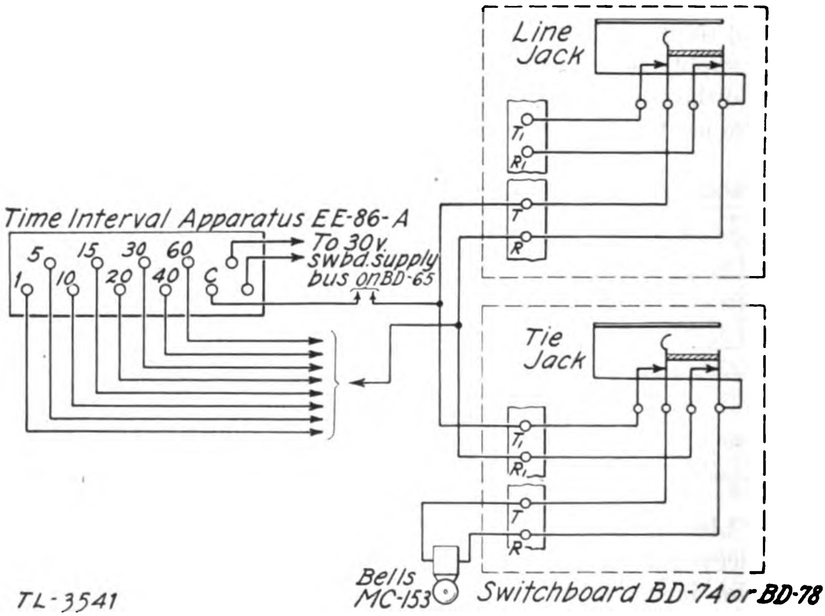


FIGURE 13.—Time interval apparatus EE–86–A—connection through switching equipment.

(*c*) If the bells are connected directly to the time interval apparatus without the use of any switching equipment, the arrangement is a series connection of time interval apparatus, battery supply, and bell (figs. 12 and 13).

(*d*) Time interval apparatus EE–86–A is designed to operate with bells MC–153, and it is recommended that bells MC–153 be used also with the time interval apparatus EE–56, although the EE–56 was originally designed for use with several older types of bells. For best operation it is suggested that the two coils of each bell MC–153 be connected in parallel up to the distance where the line loop resistance is 500 ohms, and in series beyond that point. Whether one or several bells are connected to one line depends on positions of the bells in relation to each other and distances of the bells from the time interval source. Also, if several bells are connected to one line, determination of whether the bells should be connected in series or parallel with each other depends on the distance from the time interval source and the number of bells connected. Never does one line carry bells of more than one seacoast artillery battery. The characteristics of the bell-wiring system which must be considered in designing the system are that 15 bolts are required to operate each bell and that the calculated direct-current resistance of the line and bells between the source and a particular bell should be approximately equal to and never appreciably greater than the resistance offered by that bell.

b. Mobile seacoast artillery time interval equipment.—(1) *Responsibility.*—Installation of time interval apparatus EE–85 and associated equipment, line connector unit EE–87, and time interval signal BE–65, is the responsibility of the gun battery in either tractor-drawn or railway seacoast artillery. Each gun battery is allotted one time interval apparatus EE–85, one line connector unit EE–87, and five time interval signals BE–65, in addition to the necessary number of storage batteries.

(2) *Location.*—(*a*) Time interval apparatus EE–85 is installed in the plotting room*, in a convenient and safe place, preferably in a place which allows space for associated equipment and which also is easily accessible to the telephone strip into which come readers' telephone circuits. Line connector unit EE–87 is installed in the plotting room adjacent to the EE–85 (fig. 14).

(*b*) Time interval signals BE–65 are installed at gun positions and in the plotting room in the manner best suited to assure that firing crews of all guns and range and fire-control crews will hear all signals easily. This arrangement may be for a BE–65 at each gun, one for two guns, etc., depending on distances between guns and the decision of the battery commander. In addition there should be at least one time interval signal BE–65 in the plotting room (fig. 14). The one BE–65 in the plotting room provides time interval signals for the plotting room stations of range, deflection, and battery order nets, while those at the guns provide signals for the gun position stations of these same nets. For this reason it is not obligatory to superimpose tone on telephones to these stations (fig. 14).

(3) *Connection.*—(*a*) Both time interval apparatus EE–85 and line connector unit EE–87 are connected to the same 12-volt battery power supply. Care must be taken to connect the battery to the correct

* The plotting room may be a tent, a railway car, or any other predesignated location.

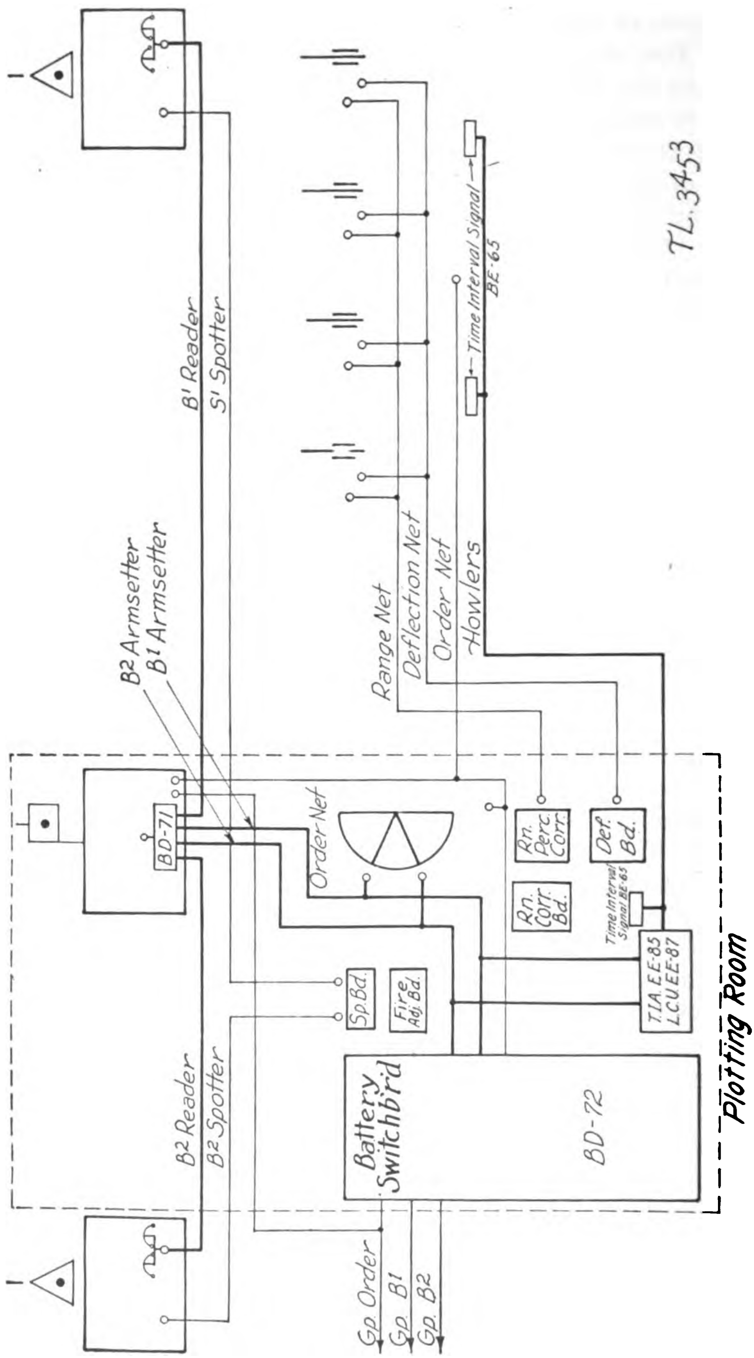


FIGURE 14.—Time interval equipments in mobile seacoast artillery.

binding posts as designated plus or minus or +12 VOLTS– on the EE–85 and EE–87.

(*b*) The binding post of the EE–85 marked C and the one required

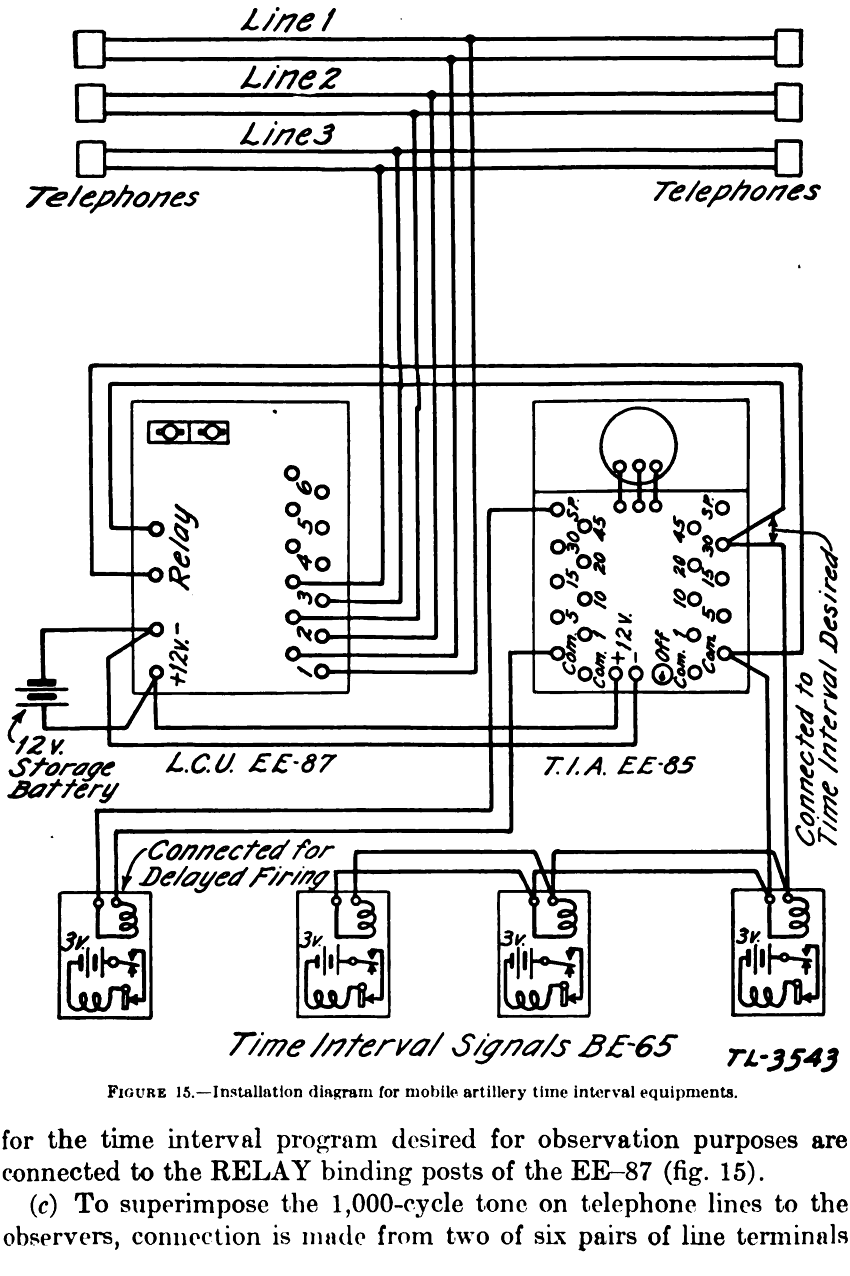


FIGURE 15.—Installation diagram for mobile artillery time interval equipments.

for the time interval program desired for observation purposes are connected to the RELAY binding posts of the EE–87 (fig. 15).

(*c*) To superimpose the 1,000-cycle tone on telephone lines to the observers, connection is made from two of six pairs of line terminals of the EE-87 to the two armsetters' telephone lines (fig. 14), preferably at the terminal strip. Because the armsetters' lines are connected directly to the readers and because observers' headsets are connected to readers' telephones in parallel with readers' headsets, tone is available to observers.

(*d*) The other four pairs of line terminals of the line connector may be used, if desired, for a third observer, to the two spotters' lines, to the range net, to the deflection net, or to the battery order net. If any of these extra lines are used, it will be principally for supplementary coordination, because the signals of the time interval signals BE-65 will be available to all mentioned except the spotters who are concerned with the splash or impact of the projectile.

(*e*) Similarly, the common C and time interval binding posts of the EE-85 which provide the desired firing time interval program are connected to the time interval signals BE-65 at the binding posts marked LINE. Delayed firing programs or different programs may be desired for different guns, but all time interval signals BE-65 for which the same time interval program is desired should be connected in parallel to keep voltage drops at a minimum and to assure good operation of every BE-65 (fig. 15).

(*f*) The two batteries BA-23 of each BE-65 are connected in series and to the binding posts +3 VOLTS−, care being taken to connect the plus binding post of one battery to the terminal strip binding post marked plus, and the negative binding post of the other battery to the terminal strip binding post marked minus. *Center binding post of BA-23 is positive.* **Caution:** The two batteries BA-23 must be disconnected from the terminal strip binding posts (fig. 10) when time interval signal BE-65 is not in use. This prevents battery drain if the sensitive relay should close during handling, and assures long life for the batteries.

6. Preparation for use.—*a. Fixed seacoast artillery time interval equipment.*—While no preliminary adjustment should usually be necessary for time interval apparatus EE-56 or EE-86-A, it may be necessary to check the governor adjustment.

(1) The governor adjustment of the EE-56 may be checked to sufficient accuracy with the use of only a stop watch. Using the small tension adjustment screw on the rotating arm of the governor (fig. 16) and timing the revolution of a mark on one of the disks, the governor may be set so that the disk arbor rotates at the required one revolution per minute, and correspondingly, the motor runs at 1,280 revolutions per minute within desired limits of accuracy. To increase the speed of the motor the screw is turned in a counterclockwise direction.

(2) The governor of time interval apparatus EE–86–A also may be adjusted to a very high degree of accuracy.

(*a*) The stroboscopic tuning fork (fig. 3) affords a positive and direct means of adjustment in connection with the use of the adjusting screw which changes the tension on the secondary spring of the governor (fig. 3). Remove the cover from the governor housing by loosening the four screws holding it in place. Remove the stroboscopic tuning fork from its compartment in the rear of the base of the apparatus. Place a light in such position that it illuminates the governor thoroughly, and shade it so that it does not shine in the eyes of the observer at the front of the apparatus. Pinch the tines of the fork to start vibration and view the rotating arm of the governor through the slots in the brass pieces at the ends of the tines of the fork. To obtain the sharpest pattern it will be necessary to turn the fork so that the plane of the viewing slots form an acute angle with the eye, thus narrowing the angle of vision. For best results in viewing the governor pattern, close the eye which is not being used.

(*b*) If the governor is correctly adjusted and the motor is running at correct speed, the viewing eye should see a sharp pattern of the rotating governor arm which may oscillate slightly back and forth. If the apparent motion of the governor is continuously in one direction, the governor should be adjusted by means of the knurled-head screw at the front of the extension arm near the top of the shaft. If the apparent motion of the governor arm is clockwise (when viewed through the slots in the fork), turn the adjusting screw in a clockwise direction to bring the motor to correct speed. If the apparent motion of the governor arm is counterclockwise, turn the adjusting screw in a counterclockwise direction to bring the motor to correct speed. Correct speed of the motor will be indicated when the viewing eye sees the sharp slowly oscillating pattern of the governor arm as previously described. In general, when it is necessary to speed up the motor, turn the governor adjusting screw slightly in a clockwise direction, and when it is necessary to slow down the motor, turn the governor adjusting screw slightly in a counterclockwise direction. Directly in back of the knurled head of the screw, the proper direction of turning the screw is designated by an arrow and the words FAST—SLOW.

b. Time interval equipment of mobile seacoast artillery.—This equipment, including time interval apparatus EE–85, line connector unit EE–87, and time interval signal BE–65, requires no preliminary adjustment.

7. Operation.—*a. Fixed seacoast artillery time interval equipment.*—(1) The organizational unit of fixed seacoast artillery which is responsible for operation of the fire-control telephone communication system is responsible also for operation of the time interval system. This responsibility depends upon the harbor-defense project and the desires of the local commanders.

(2) Since all time interval program circuits of either time interval apparatus EE-56 or EE-86-A, when operated with switching equipment, are connected directly to busses at all times, no changes in connections need be made at any time during operation. The starting switch must be turned to the ON position and the apparatus runs with no further attention, other than routine maintenance inspection. If any change of time interval program to any battery is desired, the change is made by means of the switching equipment in use.

(3) If time interval programs are connected to bells directly, when using either EE-56 or EE-86-A, any change in program is made by changing the connection at the terminal strip. The wire to the particular battery is changed from one time interval binding post to the desired time interval binding post (figs. 1 and 2). No change in the wire to the common connection binding post C is necessary.

(4) The metal cover of the governor housing of the EE-86-A must be fastened securely in place to reduce electrical disturbance. The wooden covers must be placed on both the EE-56 and EE-86-A for protection from dust and moisture.

b. Mobile seacoast artillery time interval equipment.—(1) Each gun battery of either tractor-drawn or railway artillery is responsible for operation of time interval apparatus EE-85 and associated equipment, line connector unit EE-87, and time interval signals BE-65.

(2) Once all connections have been made to supply observing and firing intervals as prescribed, no particular supervision is necessary other than to see that all equipment is functioning properly. The toggle switch of the time interval apparatus EE-85 (fig. 4) is thrown to the ON position to start the generation of time interval impulses transmitted to both line connector unit EE-87 and time interval signals BE-65.

(3) The starting key of the line connector unit EE-87 (fig. 7) is thrown either to position INT. 1 or to position INT. 2. The hummers connected to either position give signals of equal strength and clearness when new. After some use it may be more desirable to use one hummer than the other. The key of the EE-87 controlling loudness is thrown to position marked LOUD, MED., or LOW, whichever provides the most desirable signal in the head sets of observers and readers.

(4) Any change in time interval program for observing interval or

firing interval may be made by changing connections to either time interval signals BE–65 or line connector unit EE–87 at the time interval apparatus EE–85 (fig. 5). It is necessary to change only the wire to the time interval binding post, the common connection C remaining unchanged.

(5) When equipment is operating, all covers are fastened securely so that the several units will be protected from dust and moisture. This is possible because each is provided with openings for entrance of all connecting wires.

Section III

DETAILED FUNCTIONING OF PARTS

8. Time interval apparatus EE–56.—*a*. The motor of time interval apparatus EE–56 is the prime mover actuating all mechanisms which operate the several electrical contacts. These contacts in turn supply the various time interval impulses by completing circuits through a 30-volt battery power supply and switching equipment to the bells. As controlled by the adjustable-speed centrifugal-type governor, the motor runs at 1,280 revolutions per minute, if the power supply remains at from 27 to 30 volts direct current.

b. (1) The action of the governor is to open and close a contact which places a shunt across the 100-ohm resistor in series with the motor. This is done by the centrifugal force on the small weight as it rotates (fig. 16). This force acts against a tension spring, tending to cause the lever or strip to be lowered. Since the lower or movable governor contact is mounted on this strip, the contact is broken if the speed is so great that the strip is moved downward far enough. Conversely, as the motor slows up the centrifugal force is reduced, the strip is raised, the contact is closed, and the resistor is again shunted out of the motor circuit. These effects alternate continually as the governor rotates, keeping the motor at a constant speed.

(2) When the resistor is in series with the circuit of the series field motor, resistance of the circuit is greater and the field current less. Also, the reduction in field current slows the motor. As the shunt again is placed across the resistor, in series with the motor field winding, by reduced centrifugal force, resistance is reduced and the current and speed increase until the shunting contact is broken and the sequence is repeated.

(3) The lower, movable contact is connected through the governor parts and the shaft to the contact spring which is wired to one side of the resistor. The upper, stationary contact is connected through the upper contact screw, which is insulated from the rest of the governor parts, to a terminal wired to the other side of the resistor.

(4) There are two possible adjustments which change the motor speed at which the contact is made and broken (fig. 16). One is the tension adjustment of the governor spring which, when turned counterclockwise, increases the tension of the spring. The speed of the motor necessary to overcome this tension, by creating enough force on

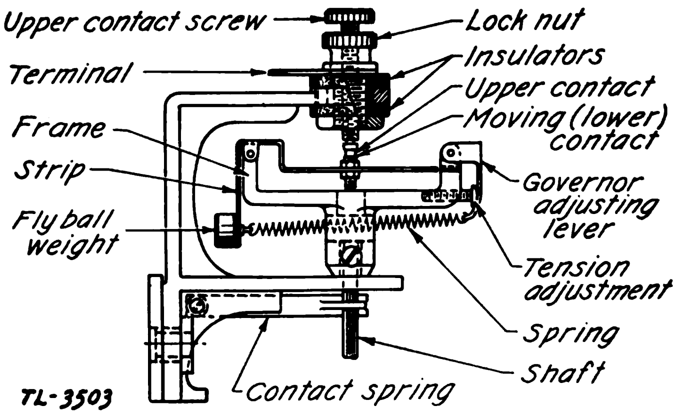


FIGURE 16.—Time interval apparatus EE-56—governor.

the weight to break the contact, is increased. Turning the adjusting screw clockwise decreases the motor speed. The other adjustment, by moving the upper contact screw, is less precise. However, if the screw is turned clockwise or downward, the contact is lowered and it takes greater movement of the strip and weight, and consequently higher speed, to break the contact. Turning this contact screw counterclockwise decreases the motor speed.

c. The reduction in speed afforded by the gear train between motor shaft and spindle shaft of the cam-arbor assembly is such that the arbor assembly rotates at one revolution per minute. The entire program group assembly is synchronized so that at least once every complete revolution all firing-signal cams, or final signals of the time interval cam groups, strike their corresponding rocker arms simultaneously.

d. (1) As each cam projection strikes the striking block at the upper end of the rocker arm, the rocker arm pivots (fig. 17). Then the lower, moving contact, mounted on the strip fastened to the rocker arm, makes contact with the upper contact as long as the rocker arm is held down by the cam projection. As the cam projection releases the rocker arm, the lower contact falls because of its weight and the tension of the retractile spring.

(2) The cam-contactor assemblies are mounted on the base of the casting and are provided with two adjustments. The first adjustment regulates the duration of contact closure. This adjustment also per-

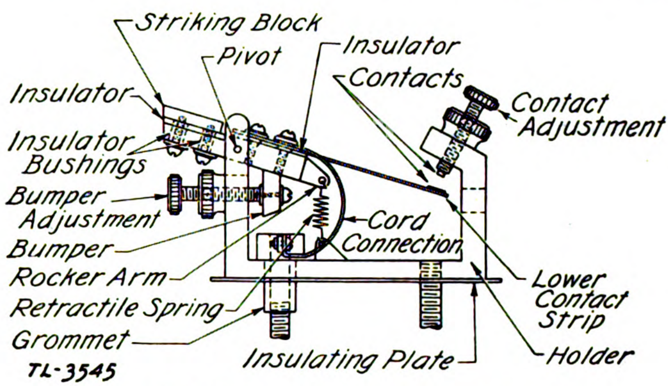


FIGURE 17.—Time interval apparatus EE-56—cam contactor.

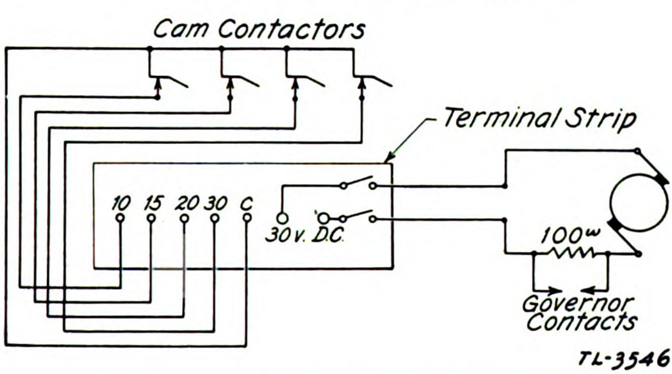


FIGURE 18.—Time interval apparatus EE-56—circuit diagram.

mits adjustment of the time of making contact so that all circuits may be made simultaneously at the synchronized position of the cam arbor. The second adjustment regulates the bumper position to secure quiet operation of the contactors and avoid metallic noise.

(3) In the electrical circuit, the terminal of the moving contact of all contactors is brought out to the common terminal C on the terminal strip, and the other terminals of the contacts are brought out individually to the terminals on the terminal strip marked 10, 15, 20, or 30, corresponding with the 10-, 15-, 20-, or 30-second time interval cam disks (fig. 18).

9. Time interval apparatus EE-86-A.—*a*. The motor of time interval apparatus EE-86-A differs from that of time interval apparatus EE-56 only in that it is designed to run at 1,380 revolutions per minute and that an electrical interference suppressor circuit is provided (fig. 19).

b. (1) The mechanical action of the governor is different from that of the EE-56, though the use of centrifugal force in making and breaking an electrical contact is fundamental. In the EE-56, the action of centrifugal force on the tension spring of the moving arm causes the strip to be lowered. However, on the governor of the EE-86-A, the vertical movement of this strip as it whirls is transmitted to a second, nonturning strip by means of a small swivel-like joint. This joint consists of tiny jaws fastened to the lower, rotating strip, which clutch a projection from the upper, stationary strip, and impart vertical movement but no rotating motion to the second strip (fig. 3).

(2) This second strip is pivoted at one end, moving against the tension of the coil spring attached to the moving arm of the governor, but aided by the tension of a coil spring attached to a stationary arm, and operates the lower contact mounted on the other end. This contact moves only up and down, so that the excessive wear of the rotating lower contact of the EE-56 is eliminated and necessary adjustments are greatly reduced in frequency and amount.

(3) Adjustment of the governor is made by turning a small screw on the stationary arm which is attached to the second, nonrotating spring. This screw adjustment is made as explained in paragraph 6*a*(2). There are also the same two adjustments which are part of the governor of the EE-56, the up-and-down adjustment of the upper contact and the adjustment of the tension spring mounted on the rotating arm. However, the primary screw adjustment explained in detail is the only one necessary for operating personnel to use.

(4) The electrical action differs only in that the resistor in series with the motor is a 125-ohm resistor, and that an interference suppressor across the contact consisting of a 0.1-microfarad capacitor in series with a 100-ohm resistor, is provided (fig. 19).

c. The cam-arbor assembly of the EE-86-A is driven like that of the EE-56, but has the additional gear train to drive the shaft of the eighth cam disk from the main shaft, increasing the speed from 1 revolution per minute to 1½ revolutions per minute, or from 60 seconds to 40 seconds for a complete revolution. The entire program group assembly is synchronized so that once for every complete revolution of the 60-second disk all firing signal cams strike their corresponding rocker arms simultaneously.

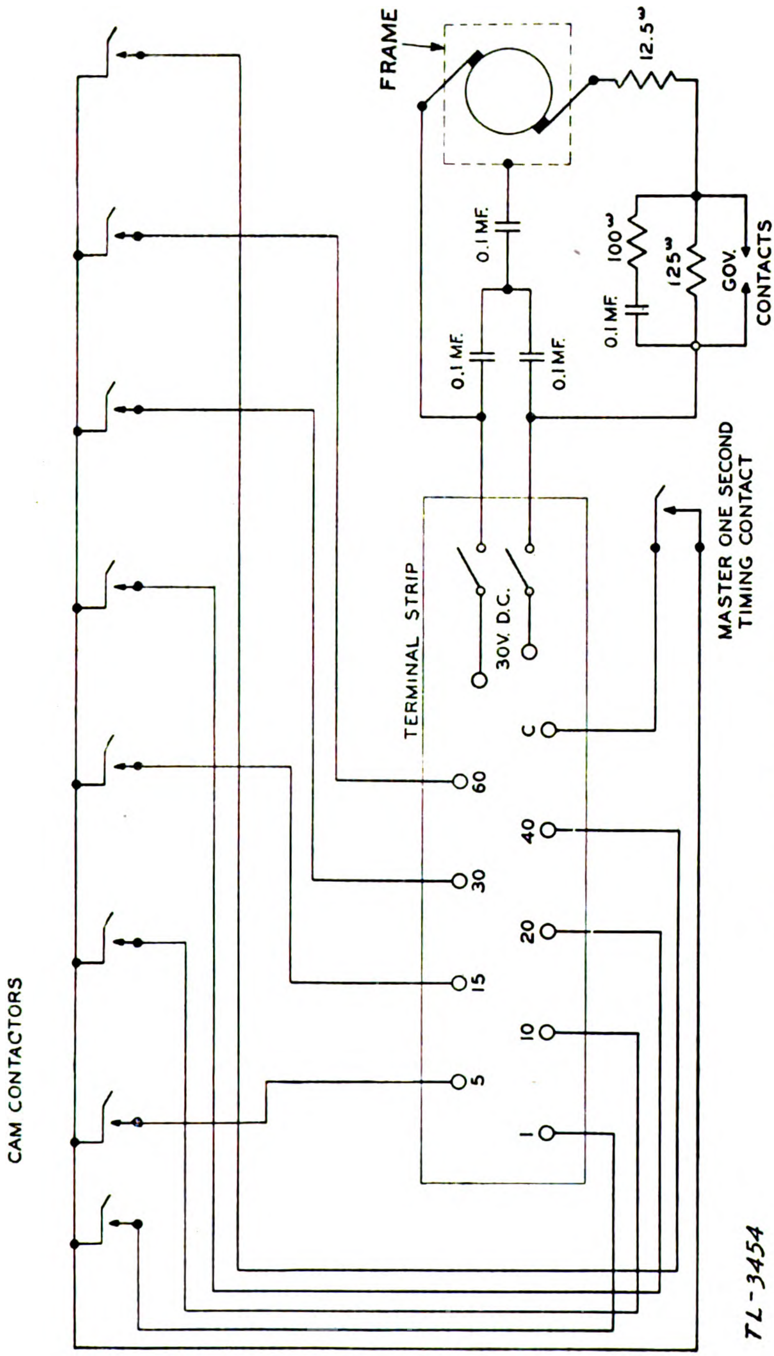


FIGURE 19.—Time interval apparatus EE-86-A—circuit diagram.

d. Action and adjustments of the cam-contactor assemblies of the EE-86-A are similar to those of the EE-56. However, the importance of the adjustments is reduced by use of the master 1-second timing contact. The master 1-second timing contact cam (fig. 3) is driven at one revolution per second, through a worm gear, by the same worm which drives the cam-arbor drive worm gear. The position of the master cam on its shaft is such that, if necessary adjustments are made on the cam-contactor assembly, all contacts which are actuated by disk cams close and open before the corresponding operation of the master 1-second timing contact. The master cam is designed so that it will hold the master contact closed until after any or all of the time interval circuits, which were closed that particular second, are opened by the disk cam projections (fig. 3). The contact is closed by the raised portion of the master cam which operates the contact spring, the spring opening the contact.

e. From *d* above it is seen that when any disk cam closes the contact of its circuit for any particular second, that circuit is completed by the master contact and opened by the disk cam contact. Thus the master cam assures the accuracy of every time interval, and the cam-contactor assembly adjustments determine the length of contact closure. As long as the governor is correctly adjusted with the stroboscopic tuning fork, the time interval is accurate because of the master cam. The time intervals remain constant over a long period because of the carefully adjusted motor speed.

10. Time interval apparatus EE-85.—*a.* The clock, or electromagnetic motor, of time interval apparatus EE-85 operates the motor contact, its own driving circuit contact, the auxiliary contact, the contact which completes the driving magnet circuit, and also the time interval program circuits (fig. 20). In the stopped position of the clock, the mechanism holds the motor contact closed so that when the apparatus is turned on and battery applied, the circuit is completed through the electromagnet, giving an impulse to the bar. The contact-operating mechanism is so constructed that the contact is closed once for each complete oscillation of the bar and weight, the time of oscillation being 1 second. The capacitor and resistor bridged in series across the motor contact prevent electrical interference with radio and other communications.

b. The auxiliary contact remains closed approximately 0.4 second during each 1-second oscillation of the clock. Each time it closes it completes one circuit through battery, switch, and driving magnet; another circuit to common connection C and 1-second interval binding posts 1 through battery and switch, which provides the 1-second interval direct from the auxiliary contact; and all circuits to the com-

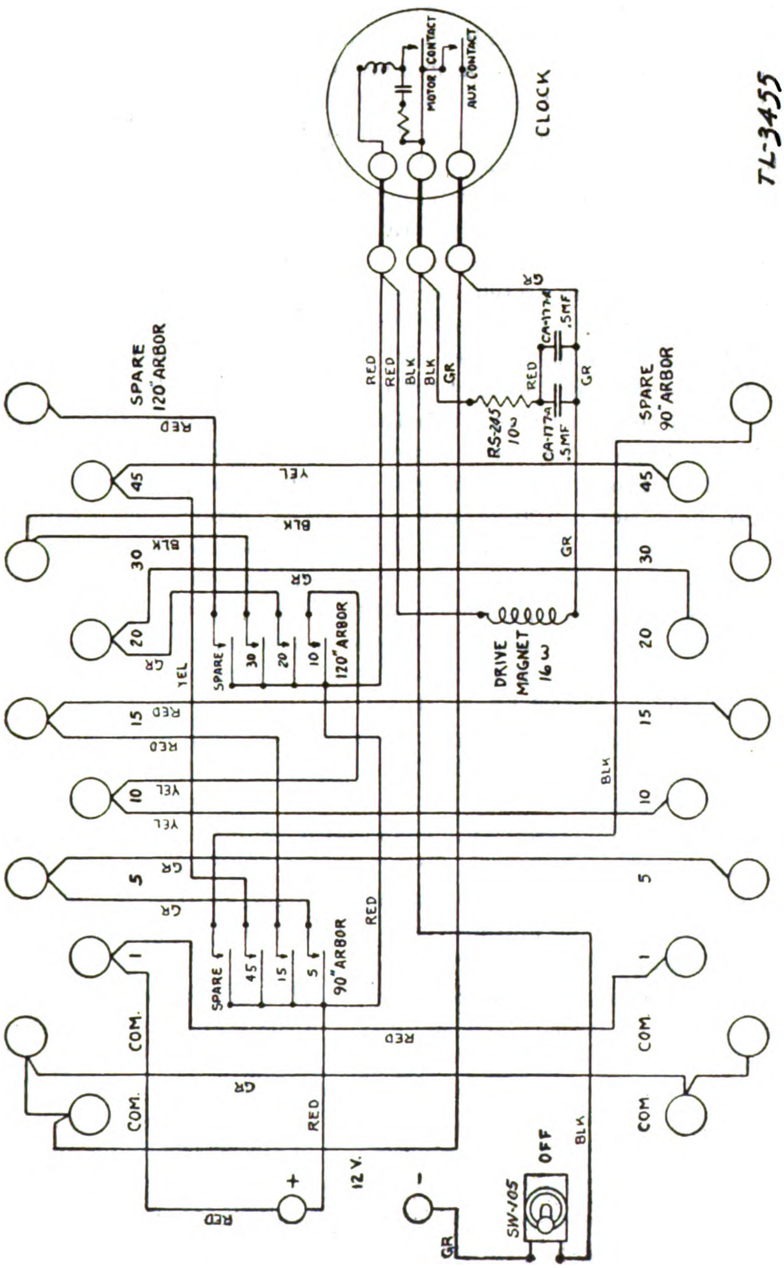


FIGURE 20.—Time interval apparatus EE-85—circuit diagram.

mon C and the other interval binding posts through battery, switch, and any interval wiping contact which is closed at the time (fig. 20).

c. As the circuit is completed through the driving magnet, the magnet armature moves the ratchet bar against the tension of the two springs. As the circuit is broken, the armature is released and the armature and ratchet bar are returned by the spring tension (fig. 6). As the ratchet bar moves back, the fitting across the long slot in the bar contacts a tooth of the ratchet wheel and turns the wheel one notch. There are 90 teeth on the ratchet wheel, so that it makes one complete revolution in 90 seconds. The small pawl, which is kept against the teeth of the ratchet wheel by the flat spring, prevents the ratchet wheel from backing up. The tension adjustment on the one spring which returns the ratchet bar, and the stop adjustments of the magnet armature stop and of the stop at the ratchet-wheel end of the ratchet bar, determine the proper action and travel of the ratchet wheel.

d. As the 90-second arbor is turned by the ratchet, it turns the 120-second arbor through two spur gears, so that the latter makes one complete revolution in 120 seconds. As the two arbors turn, the raised portions of the disks mounted on the arbors operate the wiping contacts against the action of flat contact springs which make the spring shoes ride firmly on the peripheries of the disks (fig. 6). As the moving contacts which are mounted on the contact springs are operated by the raised portions of the disks, the contacts for the particular time interval program disks are closed.

e. The disk-operated contacts close before and open after the auxiliary contact, whether the raised portion of the disk includes signals for 3 seconds or for only 1 second. Thus accuracy of length of the interval and duration of the signal both are determined by operation of the auxiliary contact. The circuit, consisting of a resistor in series with two capacitors in parallel, bridged across the auxiliary contact, reduces arcing and prevents electrical interference with radio and other communications (fig. 20).

11. Line connector unit EE-87.—*a*. The fundamental operation of line connector unit EE-87 is actuation of the multiple relay by time interval impulses generated by time interval apparatus EE-85. The coil of the relay is connected to the binding posts by which the EE-85 is connected to the EE-87 (fig. 15). When the coil is energized it moves the armature about the pivot point of the relay and against the force of the return spring of each contact. All seven contacts are closed simultaneously, completing one circuit through the battery, resistor RS-55, and the primary coil, transmitter, and receiver of the hummer in use, and six circuits each through a transformer secondary, and a capacitor CA-166 to the line binding posts (fig. 21).

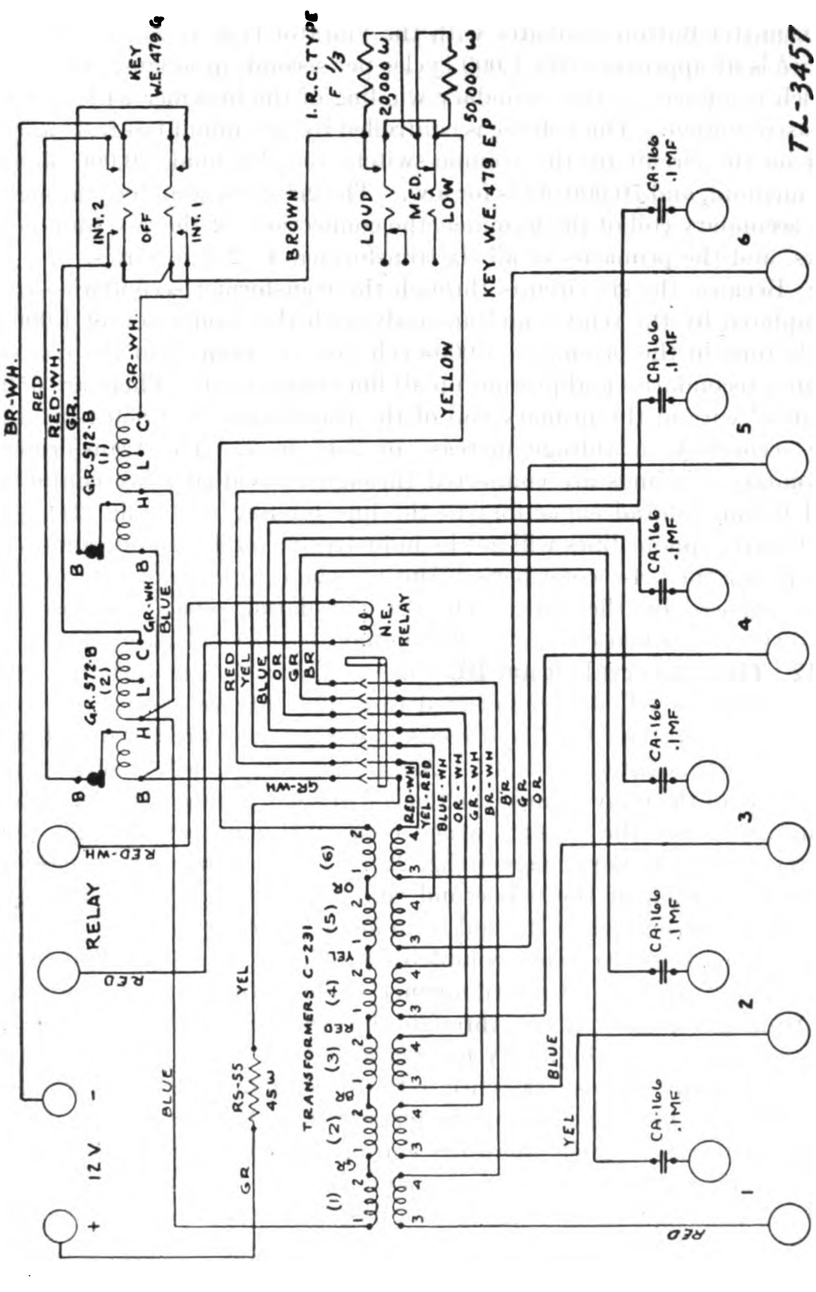


FIGURE 21.—Line connector unit EE-87—circuit diagram.

b. As the contact completes the circuit through the one push-pull type microphone hummer which is turned on, the carbon-granule transmitter button resonates with the vibrator-type receiver. Resonance is at approximately 1,000 cycles per second, producing the tone which is induced in the secondary winding of the hummer with an increased voltage. The volume is controlled by the amount of resistance put on the circuit by the volume switch: zero for loud, 20,000 ohms for medium, and 70,000 ohms for low. The circuit is complete through the secondary coil of the hummer, the connections of the two hummer keys, and the primaries of all six transformers C-231 in series.

c. Because the six circuits through the transformer secondaries are completed by the relay simultaneously with the production of 1,000-cycle tone in the primaries, 1,000-cycle tone is induced in the transformer secondaries and put out on all lines connected. There are 350 turns of wire in the primary coil of the transformer and 850 turns in the secondary, a voltage increase of 2.43 to 1. The transformer secondary windings are connected through individual relay contacts and 0.1-microfarad capacitors to the line binding posts (fig. 21), so that the telephone lines will not be inductively coupled to one another except for the 0.4-second periods during which tone is actually being superimposed on the lines. The 0.1-microfarad capacitors prevent battery drain when connected to common battery telephone lines.

12. Time interval signal BE-65.—*a*. The coil of the relay of time interval signal BE-65 is connected to a time interval circuit of time interval apparatus EE-85 and receives the impulses produced on that particular time interval circuit. As the coil is energized, it moves the armature of the relay against the tension of a coil spring (fig. 10). The armature closes the contact which completes a circuit through the batteries and the horn magnet (fig. 22). The contact remains closed for the duration of the 0.4-second signal impulse, being opened by the spring tension when the coil is no longer energized.

b. As the sensitive relay completes the horn circuit, the two batteries BA-23 energize the horn magnet. The horn magnet is a strong electromagnet, the current through the coil being relatively great. The magnet moves the heavy magnet armature which is attached to the diaphragm. A post, attached to the diaphragm, runs back through the center of the armature and the magnet (fig. 11). As the armature is drawn to the magnet, the other end of this post strikes the heavy contact spring of the vibrator contact. Because the moving contact point is mounted on this spring, the post breaks the circuit through the batteries and horn magnet.

c. The circuit may now be completed only through the 6-microfarad capacitor, which will pass only current of changing voltage, no direct current (fig. 22). However, the magnet coil does not lose its energy instantaneously; instead, the energy falls rapidly to zero. The capacitor will pass this changing current very readily. Therefore, its effect on the entire circuit through batteries, horn magnet, and capacitor is to increase the speed with which the magnet loses its energy.

d. When the horn magnet loses its energy, the armature is released, the diaphragm tends to return to its original position, and the contact spring forces the post away and remakes the vibrator contact. This

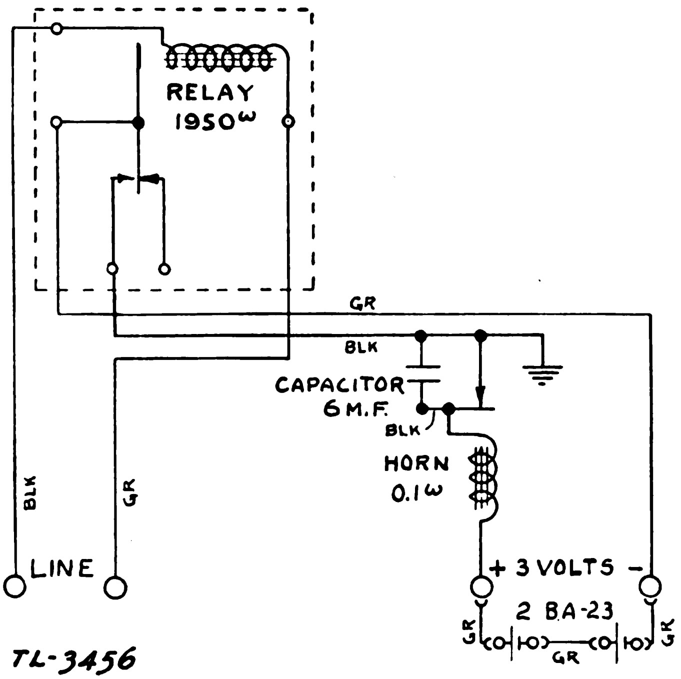


FIGURE 22.—Time interval signal BE-65—circuit diagram.

shunts the capacitor out of the circuit, again a circuit is complete for the passage of direct current through batteries and horn magnet, the magnet is energized, and the motion of the armature moves the diaphragm and breaks the magnet (vibrator) contact.

e. The rapidity with which the magnet is energized and then loses its energy, with the aid of the capacitor, is such that this action occurs many times during the 0.4-second when the relay contact is closed. Thus, the metal diaphragm vibrates rapidly, giving off a hornlike sound, the sound being intensified by the shape of the cone. The capacitor also serves to reduce arcing at the magnet contact and to prevent electrical interference with radio and other communications.

Section IV

SERVICING AND REPAIR

13. Servicing.—*a*. Servicing of time interval apparatus EE–56 and EE–86–A is limited to those minor repairs which may be made by competent mechanics of the organization which is responsible for operation of the fire-control communication system of the particular fixed seacoast artillery project. Major repair and replacement parts are the responsibility of the unit supply officer.

b. Servicing of time interval apparatus EE–85 and the associated line connector unit EE–87 and time interval signal BE–65 is the responsibility of mechanics of the communication section of a battery headquarters of mobile seacost artillery. Procurement of replacement parts and repairs which cannot be made with available tools is the responsibility of the unit supply officer.

c. Minor repairs made by mechanics of the responsible organizations include making the adjustments explained in section III and paragraph 16, cleaning contacts, and repairing electrical connections and circuits. Contacts should be cleaned with rough paper (not sandpaper) or a burnishing tool.

14. Inspection.—*a*. It is necessary to make routine inspections of time interval equipments to see that they are functioning properly and are free of dust and grease.

b. It is advisable to check the length of one of the time intervals being generated by time interval apparatus EE–56, EE–86–A, or EE–85, when it is being first put into use. In service, contacts of the governor of the EE–56 and EE–86–A wear and setting of the governor must be readjusted every 3 months as explained in paragraphs 8*b*(4) and 9*b*(3).

c. To maintain good operation it is necessary to make frequent inspections of all adjustments of contacts, spiral tension and flat springs, stops, bumpers, and vibrators. Also, all contact points should be inspected for cleanliness, and electrical circuits for broken wires or worn insulation and loose or poor connections.

15. Lubrication.—*a*. No lubrication is required for the motor of either time interval apparatus EE–56 or EE–86–A, because it is inclosed in a dustproof cover and the bearings are permanently packed in grease.

b. On the EE–86–A there are two oil cups, one inside the governor housing and one on the rear bracket of the frame casting. These cups are required to be filled every 6 months with a high-grade lubricant such as liquid petrolatum.

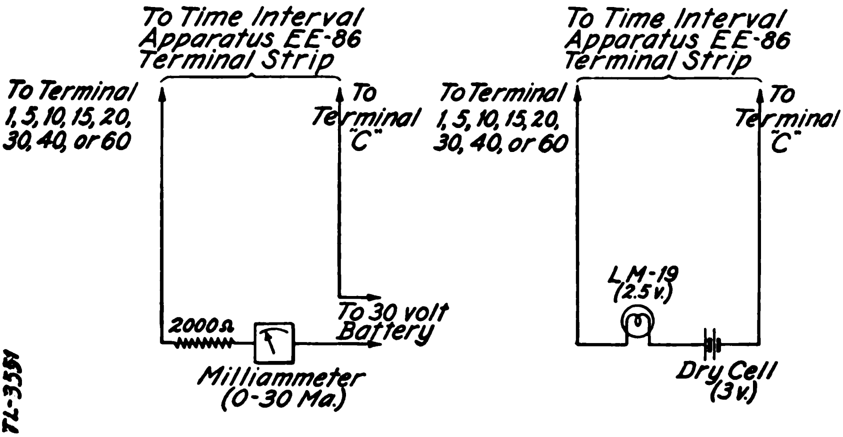
c. No lubrication is required for time interval apparatus EE–85, line connector unit EE–87, and time interval signal BE–65.

16. Special adjustments.—*a. Time interval apparatus EE–56.*—In addition to adjustments of the governor as explained in paragraph 8*b*(4), there are two adjustments of the cam-contactor assembly.

(1) *Duration-of-contact closure adjustment.*—The duration-of-contact closure, or length of time the contacts are closed, is adjustable from a minimum of 0.1 second to a maximum of 0.55 second. To secure this adjustment, use either of the test circuits illustrated in figure 23, which are used for adjusting both the EE–56 and the EE–86–A. Make connection to the time interval program circuit which it is desired to adjust. Since the normal speed of the motor is 1,280 revolutions per minute or 21.3 revolutions per second, the time in seconds for any given number of revolutions may be calculated by dividing the number of revolutions by 21.3. The duration-of-contact closure, therefore, is calculated from the number of revolutions of the governor arm (and hence the motor) from the time the contact closes to the time it opens. With the starting switch at the OFF position, rotate the governor manually in a counterclockwise direction and observe the milliammeter or light in the test circuit. ***Caution:*** Disconnect all lines from apparatus to battery supply bus except those shown in figure 23①. Note the position of the governor arm when the reading of the milliammeter in the test circuit first exceeds 10 milliamperes or the light begins to glow. Continue rotating the governor arm, counting the number of revolutions, until the milliammeter first drops to zero or the light is extinguished. The number of revolutions of the governor arm counted may then be translated into seconds by dividing by 21.3. The result will be the duration-of-contact closure when the motor is running at the speed of 1,280 revolutions per minute. In a similar manner, the interval between circuit operations in a program group or between similar points in adjacent program groups is obtained. If the duration-of-contact closure is not satisfactory, it may be changed. To increase the duration-of-contact closure, loosen the locknut on the appropriate adjusting screw (fig. 17) and turn the screw a few turns in a clockwise direction. To decrease the duration-of-contact closure, turn the adjusting screw in a counterclockwise direction. After an adjustment has been made, the duration-of-contact closure may be rechecked by the method previously used.

(2) *Adjustment for quiet operation.*—Adjustment of the rubber bumper to secure quiet operation is accomplished by means of the knurled head screws on the left-hand side of the contactor assembly just under the cam disks (fig. 17). The adjustment of this screw should be such that when the contactor arm falls off the cam projection it will first hit the rubber bumper attached to the screw and not the cam depression. Lock the adjusting screw with the locknut when the adjustment is obtained.

b. Time interval apparatus EE–86–A.—In addition to adjustments of the governor as explained in paragraph 9*b*(3), the same two adjustments are made of the cam-contactor assembly as in the EE–56. However, adjustment of the interval between circuit operations in the



① Milliammeter test circuit. ② Lamp test circuit.

FIGURE 23.—Test circuits for both time interval apparatus EE–56 and EE–86–A.

program group and between similar points in adjacent program groups is rendered unimportant by the master 1-second timing attachment. If this latter adjustment or test is used, it must be remembered that the speed is 1,380 revolutions per minute or 23 revolutions per second, the number of revolutions being divided by 23.

c. Time interval apparatus EE–85.—(1) The two extra uncut 90-second and two extra uncut 120-second arbor disks (fig. 5) may be cut for any program of intervals, synchronized, or with any desired delay. The desired program and holes for the synchronizing post are laid out with ruler, protractor, and compass. The holes are drilled and the circumference is cut out with a chisel and filed smooth.

(2) The driving mechanism of time interval apparatus EE–85 has several adjustments of the springs and stops which determine its

correct operation (fig. 6). The screw adjustment of tension of the spring which is fastened to the drive bar must be such that the spring will return the magnet armature and drive bar far enough to turn the ratchet wheel one notch, or far enough for the pawl to fall into place and to hold the wheel. This spring tension also pulls the drive bar down on the next notch as the armature is pulled to the magnet, and must be adjusted properly to do so. The stops of the armature and the drive bar must be so adjusted that the armature and the drive arm will return far enough to advance the ratchet wheel a complete notch, and that they will not return too far and operate loosely or allow the ratchet wheel to advance an extra notch. Each adjustment screw has a locking device.

(3) There are two possible adjustments of the arbor-cam contactor assemblies. To press the spring shoes of the contact springs of the time interval circuits against the disk with proper pressure, the screw in the slotted angle at the base of posts upon which the contacts are mounted may be loosened and the entire contactor assembly turned until the desired firmness of pressure is obtained (fig. 6). Also, to adjust the pressure of individual spring shoes on the disks, the contact springs may be bent adjacent to the mounting posts with a pair of longnose pliers until the desired pressure is obtained. The positions of the stationary contacts mounted on the terminal blocks with screws may be adjusted by turning the screws. These contacts must make and break easily under the motion imparted to the spring shoes by the raised portions of the disks.

d. Line connector unit EE-87.—(1) The contact springs of the multiple-contact relay may be adjusted by bending the top springs up or down with a pair of longnose pliers.

(2) The springs acting on the moving contact points of the two keys may be adjusted with longnose pliers to assure that the contacts make and break properly as the keys are thrown to their various positions.

(3) The vibrator of the hummer may be adjusted for spacing and proper operation with the small screw provided, which fastens the vibrating arm to the larger post upon which the coil is mounted.

e. Time interval signal BE-65.—(1) The armature of the small, sensitive relay may be adjusted for best operation by changing the spring tension with the screw adjustment provided and by adjusting the two screw stops (fig. 10).

(2) There are three adjustments which enter into the operation of the vibrator. While tone or volume may not be changed materially, the vibrator may be set for best operation.

(*a*) The stop of the contact spring of the vibrator must be adjusted so that the contact will make and break properly under action of the armature and post (fig. 11).

(*b*) The post is adjustable also, and access to its adjustment may be obtained by removing the screen at the front of the box (fig. 9). The post may be moved in or out by turning its slotted end (fig. 11) with a screw driver, a locknut being used to lock the adjustment. The post must be in such a position that the bumper will break the vibrator contact when the armature is pulled to the magnet, and will pull back far enough to allow the contact to be made under pressure of the spring when the armature is released.

(*c*) The arch mounted on the large base casting with the two heavy screws and upon which the vibrator contact is mounted must be parallel with the base casting. This position is adjusted by using the large screws with their locknuts (fig. 11).

SECTION V

LISTS OF REPLACEABLE PARTS

17. Time interval apparatus EE-56.—*a. Motor.*

See fig. no.	Stock no.	Name	Description	Function	Mfr.	Drawing no. (Mfr.'s)	Drawing no. (Sig. C.)
1	4H3056	EE-56	Time interval apparatus EE-56	Device for making and breaking electrical contacts at predetermined intervals; used at permanent seacoast defenses.			
1	4H3056/5	Motor	Series wound, 30-volt d-c, 1,280-rpm motor.	Prime mover	Emerson		
1	4H3056/6A	do	Series wound, 30-volt d-c, 1,280-rpm motor.	do	Diehl		
1	4H3056/6/1	Brush	Carbon brush	For Emerson motor			
1	4H3056/6.1/2	Spring	Brush spring	For Fort Wayne motor			
1	4H3056/6.2/1	Armature	Motor armature	For WE&M Co. 30-volt d-c, 1,280-rpm motor.	WE&M		
1	4H3056/6.2/3	Spring	Brush spring with wicking for grease cup.	For WE&M Co. motor			
1	4H3056/6.2/4	Wicking	Grease cup wicking	do			
1	4H3056/6.25	Brush	Carbon brush, 1 1/64" sq. x 9/16" long, with spring, 2 per set.	do			

b. Frame.

See fig. no.	Stock no.	Name	Description	Function	Mfr.	Drawing no. (Mfr.'s)	Drawing no. (Sig. C.)
1	4H3056/28	Bracket	Brass, black oxidized finish, 2½" long x 1 15/16" wide.	Motor mounting bracket			20,001D3.
1		Support	Tobin bronze, black oxidized finish, 1 51/64" long x 9/16" diam.	Support and bushing for shaft of worm wheel and containing drive pinion.			20,001D3.

c. Contacts.

See fig. no.	Stock no.	Name	Description	Function	Mfr.	Drawing no. (Mfr.'s)	Drawing no. (Sig. C.)
17	4H3056/40	Holder	Brass, brass oxidized finish, 2 13/16" x 5/8" x 1 23/32" high.	Mounting frame for contact assembly.			20,001D4.
17		Screw	Brass, 2" long, threaded full length, 0.1894" diam. x 32 threads per inch.	Fastens holder to wooden base			20,001D4.
17		do	Brass, black oxidized finish, 2 1/4" long, threaded 1 1/2" at 32 threads per inch, 0.1894" diam., end slotted and drilled.	Fastens holder to wooden base and receives cord connecting lower contact strip to common connection.			20,001D4.
17		Grommet	Hard rubber, 13/16" long, #9 drill	Insulates screw from holder			20,001D4.
17	4H3056/47	Rocker arm	Brass, black oxidized finish, 1 13/16" long by 1/4" wide.	Pivots on holder at stroke of cam projections, causing contact to make.			
17		Striking block	Medium hard steel, black oxidized finish, 1/8" x 1/4" x 11/16" long.	Receives stroke of cam projections			20,001D4.
17	4H3056/51	Bushing	Bakelite or micarta, 1/4" long, #43 drill.	Insulator for controller plate contact block screw.			20,001D4.
17	4H3056/52	do	Bakelite or micarta, 1/8" long, #43 drill.	Insulator for contact strip screw			20,001D4.
17		do	Brass, 5/16" long, #52 drill	Bearing for rocker arm pivot pin			20,001D4.
17	4H3056/54	Strip	Nickel silver with platinum points, 2 5/16" x 1/4" wide.	Lower contact strip, fastened to rocker arm.			20,001D4.
17	4H3056/55	Spring	0.0115 phosphorus bronze spring wire, 5/8" long.	Retractile spring on rocker arm			20,001D4.
17	4H3056/56	Screw	Hard brass, black oxidized finish, knurled head, #8-32, 13/16".	Bumper adjustment screw			20,001D4.
17	4H3056/57	do	Hard brass, black oxidized finish with platinum point, knurled head, #8-32, 13/16".	Main contact point and contact adjustment screw.			20,001D4.
17	4H3056/58	Nut	Hard brass, black oxidized finish, std. for #8-32 screw.	Lock nut for bumper and contact screw adjustments.			20,001D4.
17	4H3056/59	Washer	1/2" and 3/4" faces by 3/16" thick, leather.	Leather bumper			20,001D4.

	[illegible]	do	Hard brass, black oxidized finish with platinum point, knurled head, #8-32, 13/16".	Main contact point and contact adjustment screw.			20,001D4.
17	4H3056/58	Nut	Hard brass, black oxidized finish, std. for #8-32 screw [illegible]	Lock nut for bumper and contact screw adjustments [illegible]			20,001D4.
17	4H3056/59	Washer	[illegible]	[illegible]			[illegible]
17	4H3056/60	Pin	Steel, 5/8" long	Rocker arm pivot pin			20,001D4.
17	4H3056/61	Cord	Copper braid with terminals, 2" long	Connection between lower contact strip and common connection bus.			20,001D4.
17		Plate	Bakelite or micarta, 3 7/8" x 2 15/16" x 1/32" thick.	Insulates holders from brass frame			20,001D4.

d. *Contact controller.*

1		Spindle	Brass, black oxidized finish, 3 7/8" x 1 11/32" diam.	Hollow spindle upon which disks and gears are mounted.			20,001D5.
1		Disk	Brass, black oxidized finish, 9" diam. x 1/8" thick.	10-, 15-, and 20-second cam disks, upon which cam groups are mounted.			20,001D5.
1		do	Brass, black oxidized finish, 9" diam. x 1/8" thick.	30-second cam disk, pinned to spindle.			20,001D5.
1		Bushing	Brass, black oxidized finish, 7/8" long x #9 drill.	Spacers between disks			20,001D5.
1		do	Brass, black oxidized finish, 1/8" long x #9 drill.	Spacers between gear and 10-second disk.			20,001D5.
1		Rod	Brass, 3 13/16" long x 0.1894" diam., 32 threads per inch, threaded 1/4" each end.	Mounts disks and gear on spindle			20,001D5.
1		Shaft	Cold rolled steel, 5 1/4" x 3/8" diam	Stationary shaft on which entire cam-arbor assembly revolves.			20,001D5.
1		Pin	Brass, 1/4" long x 0.096" diam	Pin gear and 30-second disk to spindle.			20,001D5.
1	4H3056/85	Block	3-tooth block, medium hard steel, 1 1/2" x 1 7/32" x 1/8" thick.	3-projection program group cam			20,001D5.
1	4H3056/86	Screw	Brass, black oxidized, knurled head, #10-32 x 1 1/16".	Fasten program cams to disks			20,001D5.
1	4H3056/87	Block	Single-tooth block, medium hard steel, 1 1/2" x 1 7/32" x 1/8" thick.	Single projection program cam			20,001D5.
1		Bearing	Annular ball bearing, bore 0.2756", diam. 0.8661", width 0.2756".	Bearings for rotation of spindle about stationary shaft.			20,001D5.

e. Governor.

See fig. no.	Stock no.	Name	Description	Function	Mfr.	Drawing no. (Mfr.'s)	Drawing no. (Sig. C.)
16	4H3056/91	Frame	Aluminum alloy, 2" ong x 1 3/16" high x 1/2" wide.	Rotating governor fly-ball support			20,001D6-6.
16	4H3056/92	Strip	Steel, nickel dip finish, 1 5/16" x 1" x 1/4" wide.	Lower contact strip			20,001D6-6.
16	4H3056/93	Pin	Stubs steel, 3/4" x 0.041" diam	Pivot pin for lower contact strip, fastening it to governor frame.			20,001D6-6.
16	4H3056/94	Fly-ball	Brass, nickel dip finish, 5/16" diam	Governor fly-ball			20,001D6-6.
16	4H3056/95	Contact	Steel, blue finish, with tungsten contact; 27/64" long x 1/8" diam., threaded 48 t. p. i.	Lower governor contact			20,001D6-6.
16	4H3056/96	Nut	Hard brass, nickel dip finish, hex. nut, #5-48 x 1/16" thick.	Lower contact nut			20,001D6-6.
16	4H3056/97	Screw	Headless setscrew, #6-32 x 3/16"; iron, nickel dip finish.	Fastens rotating support to motor shaft.			20,001D6-6.
16	4H3056/98	do	Brass, nickel dip finish, slotted head, #5-48 x 1/4".	Governor spring tension adjustment screw.			20,001D6-6.
16	4H3056/99	Spring	0.016" spring steel wire, 1 5/8" long	Governor fly-ball tension spring			20,001D6-6.
16	4H3056/100	Lever	Sheet brass, nickel dip finish, 3/8" x 3/4" x 1/2" wide.	Governor spring tension adjusting lever.			20,001D6-6.
16	4H3056/101	Bushing	Hard rubber grommet, 3/8" long x 5/16" drill.	Insulates upper contact screw of governor.			20,001D6-6.
16	4H3056/102	do	Hard brass, black oxidized finish, 5/8" long x #28 drill.	Receives upper contact screw of governor.			20,001D6-6.
16		Terminal	Hard brass, nickel dip finish, 1" x 1/2" x 0.034" thick.	Provides connection for stationary contact.			20,001D6-6.
16	4H3056/104	Washer	Hard rubber, 3/4" diam. x 3/32" thick	Insulates upper contact screw from governor bracket.			20,001D6-6.
16	4H3056/106	Screw	Hard brass, black oxidized finish with platinum point and knurled head, #8-32 x 1 1/8"	Upper contact screw			20,001D6-6.

1	4H3056/104	Washer	Hard rubber, 3/4" diam. x 3/32" thick	Insulates upper contact screw from governor bracket.			20,001D6-6.
16	4H3056/106	Screw	Hard brass, black oxidized finish with platinum point and knurled head	Upper contact screw			20,001D6-6.
16		Nut	Hard brass, black oxidized finish, knurled head, 3/32" thick x #30 drill.	Locks upper governor contact screw			20,001D6-6.
16	4H3056/108	Contact spring	Phosphorous bronze, black oxidized finish, 1 11/16" x 3/16" x 0.018" thick.	Governor shaft contact spring			20,001D6-6.
16	4H3056/109	Bushing	Bakelite or micarta, 1 7/16" sq. x 1/8" thick.	Insulates governor bracket from frame of apparatus.			20,001D6-6.
16	4H3056/110	do	Hard rubber grommet, 3/8" long x #2 drill.	Insulates governor mounting screw from frame of apparatus.			20,001D6-6.

f. Shaft.

1	4H3056/120–124	Shaft	Steel	Shaft connecting motor and governor.			

g. Coils.

1	4H3056/130–35	Coil	100-ohm resistance coil, complete and assembled.	Governing resistance in series with motor field.			
1	4H3056/131, 133, 134	do	100-ohm resistance coil with shell and block.	Governing resistance in series with motor field.			
1	4H3056/133	do	100-ohm resistance coil	Governing resistance in series with motor field.			

h. Motor binding post.

1	4H3056/140–44	Binding post	Receives pin-type terminal	Provide connection for lead direct from motor; wired to binding posts to which battery is connected.			
1	4H3056/150	Block	Rubber, 9 3/4" x 2 1/8" x 1/2" thick	Mounting block of terminal strip			
1	4H3056/151/1	Screw	Knurled head	Binding post screw			

i. Gears.

See fig. no.	Stock no.	Name	Description	Function	Mfr.	Drawing no. (Mfr.'s)	Drawing no. (Sig. C.)
1		Gear	Brass, black oxidized finish	Driving gear for cam-arbor assembly			
1	4H3056/161	Worm	⅝" long	Motor shaft worm			
1	4H3056/162	Shaft	$3^{13}/_{32}$" long	Gear and pinion shaft			
1	4H3056/163	Gear	Brass, 1.6875" pitch diameter, 80 teeth.	Worm gear			

18. Time interval apparatus EE-86-A.—*a. Motor.*

See fig. no.	Stock no.	Name	Description	Function	Mfr.	Drawing no. (Mfr.'s)	Drawing no. (Sig. C.)
3		Motor	Series wound, 30-volt d-c, 1,380-rpm, ball bearing, 20° C. rise.	Prime mover			
3		Brush	Carbon brush	For motor			
3		Spring	Flat spring	Brush spring			
3		Armature					
3		Wicking		For grease cup			
3		Capacitor	0.1/μf	Prevents radio interference from motor.			
3		do	0.1/μf	do			

b. *Frame.*

3		Support	Tobin bronze, black oxidized finish	Support and bushing for shaft of worm wheel and containing drive pinion of cam-arbor.		

c. *Contactor assembly.*

17		Screw	Brass	Fastens holder to wooden base		
17		do	do	Fastens holder to wooden base and receives cord connecting lower contact strap to common connection.		
17		Grommet	Hard rubber	Insulates connection screw from holder.		
17		Rocker arm	303 stainless steel	Pivots on holder at stroke of cam projections, causing contact to make.		
17		Bushing	Hard rubber	Insulates contact strip screw		
17		Strip	With tungsten contact	Lower contact strip, fastened to rocker arm.		
17		Spring	Spiral, beryllium copper	Retractile spring on rocker arm		
17		Screw	Fillet head with slot	Bumper adjusting screw		
17		do	Fillet head with slot, tungsten contact.	Stationary contact point and contact adjustment.		
17		Washer	Leather	Rocker arm bumper		
17		Bearing	303 stainless steel	Bearing for rocker arm pivot pin		
17		Cord	Copper braid with terminals	Connecting cord for contact maker		
17		Plate	Bakelite	Insulates holders from frame		

d. Contact controller.

See fig. no.	Stock no.	Name	Description	Function	Mfr.	Drawing no. (Mfr.'s)	Drawing no. (Sig. C.)
3		Spindle	Brass, black oxidized finish	Hollow spindle upon which disks and gear are mounted.			
3		Disk	do	5-, 10-, 15-, 20-, and 30-second disks, upon which cam groups are mounted.			
3		do	do	60-second disk, pinned to spindle			
3		do	do	40-second disk			
3		do	Steel, bright finish	1-second disk			
3		Bushing	Brass, black oxidized finish	Spacers between disks			
3		do	do	Spacers between gear and 1-second disk.			
3		Rod	Brass	Holds gear and disks on spindle, except 40-second disk.			
3		Shaft	Cold rolled steel	Stationary shaft on which entire cam-arbor assembly rotates.			
3		do	do	Idler shaft of drive of 40-second disk			
3		Pin	Brass	Pin 60-second disk and gear to spindle.			
3		do	Brass, taper turned	Pin hubs of gears to idler shaft			
3		Block	3-tooth block, medium hard steel	3-projection program group cams for 10-, 15-, 20-, 30-, and 60-second disks.			
3		do	do	3-projection program group cam for 40-second disk.			
3		do	Single-tooth block, medium hard steel.	Single-projection program cams for 5-second disk.			
3		Screw	Knurled head	Fasten program cams to disks			
3		Bearing	Annular ball-bearing	Bearings for rotation of spindle about stationary shaft.			
3		Gear	Steel	Cam-arbor driving gear			
3		do	do	Turned by cam-arbor, drives idler assembly.			

3		do	do	Driven gear of idler assembly		
3		do	do	Driving gear of idler assembly, drives 40-second disk.		
3		do	do	Gear on 40-second disk spindle		
3		Frame	Brass	Supports idler assembly		
3		Clamps	do	Fasten idler shaft to frame.		

e. Governor.

3		Cover	Sheet steel stamping, black	Protecting cover of governor assembly.		
3		Frame	Aluminum-alloy	Rotating governor fly-ball support		
3		Strip	Steel, nickel dip finish	Holds clutching device which actuates lower contact strip.		
3		do	do	Lower contact strip		
3		Pin	Steel	Pivot pin for strip on governor fly-ball support.		
3		Fly-ball	Brass, nickel dip finish	Governor fly-ball		
3		Contact	Tungsten	Lower contact point		
3		do	do	Upper contact point		
3		Spring	Spring steel, spiral	Governor fly-ball tension spring		
3		do	do	Lower contact tension spring		
3		Screw	Hard brass, black oxidized finish	Upper contact screw holding upper contact point.		
3		do	Brass, dull white nickel finish	Adjusts lower contact spring tension		
3		Strip	Steel, nickel dip finish	Pivoted on stationary arm, moved by screw adjusting lower contact spring.		
3		do	do	Stationary arm upon which lower contact spring adjustment strip is mounted.		
3		Resistor	125-ohm	Governing resistance in series with motor field.		
3		do	1000-ohm	Prevents radio interference of con-		

f. Shaft.

See fig. no.	Stock no.	Name	Description	Function	Mfr.	Drawing no. (Mfr.'s)	Drawing no. (Sig. C.)
3		Shaft	Steel	Connects motor shaft to governor fly-ball support.			

g. Master cam assembly.

See fig. no.	Stock no.	Name	Description	Function	Mfr.	Drawing no. (Mfr.'s)	Drawing no. (Sig. C.)
3		Gear	Fiber	Worm gear driven from worm on motor shaft.			
3		Shaft	Steel	Shaft between worm gear and cam			
3		Cam	Brass	Actuates master 1-second contact			
3		Contact strip	Steel	Holds moving contact			
3		do	Steel	Holds stationary contact			
3		Screw	Brass	Stop for moving strip of contact			

h. Tuning fork.

See fig. no.	Stock no.	Name	Description	Function	Mfr.	Drawing no. (Mfr.'s)	Drawing no. (Sig. C.)
3		Fork	Chromium steel alloy, 46 vibrations per second ±0.05%.	Provides correct adjustment of governor.	Riverbank		

i. Panel assembly.

See fig. no.	Stock no.	Name	Description	Function	Mfr.	Drawing no. (Mfr.'s)	Drawing no. (Sig. C.)
2		Binding	Bakelite cap and base and brass screw.	Binding posts for time interval connections and battery connections.			
2		Switch	Toggle, with silver plated contacts	Starting switch			

j. Box assembly.

3		Binding posts	Bakelite cap and base and brass screw.	Provide connection for leads direct from motor; wired to binding posts to which battery is connected.			
2		Clasp	Spring clasp, nickel plated	Fasten cover to base			
3		Wire	"Ravine" #18 AWG, stranded, tinned, rubber covered, braided, and lacquered.	All wiring, except busses	Belden		

k. Worm drive.

3		Worm	Fiber	Mounted on motor shaft to drive worm wheel.			
3		Worm gear	Fiber	Mounted on shaft which has pinion cut on it.			
3		Shaft	Steel	Upon which worm gear is mounted and on which pinion is cut, to drive cam-arbor assembly.			

19. Time interval apparatus EE-85.

5		Clock	Electro-magnetic motor, 10-12 v., d-c.	Drives time interval mechanism	W & T	SK-3917-B	SC-D-3841-B.

a. Box assembly (SC-D-3842-B).

4		Hinge	Brass, dull white nickel finish, 13 9/16" long x 1 1/16" wide.	Hinges box top to box	V-R	1221	SC-D-3843-C.
5		Bracket	Brass angle, dull white nickel finish, 1/2" x 1/2", #12 B & S ga.	Support binding post panel			SC-D-3843-C.
4		Strap clamp	Brass, dull white nickel finish, 1 1/16" x 2" x 1/16".	Clamps carrying strap			SC-D-3843-C.

a. Box assembly—Continued

See fig. no.	Stock no.	Name	Description	Function	Mfr.	Drawing no. (Mfr.'s)	Drawing no. (Sig. C.)
5		Disk mounting	Brass, dull white nickel finish, 1 1/16" x 1" diam.	Mounting for spare disks			SC-D-3843-C.
4		Hinge	Brass, dull white nickel finish, 7 1/2" long x 1/16" wide.	Hinges shutter to cover	V-R	1221	SC-D-3844-C.
4		Spring	Steel, nickel plate, #14 music wire, 50 turns.	Shutter hinge spring			SC-D-3844-C.
5		Disk	Brass, dull white nickel finish, 1/2" x 1" diam.	Fastens spare disks to mounting disk			SC-D-3844-C.
5		Bracket	Brass angle, dull white nickel finish, 1/2" x 1/2" x #12 B & S ga.	Support clock, mounting panel			SC-D-3844-C.
4		Strap	OD cotton webbing 1" x 1.33 oz. x 20" long.	Carrying strap			SC-D-3842-B.
4		Recess bumper	#02 rubber tip	Protect exterior	H S		SC-D-3842-B.
4		Catch	#01796F flush hasp, brass, nickel finish.	Fastens cover	Eagle	01796F	SC-D-3842-B.

b. Time interval assembly (SC-D-3845-D).

See fig. no.	Stock no.	Name	Description	Function	Mfr.	Drawing no. (Mfr.'s)	Drawing no. (Sig. C.)
6		Post	Aluminum alloy, 53 S-T, anodized, 1 1/2" x 3/16" square.	Holds magnet armature stop			SC-D-3846-D.
6		do	Aluminum alloy, 53 S-T, anodized, 1 1/2" x 5/16" square.	Holds drive bar stop			SC-D-3846-D.
6		Block	Aluminum alloy, 53 S-T, anodized, 3/4" x 7/16" x 1/4".	Holds drive bar spring arm			SC-D-3846-D.
6		Spring arm	Aluminum alloy, 53 S-T, anodized, 1 7/16" x 15/32" x 3/16".	Holds drive bar spring			SC-D-3846-D.
6		Stud	Nickel silver, 13/32" x 1/16" diam	Fastens spring to spring arm			SC-D-3846-D.
6		Drive bar	Nickel silver, 5 21/32" x 3/8" x 0.064" thick.	Rotates ratchet			SC-D-3846 D.

6		Spring	Steel, Parkerized, linseed oil finish	Drive bar spring, retracts drive bar			SC-D-3846-D.
6		do	Steel, Parkerized, linseed oil finish, #10 music wire, 14 turns.	Magnet armature spring, retracts armature.			SC-D-3846-D.
6		Block	Tool steel, hardened and blued, 3/8" x 1/4" x 1/16".	Fastens, to drive bar, contacting ratchet.			SC-D-3847-C.
6		Stop	Tool steel, hardened 15/16" x #6-32 thread.	Drive bar stop			SC-D-3847-C.
6		Arm	Nickel silver, 1 1/16" x 5/16" x 5/32"	Fastens to magnet armature, holding drive bar.			SC-D-3847-C.
6		Screw pin	Brass, dull white nickel finish, 3/8" x 1/16" diam.	Fastens drive bar to arm			SC-D-3847-C.
6		Armature	Armcoingot iron, nickel plate, 1 1/32" x 31/32" x 3/16."	Actuates drive bar			SC-D-3847-C.
6		Hook	Steel, dull white nickel finish, 5/8" long x #18 A. W. G.	Fastens spring to magnet armature			SC-D-3847-C.
6		do	Steel, dull white nickel finish, 7/16" long x #18 A. W. G.	Fastens spring to core piece			SC-D-3847-C.
6		Insulator	Vulcanized fiber, 1" x 1" x 0.010" thick.	Insulates winding from coil			SC-D-3847-C.
6		Plate	Natural "X" phenolic plate, 1" x 5/8" x 5/8" x 3/32".	Fastens to core, mounting for terminals.			SC-D-3847-C.
6		Spacer	Natural "X" phenolic plate, 1/2" thick x 3/32" diam.	Insulates resistor from fastenings.			SC-D-3847-C.
6		do	Hard brass, dull white nickel finish, 13/16" x 5/16" diam.	Insulates capacitors			SC-D-3847-C.
6	3D177A	Capacitor	CA-177-A, 0.5 μf, fixed, paper, 160 v., d-c.	Auxiliary contact arc-spark suppressor.			SC-D-512.
6	3Z10116	Terminal	TM-1/16 oval single ear, brass (tinned)	Provides connection to magnet winding.			RL-A-878.
6		Resistor	RS-245, 10-ohm	Auxiliary contact spark suppression			RL-D-6223.
6		Eyelet	Brass, #1832	Part of magnet winding connection	Waterbury	1382	SC-D-3845-D.
6		Insulation	Varnished cambric	Insulates magnet from core			SC-D-3845-D.
6		Thread	Soft white cotton	Protects winding			SC-D-3845-D.
6		Pin	Steel, nickel plate, 0.076" x 3/16" long	Pivot between armature and core			SC-D-3845-D.
6		Escutcheon pin	Brass, #21 (0.032") x 3/8" long	Shields armature contact with core			SC-D-3845-D.

c. Panel assembly (SC-D-3848-C).

See fig. no.	Stock no.	Name	Description	Function	Mfr.	Drawing no. (Mfr.'s)	Drawing no. (Sig. C.)
4		Strap	Brass, dull white nickel finish, 2⅜" x 7/16" x #20 B & S ga.	Connect clock to time interval mechanism circuits.			SC-D-3848-C.
4		do	do	do			SC-D-3848-C.
4	3Z8105	Switch	SW-105, toggle, single-circuit SPST	Starting switch	A-H & H	20994-CN	SC-A-1042-C.
4		Binding post	TM-195, brass, dull white nickel finish, knurled cap.	Provide connection to time interval circuits.			SC-D-1132.
4	3Z252	do	TM-152, composition, knurled cap and base.	Provide connection to clock			SC-D-530.
4	3Z209	do	TM-109, bakelite, knurled cap and base, Eby Junior P-3.	Provide connection to battery	Eby		SC-D-530.
6	3Z9913	Terminal	TM-13, eye clip, oval, brass (tinned)	Provide connection to battery binding posts.			RL-A-320.
6	3Z9936	do	TM-36, eye clip, flat, brass	Provide connection to clock binding posts.			10701B1.
6		do	Brass, #4012	Provide connection to interval circuit binding posts.	P-M		SC-D-3848-C.

d. Support assembly (SC-D-3849-C).

See fig. no.	Stock no.	Name	Description	Function	Mfr.	Drawing no. (Mfr.'s)	Drawing no. (Sig. C.)
6		Post	Aluminum alloy 61 S-T, 2⅜" x ½" diam.	Forms stand for complete panel assembly.			SC-D-3849-C.
6		Collar	Aluminum alloy 61 S-T, ½" diameter x ¼" thick.	Spacers between plate and panel			SC-D-3849-C.
6		Bumper	Rubber tip, #02	Cushions on end of posts	H S		SC-D-3849-C.

e. Disk assembly (SC-D-3850-D).

See fig. no.	Stock no.	Name	Description	Function	Mfr.	Drawing no. (Mfr.'s)	Drawing no. (Sig. C.)
6		Stud	410 stainless steel, 2⅞" x 15/64" diam.	Forms disk arbor			SC-D-3850-D.
6		Sleeve	Brass, dull white nickel finish, 2" x ½" diam.	Fits over stud of disk arbor			SC-D-3850-D.

6		Stud	410 stainless steel, $1^{3}/_{32}''$ x $^{3}/_{16}''$ diam	Synchronization posts mounted on gears.			SC-D-3850-D.
6		Spacer	Aluminum alloy 61 S-T anodized, $^{3}/_{4}''$ diam. x $^{3}/_{16}''$ thick.	Separates ratchet and first disk of 90-sec. arbor.			SC-D-3850-D.
6		do	Aluminum alloy 61 S-T anodized, $^{3}/_{4}''$ diam. x $^{1}/_{4}''$ thick.	Separates gear and first disk of 120-sec. arbor.			SC-D-3850-D.
6		do	do	Separate time interval disks			SC-D-3850-D.
6		Gear	Aluminum alloy 52 S-H anodized, 3'' P. D. x $^{1}/_{8}''$.	90-sec. arbor pinion			SC-D-3850-D.
6		do	Aluminum alloy 52 S-H alloy, 4'' P. D. x $^{1}/_{8}''$.	120-sec. arbor gear			SC-D-3850-D.
6		Ratchet	Steel, nickel plate $2^{1}/_{4}''$ diam. x $^{1}/_{16}''$ thick.	Drives time interval arbors			SC-D-3851-D.
6		Disk	XXX natural phenolic plate, $3^{5}/_{8}''$ diam. x $^{3}/_{32}''$.	Generates 10-sec. synchronized intervals.			SC-D-3851-D.
6		do	do	Generates 20-sec. synchronized intervals.			SC-D-3851-D.
6		do	do	Generates 30-sec. synchronized intervals.			SC-D-3851-D.
6		do	do	Generates 20-sec. intervals; 5- and 10-sec. delay and synchronized.			SC-D-3851-D.
6		do	do	Generates 30-sec. intervals; 10- and 15-sec. delay and synchronized.			SC-D-3851-D.
6		do	XXX natural phenolic plate, $2^{3}/_{4}''$ diam. x $^{3}/_{32}''$.	Generates 5-sec. synchronized intervals.			SC-D-3851-D.
6		do	do	Generates 15-sec. synchronized intervals.			SC-D-3851-D.
6		do	do	Generates 45-sec. synchronized intervals.			SC-D-3851-D.
6		do	do	Generates 45-sec. intervals; 5- and 15-sec. delay and synchronized.			SC-D-3851-D.
5		do	XXX natural phenolic plate, $3^{5}/_{8}''$ diam. x $^{3}/_{32}''$.	Spares for 90-sec. arbor			SC-D-3852-A.
5		do	XXX natural phenolic plate $2^{3}/_{4}''$ diam. x $^{3}/_{32}''$.	Spares for 120-sec. arbor			SC-D-3852-A.

f. Contactor assembly (SC-D-3853-D).

See fig. no.	Stock no.	Name	Description	Function	Mfr.	Drawing no. (Mfr.'s)	Drawing no. (Sig. C.)
6		Post	Aluminum alloy 53 S-T cold finish anodized, 2 7/16" x 5/16" sq.	Provides mounting for contactor assembly of 120-sec. arbor.			SC-D-3854-D.
6		do	do	Provides mounting for contactor assembly of 90-sec. arbor.			SC-D-3854-D.
6		Plate	XXX phenolic plate, 1 9/16" x 1 7/16" x 1/8" thick.	Insulates and provides mounting for terminal blocks.			SC-D-3854-D.
6		Angle	Aluminum alloy 52 S 1/2-H, anodized, 3/8" x 9/16" x 3/32" thick.	Provides adjustment of contact spring pressure against disks.			SC-D-3854-D.
6		Terminal block (l. h.).	Hard brass, gold plated, 1 9/32" x 1/4" x 1/8".	Hold adjustable stationary contact and terminal of 90-sec. arbor contactor assembly.			SC-D-3854-D.
6		Terminal block (r. h.) 1/8".	do	Hold adjustable stationary contact and terminal of 120-sec. arbor contactor assembly.			SC-D-3854-D.
6		Spring shoe	302 stainless steel, 1 3/16" x 1/4" x 3/32" thick.	Makes pressure contact with disks			SC-D-3854-D.
6		Strap	Brass, gold plated, 1 5/8" x 13/16" x #24 B & S ga.	Straps moving contact connections together to get common connection for 90-sec. arbor.			SC-D-3854-D.
6		do	Brass, gold plated, 1 3/8" x 1 3/16" x #24 B & S ga.	Straps moving contact connections together on armature to get common connection for 120-sec. arbor.			SC-D 3854-D.
6		Contact spring	Beryllium copper, gold plated, 1 33/64" x 1/4" x #33 B & S ga.	Mounting for moving contact			SC-D-3854-D.
6		Contact screw	Beryllium copper, gold plated, 1/2" long x #6-32 thread.	Mounting for stationary contact, placed in terminal block.			SC-D-3854-D.
		Contact	Palladium, 1/16" thick x 1/8" diam.	Moving contact			SC-D-3854-D.
6		do	Palladium, 3/32" diam. x 0.025 thick	Stationary contact			SC-D-3854-D.
6		Pawl support	Brass, dull white nickel finish, 1 3/8" x 7/32" x 1/8".	Mounted on post, supporting pawl and pawl spring of ratchet wheel.			SC-D-3854-D.

6		Pawl	Tool steel hardened and blued, 2 3/32" x 5/16" x 0.099".	Prevents ratchet wheel from backing up.			SC-D-3854-D.
6		Pawl spring	Beryllium copper, 13/16" x 7/32" x #33 B & S ga.	Presses pawl against ratchet wheel			SC-D-3854-D.
6		Washer	Brass, gold plated, 5/16" diam. x 1/32".	Fastens straps and springs on post			SC-D-3854-D.
6		Pin	Nickel silver, 1/16" x 1/4" long.	Mounts pawl in pawl support.			SC-D-3853-C.

g. Clock mounting assembly.

5		Cup	Black molded phenolic, 4 3/16" high x 3 9/16" diam.	Contains clock			SC-D-3855-B.
5		Gasket	Thiokol (D) compound no. 2100, 3 5/8" diam. x 1/16".	Placed between clock and panel as cushion.	Thiokol		SC-D-3855-B.
5		Screw	Brass, black oxide finish, 4 5/8" long x #10-32 thread.	Fastens cup to box			SC-D-3855-B.

20. Line connector unit EE-87.

8		Relay	Multiple, 7-contact, 10-12-v.	Completes circuit through hummer and line circuits upon impulse from time interval apparatus EE-85.	North	400-Z	SC-D 3719-C.
8		Hummer	Microphone hummer, type 572-B	Produces 1,000-cycle tone for lines	G. R.		SC-D-3719-C.
8		Washer	Countersunk, brass, no. C-145, nickel finish.	Fastening resistor to bottom of box	Simpson		SC-D-3719-C.
8	3Z9936	Terminal	TM-36, eye clip, oval, brass (tinned).	For "B" connection on microphone side of hummer primary.			10701-B-1.
8	3Z4455	Resistor	RS-55, 45-ohms ±5% porcelain tube	Limits voltage across hummer primary.			RL-D-6223.
8		Washer	Phenolic plate, 5/8" o. d. x 13/64" i. d. x 3/32" thick.	Insulates resistor			SC-D-3719-C.

a. Transformer C-231 assembly.

See fig. no.	Stock no.	Name	Description	Function	Mfr.	Drawing no. (Mfr.'s)	Drawing no. (Sig. C.)
8		Transformer	Type C-231	Steps up voltage of hummer output, placing it on telephone lines.			SC-D-1614-C.
8	3Z10104	Terminal	TM-104, brass (tinned), front ear	Transformer terminal			RL-D-5035.

b. Box assembly.

See fig. no.	Stock no.	Name	Description	Function	Mfr.	Drawing no. (Mfr.'s)	Drawing no. (Sig. C.)
7		Strap clamp	Brass, dull white nickel finish, 2" x 1 1/16" x 1/16" thick.	Fastens carrying strap			SC-D-3721-C.
8		Support	Aluminum alloy, 2 7/32" x 1 3/4" x #14 B & S ga.	Supports relay			SC-D-3721-C.
8		do	Aluminum alloy, 3 3/16" x 2 7/16" x #14 B & S ga.	do			SC-D-3721-C.
8		Transformer strap.	Brass, dull white nickel finish, 10 3/32" x 3/4" x 1/8" thick.	Strap transformers in place			SC-D-3721-C.
7		Hinge spring	Steel, nickel plated, #14 music wire, 50 turns.	Shutter hinge spring			SC-D-3721-D.
7		Hinge	Brass, dull white nickel finish, #1221, 7 1/2" long x 1 1/16" wide.	Hinges shutter to cover	V-R	1221	SC-D-3722-B.
7		do	Brass, dull white nickel finish, #1221, 13 9/16" long x 1 1/16" wide.	Hinges cover to box	V-R	1221	SC-D-3722-B.
8		Bracket	Brass angle, dull white nickel finish, 1/2" x 1/2" x #12 B & S ga.	Supports panel assembly			SC-D-3722-B.
7		Catch	#01796F brass flush hasp, nickel finish	Fastens cover to box	Eagle	01796F	SC-D-3720-B.
7		Recess bumper	Rubber tip #02	Cushions on bottom and back of box	H S		SC-D-3720-B.
8		Washer	Countersunk, brass #145, nickel finish.	Fastens ends of transformer straps to box.	Simpson		SC-D-3720-B.
7		Strap	OD cotton webbing 1" x 1.33 oz. x 20" long.	Carrying strap			SC-D-3720-B.

c. Panel assembly.

8		Clip	Brass, 3/8″ wide x #20 B&S ga. thick	Fastens laced wire cable to plate			SC-D-3723-B.
7		Binding post	TM-195, brass, dull white finish, knurled cap.	Provides connection to line circuits			SC-D-1132.
7		do	TM-195, brass, dull white nickel finish, knurled cap.	Provides connection to relay circuit, from time interval apparatus EE-85.			SC-D-1132.
7	3Z209	do	TM-109, bakelite, knurled cap and base.	Provides connection for battery leads.			SC-D-530.
8	3D166	Capacitor	CA-166, 0.1 μf, fixed, paper, 200-v., d-c.	Prevent drain from telephone system batteries.	Tobe		SC-D-512.
8	3Z9913	Terminal	TM-13, eye clip, oval, brass (tinned)	For binding posts for battery leads			RL-A-320.
8		do	#4012	For binding posts of line circuits	P-M		SC-D-3723-B.
8		do	#4012	For binding posts of relay circuit	P-M		SC-D-3723-B.
7		Key	3-position, #479EP	Controls volume of hummers	W. E		SC-D-3723-B.
7		do	3-position, #479G	Switches hummers on and off	W. E		SC-D-3723-B.
8		Resistor	Type F-1/3, 20,000-ohm, 1/3-w	Regulates hummer volume	IRC		SC-D-3723-B.
8		do	Type F-1/3, 50,000-ohm, 1/3-w	do	IRC		SC-D-3723-B.

21. Time interval signal BE-65.

9	4H5005	BE-65	Time interval signal BE-65	Produces signals at intervals determined by time interval apparatus EE-85, used by mobile seacoast artillery.			SC-D-3827-A.
10		Capacitor	6-μf, 400-v., FU-748, PC-753	Acts with magnet coil to make its action more positive.	C-D		SC-D-3827-A.
10		Relay	Model 2C with coil #38	Closes magnet coil circuit	K E		SC-D-3827-A.
10		Terminal	Brass, #903	For capacitor binding posts	P-M		SC-D-3827-A.

a. Box assembly.

See fig. no.	Stock no.	Name	Description	Function	Mfr.	Drawing no. (Mfr.'s)	Drawing no. (Sig. C.)
10		Hinge	Brass, dull white nickel finish, 5⅝" long x 1 1/16" wide.	Hinges cover to box	V-R		SC-D-3830-B.
10		Strip	SAE 1020, 1/32" cold rolled steel, 5 13/16" x ⅜" x 7/32".	Retains gasket in place on cover			SC-D-3830-B.
10		do	SAE 1020, 1/32" cold rolled steel, 9 1/16" x ⅜" x 7/32".	do			SC-D-3830-B.
10		Angle	SAE 1020, 1/16" cold rolled steel, 9½" x 1 1/32" x 7/32".	Forms slide with bottom of box for battery assembly plate.			SC-D-3830-B.
10		Bracket	SAE 1020, ⅛" cold rolled steel, ⅞" x ½" x ½" wide.	Receives screw which fastens cover to box.			SC-D-3830-B.
10		Clamp	Brass, dull white nickel finish, 1⅛" x 1" x ⅛".	Fastens pad to side of box at wire entrance.			SC-D-3830-B.
10		Pad	Thiokol "D" compound #2100, 1½" x 1¼" x 3/16".	Waterproofs wire entrance	Thiokol		SC-D-3830-B.
10		Gasket	Thiokol "D" compound #2100, 9¾" x 6⅜" x ¼" sq.	Waterproofing between box and cover.	Thiokol		SC-D-3830-B.
9		Plate	1/16" cold rolled steel, pressing, 5½" sq. x 3/16".	Fastens screen to front of box			SC-D-3831-A.
9		Screen	Bronze, black oxidized finish 5¼" sq., 6-mesh, 0.047" wire, 0.120" opening.	Covers horn opening in front of box			SC-D-3831-A.
9		Gasket	Thiokol "D" compound #2100, 5¾" diam. x ⅛".	Waterproofing between plate and front of box.	Thiokol		SC-D-3831-A.
10		Screw	Brass, dull white nickel finish, knurled head, 1½" x #10-32 thread.	Fastens cover to brackets on box			SC-D-3831-A.
10		Washer	Vulcanized fiber, 7/16 o. d., 3/16" i. d. x 1/32".	Used with screw which fastens cover			SC-D-3831-A.
10		Spacer	SAE 1020 cold rolled steel, 5⅝" x ½" x ⅛".	Flat spacer between hinge and bottom of box.			SC-D-3831-A.
10		Support	Brass, dull white nickel finish, 2 13/16" x 1⅝" x 2½" wide x 1/16" thick	Supports relay at top of box			SC-D-3831-A.

9		Recess bumper	Rubber tip #02	Cushions on bottom of box	H S		SC-D-3828-C.
9		Handle	Steel, #482, size #2	For carrying box	Stanley		SC-D-3828-C.

b. Horn assembly.

11		Diaphragm	Nickel silver, 4 7/16" diam. x #19 B&S ga.	Vibrates with action of magnet armature.			SC-D-3833-C.
11		Cone assembly	2 rings and cone of aluminum alloy welded together to form a horn, 5½" diam. x 5⅞" long (approx.).	Intensifies sound of diaphragm			SC-D-3833-C.
11		Cartridge	Brass, dull white nickel finish, ⅞" x ⅜" diam.	Fits in drilled slots at sides of base, receiving screw which fastens horn assembly to side of box.			SC-D-3833-C.
11		Stud	Brass, dull white nickel finish, 1⅝" x 5/16"-32 thrd.	Fastens arch to base, fitting into adjusting screw.			SC-D-3833-C.
11		Arch	Brass, dull white nickel finish, 5¾" x 1½" x ⅜" x ⅛" thick.	Mounting for contact assembly			SC-D-3833-C.
11		Screw	Brass, dull white nickel finish, 1⅛" x ⅜"-27 thrd.	Adjusts contacts, moving arch			SC-D-3833-C.
11		Nut	Brass, dull white nickel finish, 5/16" thick hex., x ⅜"-27 tap.	Fits on adjusting screw of arch			SC-D-3833-C.
11		Washer	Brass, dull white nickel finish, 1⅛" o. d. x 41/64" i. d. x 1/16".	do			SC-D-3833-C.
11		Nut	Brass, dull white nickel finish 13/32" long x ⅜"-27 thrd., x #10-32 tap.	Fastens armature to diaphragm			SC-D-3834-C.
11		Washer	Brass, dull white nickel finish, ⅝" o. d. x .377" i. d. x 3/64".	do			SC-D-3834-C.
11		Armature	Steel, ⅛" nickel plate, 1⅞" x ⅝" x 7/32".	Magnet armature which actuates diaphragm.			SC-D-3834-C.
11		Post	Brass, dull white nickel finish, 2¼" x #10-32 thrd.	Actuated by armature to break contact, adjustable for contact spacing.			SC-D-3834-C.
11		Bumper	XX Black phenolic rod, 7/16" x 3/32" diam.	Fits on end of post which breaks contact.			SC-D-3834-C.
11		Screw	Brass, dull white nickel finish, slotted, ⅝" x #60-40 thrd.	Adjusts stop of contact spring			SC-D-3834-C.
11		Nut	Brass, dull white nickel finish, 3/16" thick x #6-40 tap.	Locks adjustment of stop of contact spring.			SC-D-3834-C.

b. Horn assembly—Continued.

See fig. no.	Stock no.	Name	Description	Function	Mfr.	Drawing no. (Mfr.'s)	Drawing no. (Sig. C.)
11		Plate	Brass, dull white nickel finish, 31/32" x 3/4" x 3/32".	Holds stop adjustment screw			SC-D-3834-C.
11		do	Brass, dull white nickel finish, 3/4" x 7/16" x 1/16".	Forms clamp on contact mountings on arch.			SC-D-3834-C.
11		Spring	Beryllium copper, 7/8" x 3/4" x 0.020".	Increases action of contact spring			SC-D-3834-C.
11		Contact spring	Beryllium copper, 1¾" x 1⅛" x 0.030".	Mounting for moving contact			SC-D-3834-C.
11		Stop	Beryllium copper, 1 1/16" x 3/4" x 1/8" x 0.040 ga.	Contact armature stop			SC-D-3834-C.
11		Screw	Nickel silver, 33/64" x 5/32" x #6-32 thrd.	Mounting for stationary contact			SC-D-3835-A.
11		Block	"LE" natural phenolic plate, 1" x 1/2" x 13/32".	Part of contact mounting on arch, spacing.			SC-D-3835-A.
11		do	"LE" natural phenolic plate, 1" x 1/2" x 5/16".	do			SC-D-3835-A.
11		Insulator	XXX natural phenolic plate, 25/32" x 15/32" x 0.050".	Insulates metallic parts of contact mounting on arch.			SC-D-3835-A.
11		Bushing	XXX natural phenolic tubing 13/64" long x 1/4" o. d. x 0.196" i. d.	Insulates long screws from metal parts of contact mounting.			SC-D-3835-A.
11		do	XXX natural phenolic tubing, 9/32" long x 1/4" o. d. x 0.196" i. d.	do			SC-D-3835-A.
11		Contact	Palladium, 3/32" diam. x 1/16" long	Stationary contact point			SC-D-3835-A.
11		do	Palladium, 3/32" diam. x 0.025" thick.	Moving contact point			SC-D-3835-A.
11		Pin	Nickel silver #14 (0.064") B and S gage x 1 1/16" long.	Goes through base and screw, fastening arch to base.			SC-D-3832-B.

c. Horn magnet assembly.

See fig. no.	Stock no.	Name	Description	Function	Mfr.	Drawing no. (Mfr.'s)	Drawing no. (Sig. C.)
11		Angle	Brass, dull white nickel finish, 1/4" x 1/4" x 1¾" long x 1/16" thick.	Forms base of magnet			SC-D-3836-C

11		Clip	Nickel silver, 7/8" x 13/16" x 0.020"	Fastens winding to core			SC-D-3836-C.
11		Sleeve	Black "LE" phenolic tubing, 11/16" sq. x 23/32" long x 1/32" thick.	Spool upon which winding is placed			SC-D-3836-C.
11		Insulator	"LE" phenolic plate, 13/16" sq. x 1/64".	Insulates winding from bottom head			SC-D-3836-C.
11		Head	"LE" phenolic plate, 13/16" sq. x 1/32".	Holds winding in shape and insulates it at top and bottom.			SC-D-3836-C.

d. Panel assembly.

10		Spacer	Brass, dull white nickel finish, 1½" x ½" o.d. x 13/64" i.d.	Separates panel from base			SC-D-3837-A.
10	3Z252	Binding post	TM-152, composition, knurled cap and base.	Provides connection for battery leads			SC-D-530.
10		do	TM-195, brass, dull white nickel finish, knurled cap.	Connection for line wires			SC-D-1132.
10	3Z9936	Terminal	TM-36, eye clip, flat, brass.	For battery binding posts			10701B1.
10		do	#4012	For line wire binding posts	P-M		SC-D-3837-A.

e. Battery tray assembly.

10		Battery support	Black molded phenolic compound, XM-3510 black bakelite, 5½" x 1¼" x ¾".	Supports battery			SC-D-3838-B.
10		Insert	Brass, knurled, ¼" long x ¼" o.d. x #6-32 tap.	Receives screws fastening supports to plate.			SC-D-3838-B.
10		do	Brass, knurled, 3/8" long x ½" o.d. x #10-32 tap.	Receives threaded end of post in center of support.			SC-D-3838-B.
10		Clamp	Brass, dull white nickel finish, 55/32" x ½" x 5/8" wide x 1/16" ga.	Holds batteries on supports			SC-D-3838-B.
10		Post	Brass, dull white nickel finish, 3" x x 10-32 thrd.	Mounting for clamps			SC-D-3838-B.
10	3Z9929	Terminal	TM-29, spade clip, brass (tinned)	For battery wires			10701B1.
10		Wire	#18 (0.0403") AWG x 6" long green wire, code "ravine".	Connect batteries in series and to panel terminals.	Belden		SC-D-3838-B.

Appendix

ADDRESSES OF MANUFACTURERS

Diehl	Diehl Manuacturing Co	Elizabethport, New Jersey.
Emerson	The Emerson Electric Mfg. Co	St. Louis, Missouri.
WE&M	Westinghouse Electric & Mfg. Co	Pittsburgh, Pennsylvania.
Riverbank	Riverbank Laboratories	Geneva, Illinois.
Belden	Belden Manufacturing Co	Chicago, Illinois.
W&T	Wallace & Tiernan Products, Inc	Belleville, New Jersey.
V-R	Veeder-Root, Inc	Bristol, Connecticut.
H S	Hammacher, Schlemmer & Co	New York, New York.
Eagle	The Eagle Lock Co	Terryville, Connecticut.
Waterbury	Waterbury Brass Goods, Inc	Waterbury, Connecticut.
A-H & H	Arrow-Hart & Hegeman Electric Co	Hartford, Connecticut.
Eby	Hugh H. Eby, Inc	Philadelphia, Pennsylvania.
P-M	Patton-MacGuyer Co	Providence, Rhode Island.
Thiokol	Thiokol Corporation	Yardville, New Jersey.
North	North Electric Manufacturing Co	Galion, Ohio.
G. R	General Radio Co	Cambridge, Massachusetts.
Simpson	Edwin B. Simpson Co	Brooklyn, New York.
Tobe	Tobe Deutschmann Corporation	Canton, Massachusetts.
W. E	Western Electric Co	Chicago, Illinois.
IRC	International Resistance Co	Philadelphia, Pennsylvania.
C-D	Cornell-Dublier Electric Corporation	South Plainfield, New Jersey.
K E	Kurman Electric Co	New York, New York.
Stanley	The Stanley Works	New Britain, Connecticut.

[A. G. 062.11 (7-10-42).]

By order of the Secretary of War:

G. C. MARSHALL,
Chief of Staff.

Official:

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The Adjutant General.

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IC and H 4 (5); IC 11 (3).
(For explanation of Symbols see FM 21-6.)

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WAR DEPARTMENT

TECHNICAL MANUAL

SPOTTING SET PH-32-B

May 12, 1942

TECHNICAL MANUAL No. 11-434

WAR DEPARTMENT,
WASHINGTON, May 12, 1942.

SPOTTING SET PH-32-B

SECTION I

GENERAL DESCRIPTION

1. **Purpose.**—Spotting set PH-32-B is designed for the purpose of aiding in the analysis of the effectiveness of antiaircraft fire by providing a means for the acurate determination in three dimensions of the positions of the shell bursts with respect to the target.

2. **Component parts.**—The spotting set PH-32-B consists of the component listed in paragraph 59*a*.

3. **Axle RL-27-A, wire W-110-B, and reels DR-4.**—The axle RL-27-A is used to lay the wire supplied on the reels DR-4 for the

line between the two theodolite stations O_1 and O_2. Figure 1 shows the combination of reel, axle, and wire.

4. Theodolite PH-( )-33.—The theodolite is of the recording type, consisting of the theodolite proper and a built-in 35-mm motion picture camera oriented and focused so that the center of the picture continually coincides with the center of the field of view of the telescope. The theodolite has internal azimuth and site counter indicators which, along with a time counter and the camera serial number. are photographed on each frame of the motion picture film. External azimuth and site counters are also provided. A junction box JB-40 and cord CD-407 are provided with each theodolite for connecting storage battery BB-46 (power source) and the connection of the time interval device. (See fig. 2.) Each theodolite is supplied with one

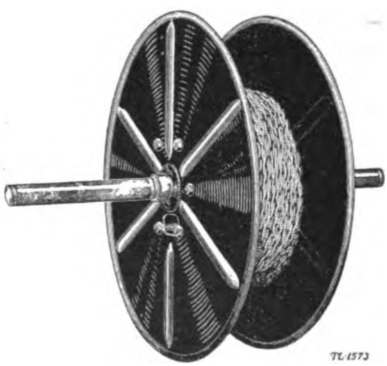


FIGURE 1.—Axle RL-27 with reel DR-4.

instruction book. Each theodolite is packed in a separate carrying case for transportation, the junction box, cord, filters, and exposure meter being packed in compartments in the same case. The above information is applicable to all models of the theodolite, while the information particular to the individual models is given below:

a. Theodolite PH-BC-33.—Figures 3 and 4 show the theodolite PH-BC-33. Component parts of the theodolite are indicated in these figures. The camera optical system consists of a 6-inch lens and a right angle prism and has a field of view of 100 mils.

b. Theodolite PH-BD-33.—Figures 5 and 6 show the theodolite PH-BD-33. Component parts of the theodolite are indicated in these figures. The camera optical system consists of a 12-inch lens and a mirror and has a field of view of 50 mils.

c. PH-BE-33.—This model, not illustrated, is very similar in appearance and operation to the PH-BC-33, but has an optical system similar to that of the theodolite PH-BD-33, having the 12-inch lens, mirror, and 50-mil field of view.

5. Time interval device PH-103.—This time interval device (fig. 7) is permanently mounted in its carrying case. Receiving power for operation from two batteries BA-26, it supplies direct current pulses at a rate of one per second to operate the relays in the time interval multiplier and the theodolites.

6. Time interval multiplier PH-264-( ).—This multiplier (fig. 8) receives pulses at a rate of one per second from the time interval device and delivers pulses at either 5-second or 10-second intervals to

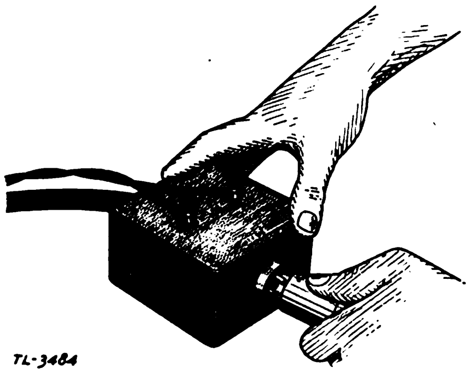


FIGURE 2.—Junction box JB-40.

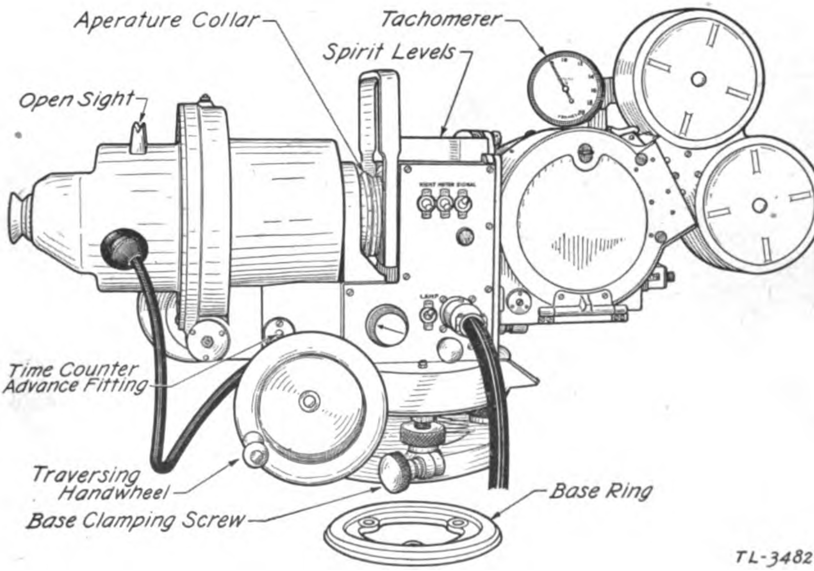


FIGURE 3.—Theodolite PH-BC-33 (front view).

the line connector unit EE–87 or the time interval signals BE–65. The multiplier will deliver one pulse of one second's duration every 5 seconds, or a group of three pulses of one-half second's duration at 1-second intervals every 10 seconds. It receives its power for operation from a 12-volt storage battery BB–46.

7. Line connector unit EE–87.—This unit (fig. 9) supplies tone to telephone lines for time indications. It contains a line relay, tone generator, and transformers for supplying tone to the telephone lines, and receives its power for operation from the same battery used for operation of the time interval multiplier.

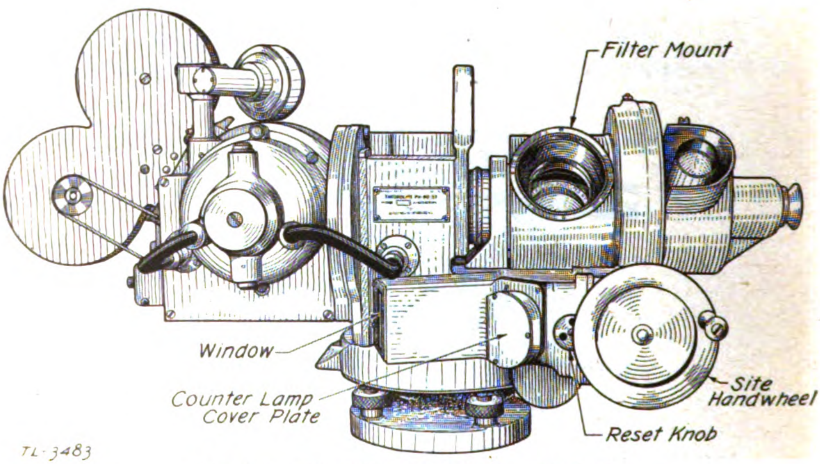


FIGURE 4.—Theodolite PH–BC–33 (rear view).

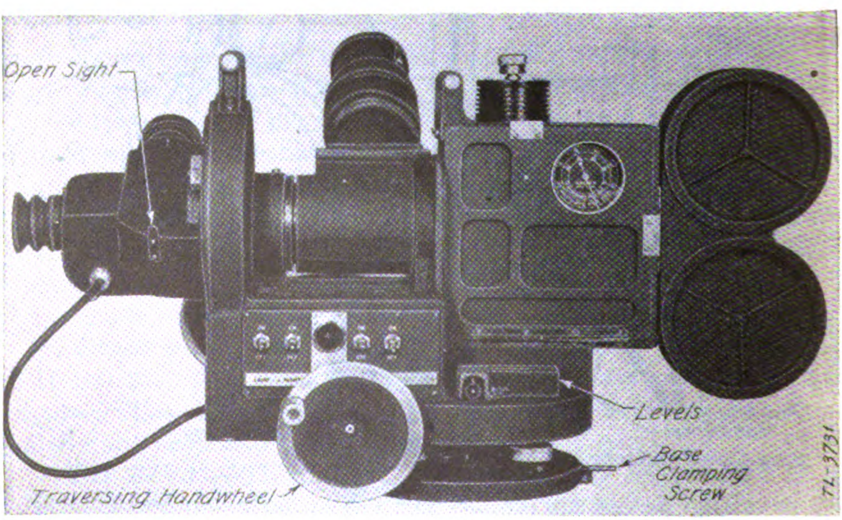


FIGURE 5.—Theodolite PH–BD–33 (front view).

8. Time interval signal BE-65.—This signal (fig. 10) consists of an electrically driven horn controlled by a local relay. The relay receives its power for operation by wire from a remote control point, either manually or automatically controlled. The horn is driven by two batteries BA-23.

9. Film.—This is standard commercial panchromatic film having a Weston emulsion speed of 64. The 200-foot rolls (wound emulsion side in) may be placed directly in the magazines of the theodolites. Film must be stored in a cool, dry place.

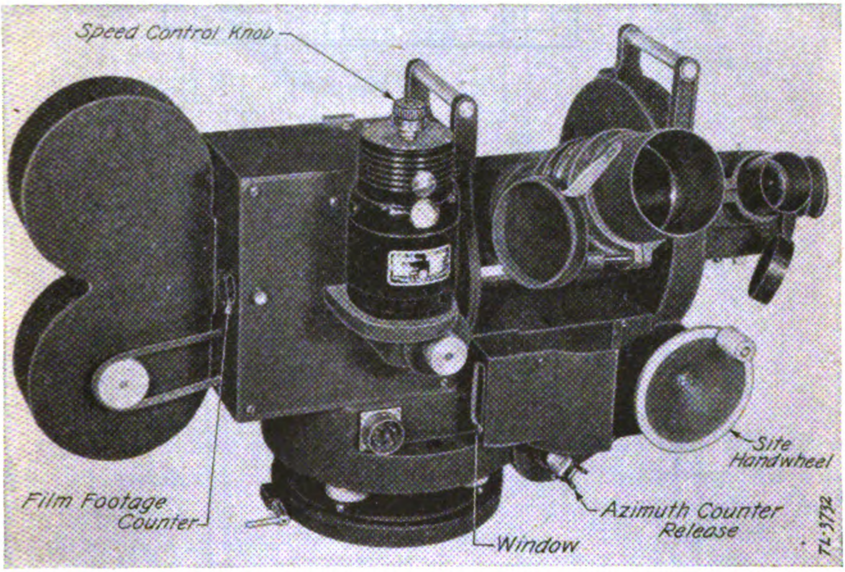


FIGURE 6.—Theodolite PH-BD-33 (rear view).

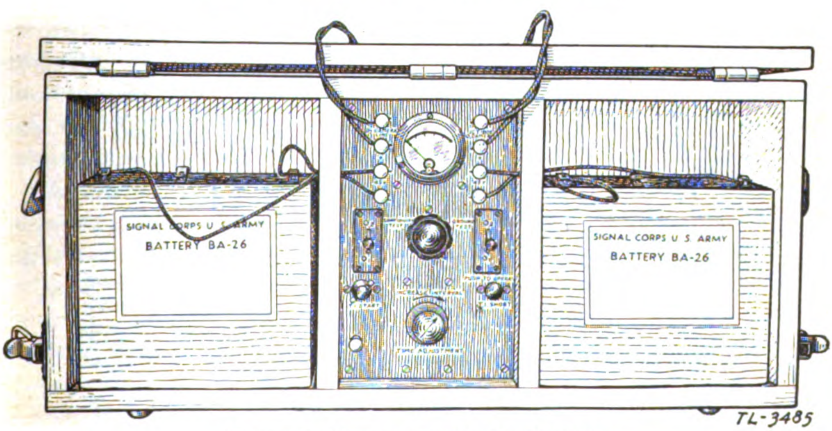
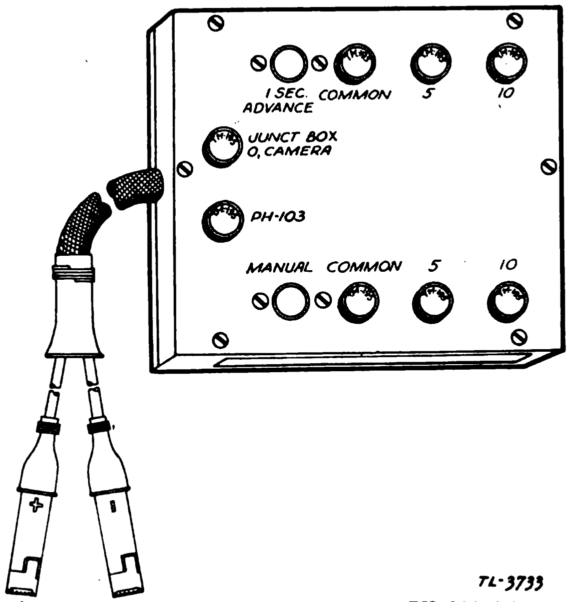


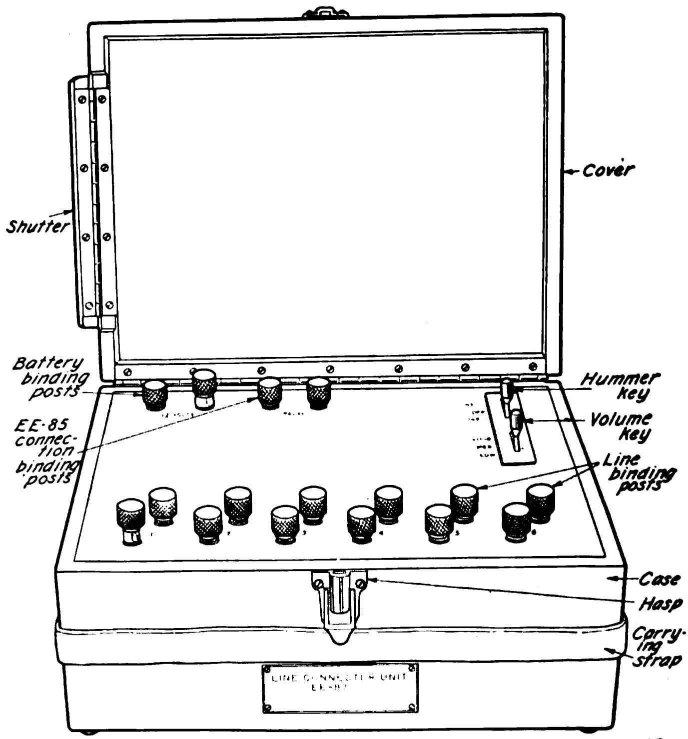
FIGURE 7.—Time interval device PH-103.

SPOTTING SET PH-32-B



TL-3733

FIGURE 8.—Time interval multiplier PH-264-( ).



TL-3535

FIGURE 9.—Line connector unit EE-87.

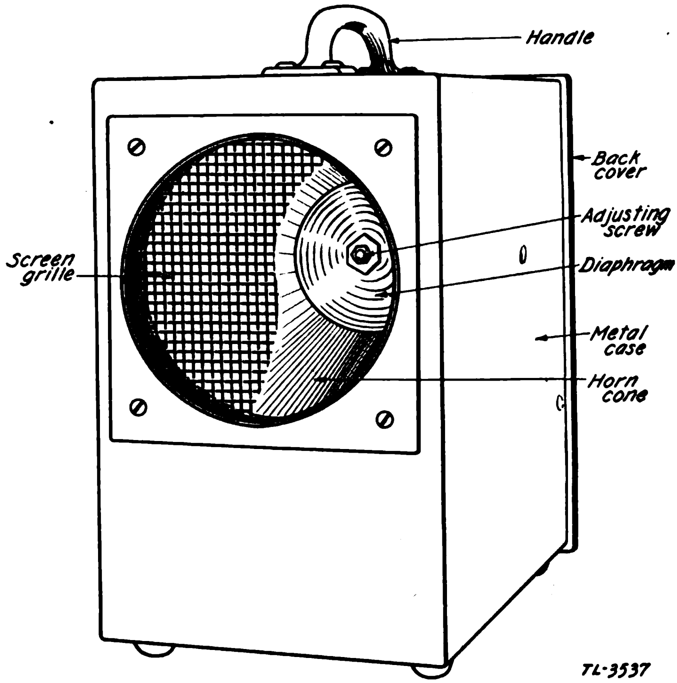


FIGURE 10.—Time interval signal BE-65.

10. Developing equipment PH-41 and drying rack PH-42.—This equipment (fig. 11) is used for processing the film exposed with the cameras in the theodolites. The Eastman D-11 developer and fixing solution are used for processing the film.

11. Exposure meter PH-77-B or PH-252-A.—One exposure meter is packed in the case with each theodolite. Figure 12 illustrates the meter which is a photoelectric cell type, used to measure the light intensity for determining the camera stop opening to be used for photographing the shell bursts. It is supplied with a leather carrying case which is to be fastened to the soldier's belt and a neck string to ensure against accidental dropping of the meter.

12. Film viewer PH-97-A.—This viewer (fig. 13) is used for inspecting the pictures taken with the recording theodolites. A viewing attachment PH-98-A is provided with a reticle and microscope for orienting the picture and determining the deviation of the burst from the azimuth and the site readings. Two instruction books are supplied with each viewer. The rewinder PH-92, the splicer PH-91, and the film cement are used in conjunction with the viewer. None of this equipment is needed during the photographing of the bursts.

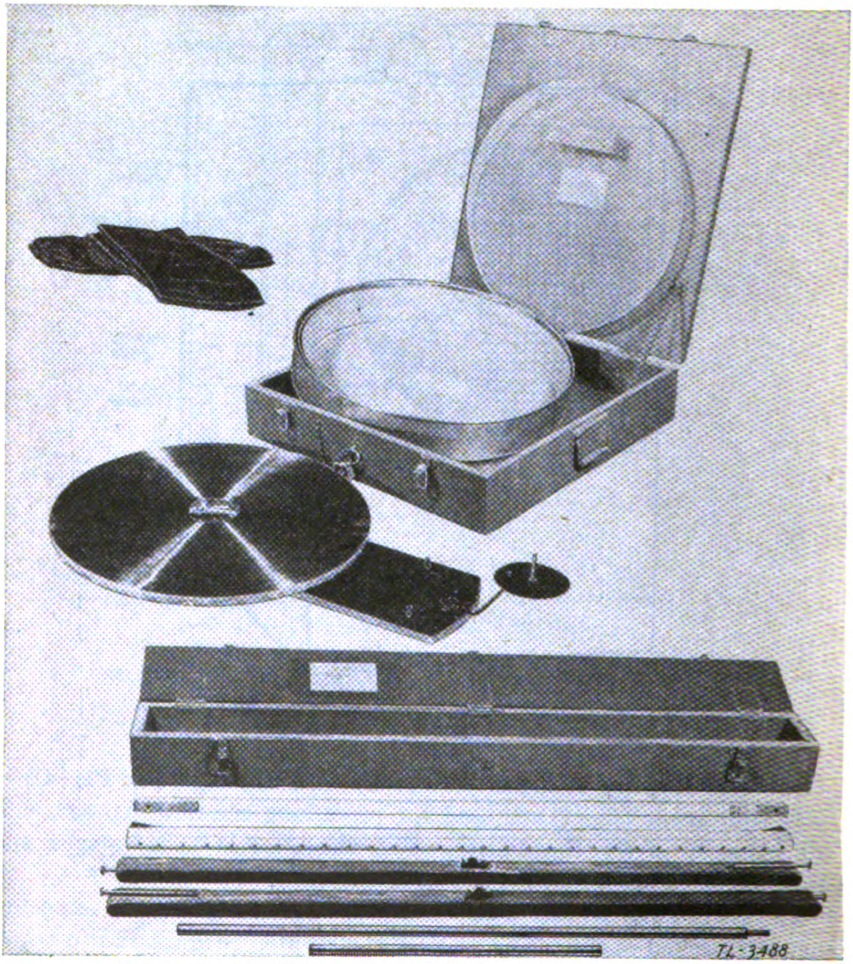


FIGURE 11.—Developing equipment PH-41 and drying rack PH-42.

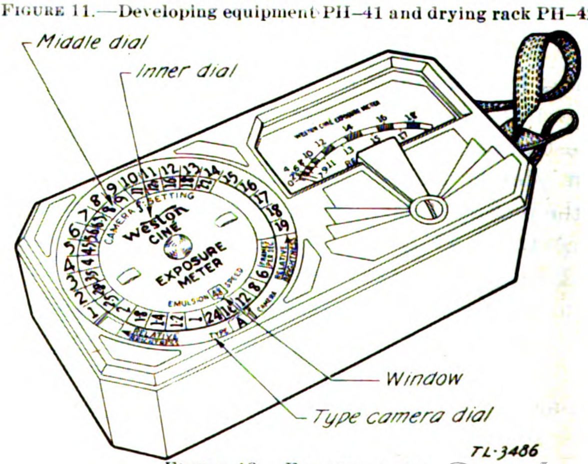


FIGURE 12.—Exposure meter.

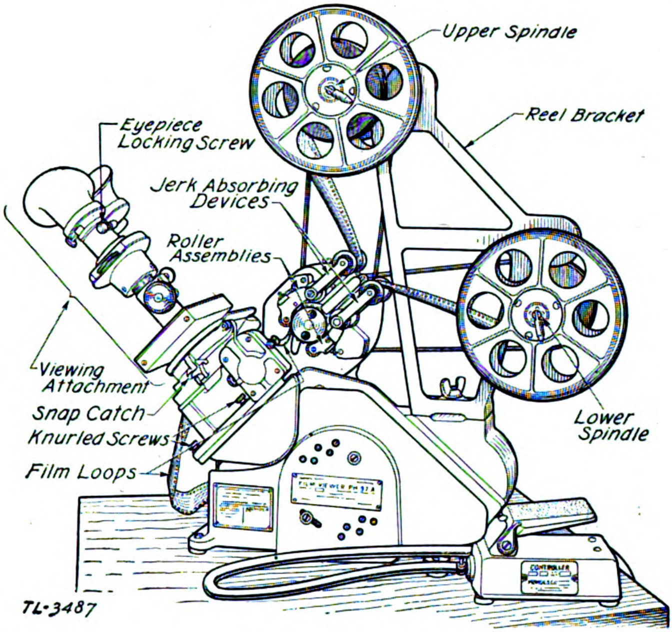


FIGURE 13.—Film viewer PH-97-A.

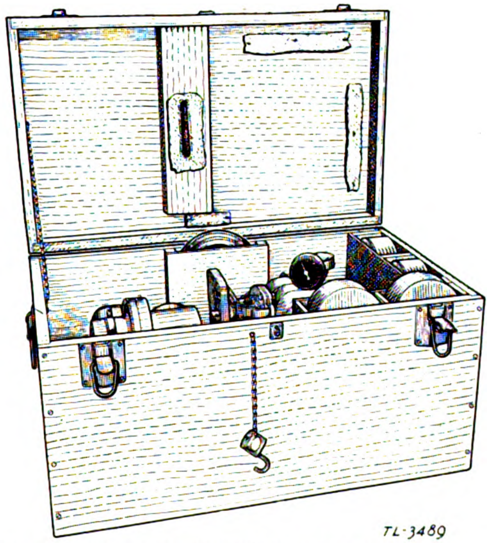


FIGURE 14.—Theodolite PH-BC-33 in carrying case.

13. Transportation.—In transporting this equipment it is desirable that it be moved by truck to a place very near to that where it will be used. Two men can carry any component of the spotting set for short distances over level terrain.

a. Theodolite PH-BC-33.—Figure 14 shows the theodolite in its carrying case, with the base ring and film magazines; the junction box with its cables is in a covered compartment just below the camera end of the theodolite. The exposure meter and filters are in other compartments. The theodolite must *always* be clamped in the carrying case when being moved, using the clamping saddle and the wing nuts on the clamping rods. When packing for shipping long distances use ordinary nuts with lock nuts for clamping to prevent the clamps from shaking loose. The carrying handle of the theodolite rests in a recess in the lid of the carrying case when the case is closed.

b. Theodolite PH-BD-33.—Figure 15 shows the theodolite in its carrying case, with the base ring and film magazines; the junction box with its cables is in a covered compartment in the bottom of the case. Tools, exposure meter, and filters are in other compartments. The theodolite must always be clamped in the carrying case when being moved, using the clamping device. When packing for shipping long distances use ordinary nuts with lock nuts to prevent the clamps from shaking loose.

c. Theodolite PH-BE-33.—This theodolite is packed in the same manner as theodolite PH-BC-33, and the same precautions should be taken as prescribed in *a* above.

d. Time interval device PH-103.—Since this unit is permanently mounted in its carrying case the only preparation required for transportation is the closing and clamping of the lid. The batteries BA-26 should be removed if the equipment is to remain out of service for over 48 hours.

e. Time interval multiplier PH-264-( ).—This unit is self-contained and has no carying case.

f. Line connector unit EE-87.—This unit is self-contained and has no carrying case.

g. Time interval signal BE-65.—This unit is self-contained and has no carrying case.

h. Exposure meter PH-77-B or PH-252-A.—The meter is normally packed in the theodolite carrying case in a separate compartment. For shipping the meter should be packed with paper to prevent its moving around in the compartment.

i. Filters.—These filters, a part of the theodolite, are packed in prepared mounts in the theodolite carrying cases.

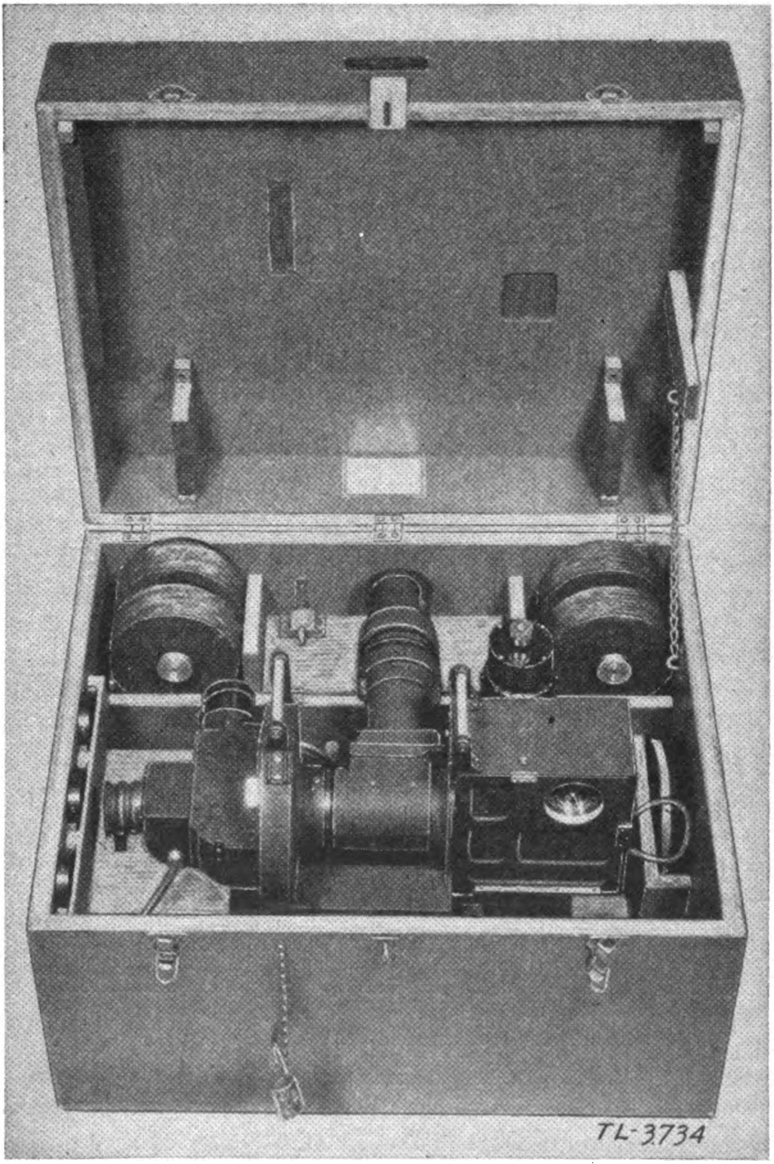


FIGURE 15.—Theodolite PH–BD–33 in carrying case.

j. Film viewer PH–97–A.—Figure 16 shows the film viewer in the case used for transportation and storage.

k. Storage battery BB–46.—Care must be exercised in transporting the storage batteries to prevent tipping and spilling of the contained acid. Storage batteries *must be kept well charged* and properly filled with distilled water at all times.

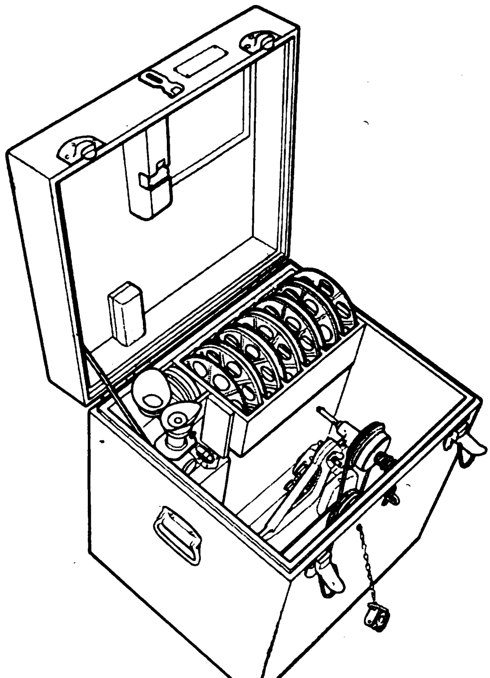


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FIGURE 16.—Film viewer PH-97-A in carrying case.

l. Developing equipment PH-41 and drying rack PH-42.—Figure 11 shows these with their carrying chests.

m. Volume and weight when packed.—The following are the approximate dimensions and weights of the various components of the spotting set when packed for transportation:

Item	Approximate dimensions	Approximate weight
	Inches	*Pounds*
Theodolite PH-BC-33	33 x 20 x 18	160
Theodolite PH-BD-33	30 x 24 x 20	165
Theodolite PH-BE-33	33 x 20 x 18	160
Time interval device PH-103	27 x 12 x 7	23 [1] 45
Line connector unit EE-87	15 x 12 x 7	27
Time interval multiplier PH-264 ( )	6 x 7 x 4	3
Time interval signal BE-65	10 x 7 x 11	23
Film viewer PH-97-A	20 x 20 x 17	106
Storage battery BB-46	21 x 12 x 20	122
Developing equipment PH-41	26 x 26 x 5	50
Drying rack PH-42	4 x 5 x 50	12

[1] With batteries.

Section II

EMPLOYMENT

14. Placing of pier mounts.—Two pier mounts are required. One should be directly behind the battery and not over 35 yards distant. The other must be at the end of a surveyed base line, preferably 4,000 to 5,000 yards from the battery, and outside the area endangered by gun fire. The pier mounts consist of rigid, vertical, solidly placed posts extending approximately 4 feet 6 inches above ground, with flat tops approximately level. Permanent pier mounts of steel or steel encased in concrete are desirable at permanent firing points. The top of each pier mount must be adapted for securing the base ring of the theodolite to it by means of three machine bolts or lag screws. Both pier mounts should be accessible by road so that theodolites need not be carried by hand, and located to have an unobstructed view of the entire field of fire.

15. Duties of members of theodolite crew.—Three men are required for the crew of each theodolite. Their titles and respective duties are listed below:

a. Operator.—The operator services the theodolite, loads film magazines, interchanges magazines on camera, controls the speed of the camera, reads the exposure meter, mounts the filters, sets the camera aperture, controls all switches for motors and lamps, and is responsible for securing orientation data from the officer in charge of the section and for checking the observer in the orientation of the instrument. In addition, the operator of the battery (O_1) theodolite is responsible for the setting up of the time interval device and time interval multiplier and the command of the theodolite during the photographing of the bursts.

b. Observer.—The observer orients and levels the instrument and tracks the target, keeping it centered at the intersection of the cross hairs by operation of the azimuth and site handwheels.

c. Recorder.—The recorder keeps the following records:

(1) *For each practice.*

(*a*) Date.

(*b*) Time.

(*c*) Place (whether the O_1 or O_2 position).

(*d*) Serial number of camera (located below internal time counter).

(*e*) Name of recorder, operator, and observer.

(*f*) Designation of firing battery.

(2) *For each course.*

(*a*) Serial number of course.

(*b*) Time counter readings at beginning and end of each course.

(*c*) Position of sun with reference to theodolite.

(*d*) Type of sky background.

(*e*) Exposure meter reading (value indicated by galvanometer needle).

(*f*) Film emulsion speed.

(*g*) Type of light filter.

(*h*) Filter factor.

(*i*) Frames per second shown by tachometer.

(*j*) Aperture setting.

(*k*) Number of rounds fired on course.

(*l*) Remarks covering anything unusual.

16. Mounting theodolite for use.—*a. Mounting base ring.*—Fasten the base ring (fig. 3) to the pier mount by means of bolts for metal mounts or lag screws for wooden mounts.

b. Placing theodolite.—Unclamp the theodolite so that it may be removed from the case. Then lift the theodolite by its carrying handle (or handles for PH-BD-33) and set it carefully on the base ring. Two men should lift the theodolite to the base ring, each having one hand on the handle and the other on the leveling plate to assist in lifting and to guide the leveling plate of the theodolite to the base ring.

c. Orienting theodolite.—(1) *Theodolites PH-BC-33 or PH-BE-33.*—Turn the traversing handwheel (fig. 3) slowly (rapid rotation of the handwheels may damage counters) until you see the azimuth reading of the datum point on the external azimuth counter; then grasp the theodolite by its leveling plate below the leveling screws and turn it on the base ring until the datum point can be seen on the vertical cross hair in the telescope. The external counters have three wheels which designate thousands, hundreds, and tens, and a drum indicating units. The indicator marks on the units drum are 0.2 mil apart, so the azimuth reading of the datum point can be set to the nearest 0.2 mil. Adjust the telescope by turning the eyepiece, removing the parallax from the eyepiece and focusing it on the datum point. Turn the theodolite on the base ring if needed to set the vertical cross hair on the datum point and clamp it to the base ring by tightening the base clamping screw (fig. 3). Use the fingers and not a wrench or pliers. Always grasp the theodolite below the leveling screws when turning it on the base ring.

(2) *Theodolite PH-BD-33.*—Turn the theodolite on the base ring until the datum point can be seen on the vertical cross hair and clamp the theodolite to the base ring. Adjust the telescope by turning the eyepiece, removing the parallax from the eyepiece and focusing it on the datum point. If the adjusting of the telescope changed the position of the datum point with respect to the vertical cross hair, rotate the telescope with the traversing handwheel (fig. 5) until the datum point again can be seen on the vertical cross hair. Now grasp the azimuth counter release (fig. 6) and rotate the azimuth counter independently by turning the knurled collar at the base of the release device until the azimuth reading of the datum point appears in the window on the external counter. After this adjustment is made the counter release must not be touched except for correcting the datum point setting.

d. Leveling theodolite.—Turn the traversing handwheel slowly until the two spirit levels on the theodolite (fig. 3 or 5) are in line with the leveling screws at the bottom. Grasp two opposite leveling screws (fig. 17), one in each hand, and turn them in opposite directions at the same time to make the bubble in the spirit level in line with them move to the center between the two marks on the glass. The bubble will move in the direction your left thumb does as you turn the leveling screws. When you have one bubble exactly between the lines on the glass, do the same with the other pair of leveling screws to center the other bubble.

Keep the leveling screws just tight enough to hold the theodolite firmly. Forcing will distort the top carriage casting. Check to see if the first bubble is centered and, if it is not, readjust the leveling screws to center it. Then check the second bubble. When both bubbles are centered, traverse the theodolite slowly through 360 degrees (6,400 mils) and watch to see that neither bubble moves from the center. When they do *not* move the theodolite is level. Now traverse the theodolite *back* to the azimuth setting of the datum point, using the traversing handwheel, and see if the datum point is on the vertical cross hair in the telescope.

17. Loading film magazine.—*a.* Take an empty film magazine from its rack in the carrying case and unscrew the two covers which are on the side opposite from the pulley. Hold the magazine firmly in your left hand and turn the covers counterclockwise with the palm and fingers of your right hand.

b. Put the empty magazine, its upper cover, and a can of unexposed film in the changing bag and button the bag shut. Put your arms through the armholes in the changing bag as shown in figure 18, take the roll of unexposed film out of the can, and put it on the spindle in the top of the magazine with the film feeding off the bottom of the roll. Thread the film out through the upper slit, replace the cover on the top of the magazine, and remove the magazine from the changing bag. Thread the end of the film into the magazine through the lower slit, remove the collapsible spool from the lower spindle, and thread the end of the film on this spool. Replace the collapsible spool and turn it so that the film winds on it as follows:

(1) For theodolite PH-BC-33 and PH-BE-33, wind film on the take-up spool emulsion side in (over the top of the spool).

(2) For theodolite PH-BD-33, wind film on the take-up spool emulsion side out (under the spool). An arrow painted on the inside of the magazine indicates direction of rotation of the take-up spool, as does also an arrow stamped on its drive pulley.

c. Replace the cover on the lower part of the magazine and turn the lower or take-up spindle by means of the pulley several turns to ensure that the film will not slip off the collapsible spool. When replacing covers do not spin them on tight as they will be hard to take off. Screw them on slowly and tighten only with the fingers. The magazine is now loaded and ready to be placed on the camera. The magazine may be loaded in a photographic darkroom (total darkness, no safelights) instead of using the changing bag if a darkroom is available.

18. Loading camera.—*a. Theodolite PH-BC-33 and PH-BE-33* (fig. 19).—(1) Open the camera door by releasing the catch at top of the door and release the two rollers from the driving sprocket by turning the two knurled heads. Turn the motor flywheel on the back of the camera until the pulldown claws are at the farthest point from the film guides below the film gate.

(2) Take a loaded magazine in one hand, holding your thumb on the film where it enters the bottom slit, and with your other hand pull out enough film from the upper roll to thread the camera mechanism. Attach the loaded magazine to the camera by setting the tongue of the magazine in the groove on the camera and swinging it into place so that the snap catch fastens it on firmly.

(3) Thread the film through the film gate by pushing the hinged

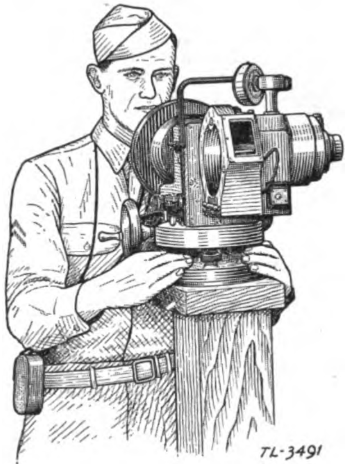

FIGURE 17.—Soldier leveling theodolite.

FIGURE 18.—Soldier loading film magazine with changing bag.

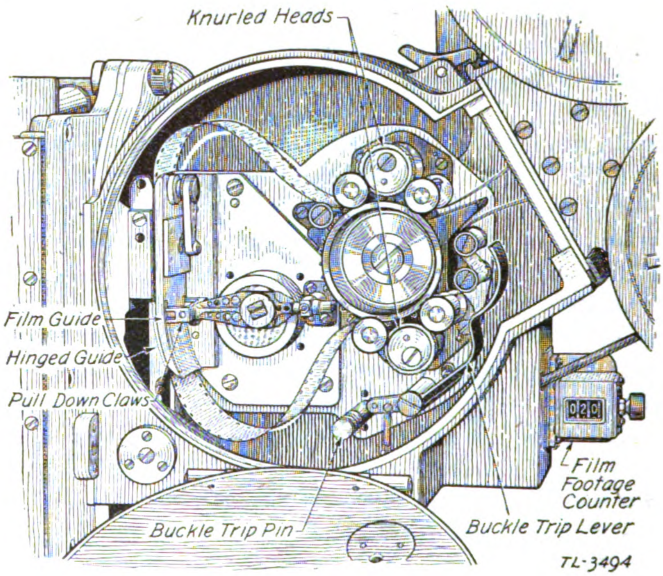

FIGURE 19.—Camera mechanism of theodolite PH-BC-33 and PH-BE-33.

guides open and sliding the loop of film into place. Thread the film between the rollers and sprocket and around the pins as shown in figure 19 and close the rollers on the sprocket by turning the two knurled heads. The white lines painted on the inside of the camera show the size of the film loops. A pin on each of the knurled heads fits into the hole on one of the raised portions of the camera door when the door is closed. The door cannot be closed unless both sprocket rollers are properly closed. Put the belt on the take-up pulley on the back of the magazine.

(4) Turn the motor flywheel on the back of the camera to make the pull down claws move up, over to the film, and down, moving the film down through the film gate twice, and check to see that the film does not rub on the camera case. If it rubs, shorten the loop that is rubbing and recheck for proper film movement. Pull out on the buckle trip pin, hold it momentarily, and release it; if the buckle trip lever has been moved by film jamming, the buckle trip spring will return it to the normal position when the pin is pulled out. Close the camera door and set the Veeder film footage counter to zero.

b. Theodolite PH-BD-33 (fig. 20).—(1) Open the camera door by releasing the catch at the top of the door and open the sprocket film guide by pressing down on the pin handle. Turn the camera hand drive wheel on the back of the camera until the pull down claws are at the farthest point from the film guides below the film gate.

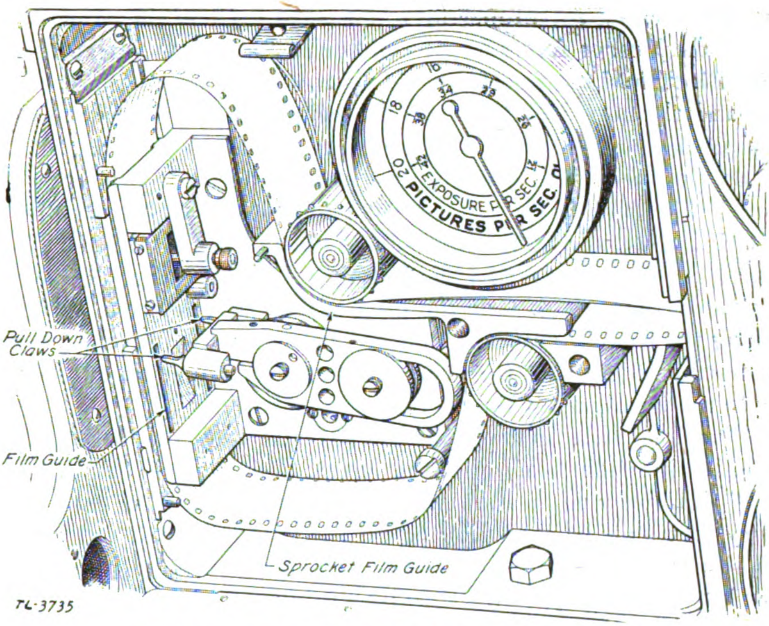

FIGURE 20.—Camera mechanism of theodolite PH-BD-33.

(2) Take a loaded magazine in one hand, holding your thumb on the film where it enters the bottom slit, and with your other hand pull out enough film from the upper roll to thread the camera mechanism. Attach the loaded magazine to the camera by sliding the tongue on the magazine up into the groove of the magazine mount on the camera case, moving the lower part of the magazine up against the camera case, and lowering the magazine gently until it rests solidly in the mount.

(3) Thread the film through the film gate by pushing the hinged guides open and sliding the loop of film into place. Thread the film under the upper sprocket and over the lower sprocket as shown in figure 20 and close the sprocket film guide by pushing up on the pin handle. The white lines painted on the inside of the camera show the size of the film loops. The pin handle on the sprocket film guide fits into a hole on the camera door when the door is closed. The door cannot be closed until this guide is properly closed, and when the camera door is closed the guide cannot open. Put the belt on the take-up pulley on the back of the magazine.

(4) Turn the camera hand drive wheel on the back of the camera to make the pull-down claws move up, over to the film and down, moving the film down through the film gate twice to see that the film does not rub on the camera case. If it rubs, shorten the loop that is rub-

bing, and recheck for proper film movement. Close the camera door and set the Veeder film footage counter beside the magazine to zero.

19. Electrical connections.—*a.* Remove the junction box with its cable and the cord CD-407 from the compartment in the theodolite carrying case and insert the plug on the junction box cable into the jack on the theodolite, pressing the locking button down with your thumb. The jack is on the control panel of theodolite PH-BC-33 and PH-BE-33, and on the back side of theodolite PH-BD-33. When the plug is properly inserted the locking pin on the plug will catch in the hole on the jack so that the plug cannot be taken out except by pressing the locking button. Plug the battery cable into the junction box, testing to see that the locking pin catches, and attach the two clips to the terminals of the 12-volt storage battery.

b. Place the time interval device PH-103 near the battery (O_1) theodolite junction box, open the cover, and connect two batteries BA-26 (carried one in each side compartment), one to each set of battery terminals as shown on figure 7. Drive a metal rod into the ground and connect it with a single wire to the binding post at the lower left-hand corner of the time interval device control panel. This ground is used only for testing for grounded line circuits. Connect a single wire from one of the junction box O_1 camera terminals on the time interval device to one terminal on the junction box of the O_1 theodolite. Connect another single wire from the other junction box O_1 camera terminal to the PH-103 terminal on the time interval multiplier PH-264-( ). Connect a third single wire from the junction box O_1 camera terminal on the multiplier to the remaining terminal on the junction box of the O_1 theodolite. Connect the battery cable of the time interval multiplier to the remaining battery BB-46, which has been left at the O_1 station. Further connections of the time interval multiplier, line connector unit, and time interval signals will be made by the communication section for the use of the visual section. A 2-wire line should previously have been laid between the two theodolite positions using the axle RL-27-A and the wire on the drums DR-4. Connect the "battery end" of this line to the O_2 terminals on the time interval device, and the "flank end" to the terminals on the flank theodolite (O_2) junction box. Turn the line current dial to the minimum current position (counterclockwise to stop). Snap the signal switches of both the theodolites to "on".

c. Operate the ground test key on the time interval device to the "O_1" position and observe the meter. A deflection of the meter needle indicates that the O_1 line from the time interval device to the junction box of the battery (O_1) theodolite (camera) has a ground on it. If no deflection is observed the line is clear. If the line is grounded, it should be cleared and retested. Test the O_2 line to the flank (O_2) theodolite (camera) in the same manner by operating the key to the "O_2" position.

d. Operate the continuity test key on the time interval device to the "O_1" position to check the O_1 line. A reading on the meter indicates that the line is closed; no reading indicates an open line, which must be repaired. Test the O_2 line in the same manner by operating the key to the "O_2" position. The meter readings will probably not be the same, due to differences in length of lines. The signal lamp of the theodolite connected to the line being tested will light and its time counter will advance one unit each time the continuity test key is operated. The continuity test key may be used to advance either counter for synchronization.

e. Press the T. I. short switch, adjust the line current reading to a value between 25 and 30 milliamperes by turning the line current dial, and release the switch. The T. I. short switch may be used at any time to advance both counters simultaneously one unit at a time. Reset the time counters on both theodolites to the same setting as desired, using the reset knob on theodolites PH-BC-33 and PH-BE-33 (fig. 4), or the reset pin inside the signal lamp door of theodolite PH-BD-33, and snap the signal switch of the battery (O_1) theodolite to "off." Operate the T. I. start switch (just below the continuity test key) to the T. I. start position just before starting to use the theodolites. The click of the relays may be heard in the time interval device as it operates.

f. Turn on the camera motor with the motor switch and adjust the camera speed to the number of frames per second required. The motor speed control of theodolites PH-BC-33 and PH-BE-33 is the knob on the control panel. The motor speed control of theodolite PH-BD-33 is the knob on the top of the motor. Do not let the motor run any longer than necessary to adjust the speed. For normal daylight operation use a camera speed of 10 to 15 frames per second. Night operation speed is 18 to 20 frames per second. Check the camera speed with the officer in charge.

20. Selecting and mounting filters.—You will have to know the color of burst, sky background, and target to determine which of the four filters you will use. Choose from table I the filter to be used, remove it from the case, and mount it on the theodolite according to the following instructions:

a. For theodolites PH-BC-33 and PH-BE-33 screw the filter into the filter mount over the camera objective lens.

b. For theodolite PH-BD-33 remove the sunshade by loosening the clamping screw and pulling the shade out. Remove the filter which was held in place by the sunshade if it is not the filter you wish to use. Insert the proper filter in the end of the lens barrel and replace the sunshade.

TABLE I.—*Selection of filters*

Color of burst	Sky background	Target color	Filter (written designation and color)	Filter factors
White	White	Red	5N5 Yellow Green	12.5
Do	Blue	White	29F Dark Red, or 25A Red	8 5
Do	do	Red	5N5 Yellow Green	12.5
Black	White	do	do	12.5
Do	Blue	White	39 Blue	5
Do	do	Red	do	5

Read from table I the filter factor of the filter you are using and remember it. You will need to know it when you use the exposure meter. Do not use any filter for night firing.

21. Using exposure meter.—*a. Exposure meter PH-77-B or PH-252-A* (*Weston Ciné exposure meter M819*).—Attach the leather carrying case to your belt and put the cloth neck string around your neck so that you will not drop the meter on the ground and damage it. This meter is a delicate instrument and must be cared for accordingly. *Do not drop it or aim it directly at the sun.* Always carry it in the case when you are not using it.

(1) Take the meter out of the case and rotate the type camera dial (fig. 12) to type A.

(2) Divide the emulsion speed of the film to be used (50 for the film specified for use with the theodolite) by the filter factor of the filter to be used (see par. 20) and set the inner dial on the exposure meter to show in the window the quotient or the nearest value to it (below it if the quotient is halfway between two values on the scale). This quotient is a "corrected" emulsion speed to adjust for absorption of light in the filter. Table II shows "corrected" emulsion speed settings to be used with the filters for various film speeds. Use this table, if the emulsion speed of the film you are using is listed on it, instead of calculating the "corrected" emulsion speed.

(3) Rotate the middle dial until the arrow under the emulsion speed value points to the number of frames per second (camera speed to be used) on the camera type dial. (See par. 19*f*.)

(4) Hold the exposure meter in one hand, grasping it at the end opposite the meter, and aim the window on the back side, opposite the dial, at the portion of the sky where the bursts are to be photographed.

TABLE II.—*Corrected emulsion speed settings*

Film speed	Filter		
	5N5	29F	25A or 39
125	8	16	24
100	8	12	16
80	6	8	16
64	6	8	12
50	4	6	8
40	3	4	8
32	2	4	6
24	2	3	5

While holding the meter aimed at the sky observe the average relative brightness reading on the meter scale.

(5) Locate the relative brightness value on the relative brightness (outer) row of figures and opposite this value read on the middle dial the correct "f" value of aperture setting for photographing the bursts, using a certain filter under the existing light conditions.

(6) Readjust the dials for emulsion speed and frames per second when filter or camera speed is changed.

(7) As an example make the following assumptions:

Film speed	50
Filter factor	5
Camera speed	12 frames per second
Relative brightness value	13

and determine the proper "f" value of aperture setting. These conditions would give an "f" value of 9.

b. Exposure meter 252–A (*Weston master Ciné exposure meter M720 or equal*).—The Weston M720 meter is identical with the PH-252-A. Use it in the same manner as described in *a* above. Exceptions in use are—

(1) A release catch at the end of the meter must be pressed in order to rotate the type camera dial.

(2) The relative brightness values are different.

(3) A perforated window over the photoelectric cell may be opened to increase the sensitivity of the meter. As the window is opened the meter dial scale is automatically changed so that the meter is still direct reading in relative brightness. Use the more sensitive range of the instrument very infrequently if at all.

c. If the light conditions are varying take exposure meter readings before each course. This is especially necessary in late afternoon.

22. Setting camera aperture.—*a.* Having determined the correct aperture setting as described in paragraph 21, rotate the aperture collar on the theodolite until the correct "f" value engraved on the collar is opposite the index mark beside the collar. If the "f" value obtained is not engraved on the collar it will be between two values engraved on the collar; the collar would then be set so that the index mark is centered between the two engraved values. (The example in par. 21*a* (7) gave a value of "f" equal to 9. The collar would be turned until the index mark was midway between the engraved figures 8 and 11.)

b. If an exposure meter is not available to determine the correct aperture setting the following simple rules may be used:

(1) Poor light—set aperture at f5.6.

(2) Bright light—set aperture at f16.

(3) Night firing—set aperture at f2.7 for PH-BC-33, or f5 for PH-BD-33 or PH-BE-33, using camera speed of 18 to 20 frames per second.

23. Final preparations for use.—*a.* For daylight operation choose a well-defined object at zero site and at least 600 yards from the pier mount and carefully aim the theodolite at the point (so that its image in the eyepiece of the telescope is exactly at the intersection of the cross hairs). Using the exposure meter (pointed at the object to be photographed), determine the camera aperture setting as described in paragraph 21 and adjust the aperture to that setting (see par. 22). Turn on the camera motor for about 3 seconds to photograph the object. "Dump" the theodolite by rotating it slowly through exactly 3,200 mils in both azimuth and site and rephotograph the object. Rapid rotation of handwheels may damage counters. These two photographs serve to check the collimation of the theodolite. "Dump" the theodolite back approximately to the original setting and reset the camera aperture to the proper "f" value for photographing the bursts against the sky background.

b. For night operation it is impossible to photograph an object for record as in *a* above. Turn on the *night* switch, set the camera speed to 18 to 20 frames per second, remove any filters from camera, and set the camera aperture to f2.7 for PH-BC-33 or f5 for PH-BD-33 and PH-BE-33.

c. Traverse theodolite to approximate starting point of course so that the azimuth reading of the normal to the course will be less than 6,400 (see par. 31).

24. Tracking target (observer's duties).—*a.* When the target comes into view aim the theodolite at it by using the open sight (fig. 3 or 5) until you are able to see the target in the telescope. Use the traversing and site handwheels to aim the telescope. When you can see the target through the telescope, adjust the azimuth and site (using handwheels) to bring the image of the target to the intersection of the cross hairs and continue to "track" the target as it travels across the course, always keeping the image of the target at the intersection of the cross hairs.

b. At the end of the course traverse the theodolite back to the starting point by traversing in a reverse direction to that traversed while tracking the target. Do not traverse the theodolite through one complete revolution. Doing this will cause incorrect azimuth readings in the next course (see par. 31*d*(1)) and wind the connecting cable around the pier mount.

c. Track the target and traverse back to the starting point as described above for each succeeding course.

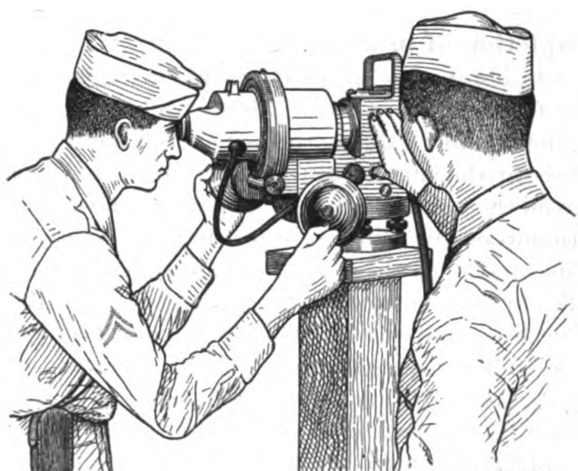

FIGURE 21.—Observer tracking and operator at "Stand by" position.

25. Operator's procedure.—*a.* When a course is started, at the command of STAND BY FOR TIME ZERO, READY, TAKE, the operator of the O_1 theodolite will snap the signal switch of the O_1 theodolite to "on," which starts both the O_1 and O_2 time counters.

b. As the target approaches safe field of fire the O_1 operator commands: STAND BY (which the O_2 operator receives over a telephone system supplied by the communication section); both operators place their hands at the motor switches and are ready to turn on the camera motors. Figure 21 shows the observer tracking and the operator at the "Stand by" position, using theodolite PH-BC-33.

c. Just before the first burst occurs (as determined by the time of flight of that round, or about 5 seconds after the first round is fired) the O_1 operator commands: CAMERA (which the O_2 operator receives by telephone), and each operator turns on his camera motor with the *motor* switch, allowing it to run until after the last burst occurs, when the O_1 operator commands: CUT, and each operator stops his camera and remains at the stand by position until the next round or the course is completed.

26. Preparations for succeeding course.—At the end of the course the O_1 operator opens his signal switch to stop the time counters and both operators read and compare their time counter readings, which the recorders print on their record charts. The time counters (internal) are read through the window (fig. 4 or 6) on the theodolite after turning on the lamp switch. After comparison of time counter readings, and synchronization if necessary, each operator turns off his lamp switch. Succeeding courses are repetitions of the above procedure.

27. Completion of practice.—When a practice is completed, take another set of photographs of the object photographed before starting the practice (see par. 23). About 2 feet of film also should be run off as a precaution against fogging the last shots when the camera door is opened. Record the film footage counter reading, open the camera door, unthread the film, take the film magazine off the theodolite, place your left thumb on the film where it comes out of the upper part of the magazine, and wind the slack film onto the take-up spool by turning the pulley on the magazine with your right hand. Label the magazine to show the number of feet of unexposed film it contains and remove exposed film (using changing bag or darkroom), placing it in a can, sealing, and labeling for development. Turn off all switches on the theodolites and time interval device.

28. Dismounting and packing equipment.—After the film magazine has been removed at the end of a practice, replace camera, telescope, and lens covers, disconnect the electrical connections, and place the junction box with its cable and the battery cable in the compartment in the theodolite carrying case. Place the exposure meter and filters in their compartments in the case. Loosen the base clamping screw (fig. 3 or 5), lift the theodolite carefully by the handle and leveling plate from the base ring, and place it in the proper position in the carrying case (fig. 14 for PH-BC-33 or PH-BE-33, fig. 15 for PH-BD-33), clamping it securely in the case. Two men should work together in lifting the theodolite from the base ring. Be careful to lift only on the handle and leveling plate when moving the theodolite, for lifting on the upper part of the theodolite may damage it and destroy the calibrations. Remove the base ring from the pier mount and place it in the carrying case holder. Check to see that all film magazines are in the case and close it. Close and lock the cover on the time interval device. The batteries BA–26 should be removed from the time interval device if it is to be out of service for more than 48 hours.

29. Processing exposed film.—The successful determination of the data from the film depends entirely on careful and proper development and handling of the film. Scratches or water spots may render all of the work of taking the photographs useless. Use extreme care in processing the film. Part of the operations in processing the film must be done in a completely dark room: loading reel, development, rinsing, and fixing. After fixing is completed, lights may be used. Do not dry film in sunlight.

a. Preparations for processing.—Open carrying chest of developing equipment and remove the changing bag, reel holding rack, reel, and screen. Figure 11 shows this equipment partially removed from its case.

(1) Set up the Stineman reel and film holder on the rack as shown in figure 11.

(2) Remove the smallest tank from the chest and pour into it previously prepared developer solution (Eastman Kodak Company D–11) to a depth of approximately 3 inches. Always use this small tank for developer. The developer is mixed in 5-gallon lots according to directions on the package, one lot being sufficient to develop 1,000 feet of film before being thrown away. *Do not use developer if it is dark brown or has been mixed for over 1 week!*

(3) Remove the middle-sized tank from the chest and pour clear water in it to a depth of about 3 inches. (Always use this tank for water.)

(4) Remove the large tank from the chest and pour previously prepared fixing solution (hypo) into it to a depth of about 3 inches. Always use this large tank for fixing solution. Hypo is mixed in 4-gallon lots (eight 1-pound packages of powder) according to directions on the package and may be used as long as two 5-gallon lots of developer.

(5) Remove the drying rack from its case and assemble it for use. The assembled rack is shown in figure 23. You may do this while the film is in the fixing solution to save time.

b. Loading film onto reel.—Do this in *total* darkness (photographic darkroom or any completely dark room). Remove the exposed film from the can and determine which side of the film has the emulsion on it. Do this by pressing the film between your moistened fingers or lips. The wet fingers or lips will stick to the emulsion side of the film. Rewind the film *emulsion side in*, and place it on the film holder as shown in figure 22. Rewinding the film before putting

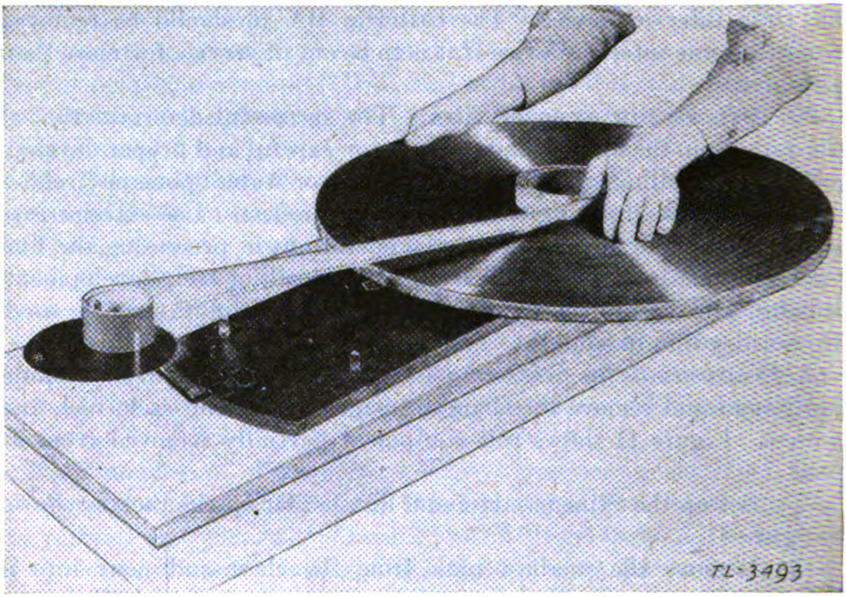

FIGURE 22.—Loading film onto Stineman reel.

it on the film holder will put the counter edge of the film next to the Stineman reel so that the possibility of scratching the burst photograph portion of the film is lessened. Secure the end of the film by one of the perforations on the hook on the inner end of the reel spiral so that the film will wind on the reel emulsion side out. Always check for emulsion side of film as described above before loading it into the reel. Guide the film with the left hand as in figure 22 and rotate the reel in a counterclockwise direction to wind all of the film tightly on the reel, emulsion side out. When you have it all on the reel, double back about one-half inch of the outer end and insert in the spiral to hold this outer end secure. Two or more short pieces of film may be hooked together by doubling each back and hooking together so that the reel may be filled before developing.

c. Developing film.—Do this in *total* darkness (photographic dark-room or any completely dark room). Using the hand hold at the center of the reel, set it in the tank of developer, and move it quickly up and down about one-half inch several times to drive out any air bubbles that may stick to the film. Allow the film to develop according to the following time-temperature relationship:

Developer temperature	*Time of development*
65° F	5 minutes
70° F	4½ minutes
75° F	4 minutes

All solutions should be kept within this temperature range.

d. Rinsing film.—Do this in *total* darkness (photographic dark-room or any completely dark room). After the film has developed for the required time, lift the reel by the handle out of the developer, allow it to drain for 15 or 20 seconds, put it in the second tank with water (this water should be nearly the same temperature as the developer), and remove air bubbles as in *c* above. Allow to remain in this water rinse for about 1 minute.

e. Fixing film.—Do this in *total* darkness (photographic darkroom or any completely dark room). After the film has been rinsed, lift the reel by the handle, allow it to drain, put it in the third tank with the fixing solution (hypo), and remove air bubbles as in *c* above. Leave the film in the fixing solution for 10 to 15 minutes (this solution should be nearly the same temperature as the developer and rinse).

f. Storage of developer and preparation for washing film.—While the film is in the fixing solution, pour the developer, if no more developing is to be done immediately, back into the brown glass bottle (or bottles) it was taken from. In order to exclude air from the bottle (or bottles), pour clean pebbles into the bottle (or bottles) to bring the surface of the developer up into the neck and cork tightly. Developer deteriorates under light and in contact with the air. Thoroughly rinse the developer tank and place it in a position where it will completely drain and dry. Also, during this time, empty the rinse water tank, rinse thoroughly, and fill to a depth of about three inches with clear water.

g. Washing film.—This and further operations may be done with light, but not in direct sunlight. After the film has been in the fixing solution (hypo) for 10 to 15 minutes, lift the reel by the handle out of the solution, allow to drain for 15 or 20 seconds, and place it in the second tank of water to wash. Move the reel rapidly up and down in this wash water for 15 or 20 seconds. Lift from water, allow to drain for a few seconds, and shake off the surplus water. Change the water in the tank and repeat the washing operation. Repeat through five to eight changes of water.

h. Removing film from reel.—When washing is completed, release *both ends* (and any joints) of the film so that it lies free in the reel. Turn the reel, with the film still on it, upside down, using the handles, and immerse it in the water in the middle-sized tank. Agitate the reel to release the film and lift the reel out of the water, leaving the film in the tank. Place the reel in a position to dry thoroughly after shaking out excess water.

i. Winding film onto drying rack.—After the film is removed from the reel in the water, wind the film under water carefully into a com-

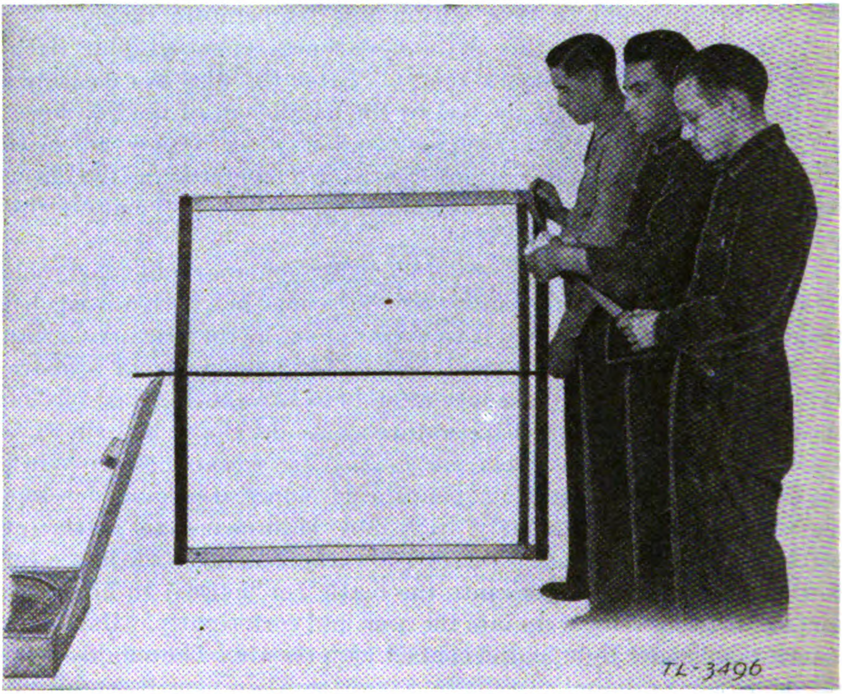

FIGURE 23.—Soldiers wiping and winding film onto drying rack.

pact roll so that it will not scratch when handled. Take the roll of film from the water and fasten the end to the drying rack so that the film will be wound on the rack emulsion side out. Hold the roll of film between the thumb and one finger as illustrated in figure 23. Using *three* men as illustrated in figure 23, wind the film loosely on the drying rack, first wiping carefully between two viscose sponges which have been wet in clear water and then squeezed as nearly dry as possible with the hands. Use care in this wiping to get as much as possible of the loose water off the film without scratching or sliding the emulsion on the film. One man holds the rack and turns it to wind the film on it. The other end of the rack may be rested on the open cover of the case holding the developing equipment. A second man wipes the film carefully with the viscose sponges. The third holds the roll of wet film. If the film shrinks tight on the rack as it dries, loosen it to prevent stretching or breaking.

j. Storage of fixing solution.—While the film is drying pour the fixing solution back into the storage container for reuse and cork the container. Thoroughly rinse the tank and place it in a position where it will completely drain and dry. Empty the wash water from its tank and place the tank to dry.

k. Removing film from drying rack.—When the film is dry use the rewinder PH-92 to wind it on one of the reels of the film viewer, emulsion side in, and with the leading end (lowest time counter numbers) on the outside of the reel. Wound this way it is ready to be placed on the upper spindle of the film viewer PH-97-A.

30. Using film viewer PH-97-A.—*a. Preparation for use.*—Open the carrying chest and unclamp the viewer by loosening the wing nut and lifting and turning the wooden clamping block one-fourth turn in a clockwise direction. Grasp the reel bracket (fig. 13) and take the viewer out of the case by first tilting it to the right and then sliding it to the left, lifting at the same time. Place it on a firm level support with the name plate on your right and the switch plate to the front. Unlatch the lower rear compartment in the case and remove the two connecting cords, one of which has a foot speed controller permanently attached to it. Insert the two-prong plug on the controller cord into the jack at the front left of the viewer and turn clockwise to lock it in place. Insert the plug of the other cord into a 110-volt outlet (d-c or 25-60 cycles a-c) and clip the Fahnestock clip to a ground connection at the outlet. Fit the other end of this cord to the three-prong polarized plug at the front left of the viewer and turn clockwise to lock it in place. Set the speed control rheostat midway between the end stops (continued operation at the lowest speed will overheat the rheostat). This completes the electrical connections. Remove the viewing attachment PH-98-A from its holder in the upper left corner of the carrying chest by unlocking the holder and sliding the viewing attachment forward. Screw this three or four turns into the mount on the front of the viewer, adjusting it to have the name plate of the viewing attachment at the top, and tighten the locking ring on the mount to hold the viewing attachment in this position.

b. Threading film in viewer.—The film to be viewed has been wound on one of the reels, emulsion (dull) side in and with the leading end of the film on the outer end of the reel. Put this reel on the upper spindle (fig. 13) so that the film feeds off the top of the reel toward the front of the viewer. The keyway in the spindle hole on the reel must be fitted over the key on the spindle before the reel will slide on the spindle far enough to permit fastening the reel by means of the flip lock on the end of the spindle. Put an empty reel on the lower spindle. Set the motor reversing switch on the switch panel to the "backward" position. Open the upper and lower rollers by lifting and pushing down on the respective handles (fig. 13), and the film guide cover by pressing down on the snap catch (fig. 13) and swinging it to your left. Unwind about two feet of film from the upper reel, slide the film from the right side under the upper jerk absorbing device (fig. 13) and over the film feed sprocket and film guide. When the perforations of the film are engaged by the teeth of the film feed sprocket close the upper roller to hold the film against the film feed sprocket. Put a small loop of film between the film feed sprocket and the intermittent movement sprocket as in figure 13, engage the teeth of the intermittent sprocket in the film perforations, make sure that the film lies straight in the film guide, and close the film guide by swinging the viewing attachment back into place. Operate the viewer by hand to make sure this loop is large enough that the film does not pull tight between the two sprockets. Operate the viewer in the "backward" direction (by pressing the foot speed controller) to provide a free end of about three feet of film, leave a sizable loop (as in fig. 13) below the film guide, and slide the film into the slot on the right side of the machine, under the film feed sprocket and over the lower jerk absorbing device. Engage the teeth of the sprocket in the perforations of the film and close the lower sprocket roller. Pass the end of the film under the lower reel, slip the end into the slot on the reel hub to secure it, and wind up the slack film, turning the reel by hand. The film is now threaded in the viewer.

c. Adjusting optical system.—Operate the light switch to the "on" position. Loosen the eyepiece locking screw (fig. 13) and, while looking into the eyepiece of the viewing attachment, slide the eyepiece barrel to focus the eyepiece on the circular reticle and tighten the locking screw (do not force). Using the foot controller, operate the viewer in the backward direction until a frame of film with the vertical and horizontal indicator marks comes into the field of the viewing attachment and stop the viewer. Operate the viewer by hand (using the smooth handwheel on the left side) to a position where slight back and forth movement of the handwheel does not move the film. Then, using the vertical framing lever, the horizontal framing screw, the reticle rotating ring, and the magnification adjustment (loosen locking screw before adjusting magnification), adjust to make the indicator marks and the reticle appear in the eyepiece as shown in figure 24.

d. Obtaining data concerning location of bursts.—Operate the film viewer in the backward direction at such a speed as will enable you to see photographs of bursts as they appear in the viewer eyepiece.

(1) Record the azimuth and site readings for 5-second intervals as you run the film through the viewer. Read the O_1 film first and then take corresponding readings for corresponding times on the O_2 film.

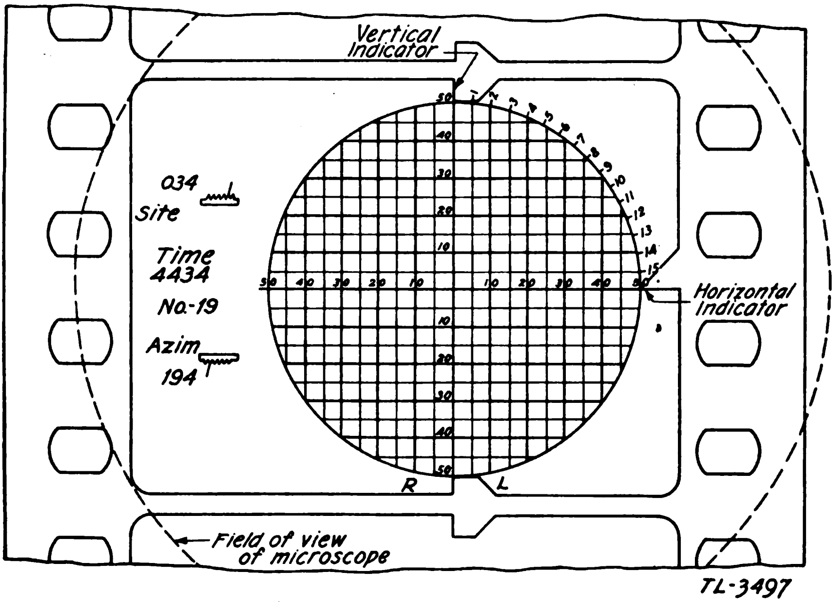

Figure 24.—Single frame of film showing reticle image.

(2) Bursts will appear either as a light spot on a dark background or a dark spot on a light background. When you see the image of a burst stop the viewer immediately, change the direction of operation to forward and operate the viewer until the time reading on the film changes to one unit less than the reading on the first frame on which the burst was photographed. Change direction to backward and operate the viewer by hand until the first frame on which you saw the burst comes into view, counting the frames having the same time number on them. Record the time reading and the number of the first frame showing the burst. (Example: 113–6 indicates 113th second and sixth frame.) Adjust the reticle-indicator relationship as described in *c* above.

(3) Read and record the site and azimuth readings on the film. These readings are composed of three digits and a sawtooth scale with a line crossing it. The location of the line crossing the sawtooth scale indicates the units reading; the crests of the teeth represent (from left to right) 1, 3, 5, 7, and 9 mils and the troughs 2, 4, 6, 8, and 0 mils. The figures on the counters represent the tens, hundreds, and thousands. The readings in figure 24 are: site 349 mils, azimuth 1,943 mils.

(4) Rotate the reticle (using the knurled ring) until the reading (0–16 hundred) on the circumference at the upper vertical indicator is the same as the site reading in hundreds on the film. Interpolate

between marks to nearest 50 mils. For example, the site reading in figure 24 is 349, which you would call 3½ hundreds. The reticle would be rotated to 3.5 on the circumference scale.

(5) Having rotated the reticle to agree with the site counter reading, record the deviation of the burst (and target if visible) from the center lines of the reticle. For viewing film from theodolite PH-BC-33 (field of view 100 mils) the lines on the reticle will be 5 mils apart, but for viewing film from theodolites PH-BD-33 and PH-BE-33 (field of view 50 mils) the lines will be 2½ mils apart. *Rights and lefts are reversed on the reticle* due to the prism or mirror in the camera. This is indicated on the reticle of some of the viewers but not on all of them. For both battery and flank film records record the deviations as right (or left), *remembering reversal*, and above (or below). Form AA18 as indicated in TM 4-235 is used for recording these data.

e. Removing film from reels.—When you are finished with a reel of film remove the reel from the spindle and, using a pencil as a shaft to support the reel, wind the film slowly onto the hub of the aluminum hand wheel on the belt side of the viewer. Use the foot speed controller and wind very slowly. Wind several turns of film on the hub to secure the inner end and when the film is all wound on the hub grasp the roll and slide it from the hub with a rotational motion and place it in a can, properly labeled, for storage.

Section III

DETAILED FUNCTIONING OF EQUIPMENT

31. Theodolite PH-BC-33.—*a. Support and leveling mechanism.*—A base ring is mounted on a pier mount, and the leveling plate of the theodolite rests on this base, on which it may be rotated before being clamped by means of the base clamping screw, which prevents any further relative motion between the base ring and the leveling plate. A ball joint spindle and four leveling screws on the leveling plate support an azimuth gear. The leveling screws are so threaded that the motion of the bubble in the level on the theodolite follows the motion of the left thumb as the leveling screws are turned. The levels are graduated to one minute of arc.

b. Azimuth tracking mechanism.—The frame of the theodolite is supported on the azimuth gear by a ball thrust bearing and may be rotated about the vertical axis of this gear by turning of the traversing handwheel (fig. 3) on the body of the theodolite, which turns a single thread worm gear meshing with the azimuth gear. The periphery of the azimuth gear serves as a guide to hold the frame of the theodolite. By means of this handwheel (fig. 3) the theodolite may be rotated continuously about its vertical axis. One revolution of the handwheel rotates the theodolite 40 mils.

c. Site tracking mechanism.—The telescope is on the camera prism mount (equipped with a 160-tooth gear) which rotates on an axis perpendicular to and in the same plane as the axis of vertical or azimuth rotation. The gear in this mount is driven by a single thread worm gear on a shaft on the theodolite frame. The site handwheel (fig. 4) turns the worm, one complete rotation of the handwheel changing the site angle 40 mils. Since the telescope and camera prism or mirror rotate together the centers of fields of view of the telescope and camera optical system coincide after they are initially adjusted to do so.

d. Counter mechanism.—(1) Two azimuth counters are driven by a gear on the shaft carrying the azimuth handwheel and worm gear. Both of the counters are Veeder type, reading from 0 to 9,999 and repeating. Under certain conditions the azimuth readings will be greater than 6,400, which will require corrections to determine the true azimuth angle. Figure 25 shows the actual readings under various conditions and the corrections to be applied thereto.

After orienting the instrument, any traversing beyond the indicated rotation in figure 25 will lead to needlessly complicated corrections. Range of traverse should not be beyond that indicated in this figure. One of the counters is placed inside the theodolite, illuminated by a lamp for photographing on each frame of the motion picture film. The units wheel of the counter has a spiral which in connection with a sawtooth scale indicates mils. The counter is read as described in paragraph 30*d*(3) through the window (fig. 4). The other counter is just below and to the left of the telescope eyepiece, for external reading in checking and orientation. The units drum of this counter has figures indicating mils and small divisions between units representing two-tenths of a mil.

(2) Two site counters are driven by a gear on the shaft carrying the site handwheel and worm gear. They are of the same type respectively as the internal and external azimuth counters, and are read in the same manner. Both the internal and external site counters are above the corresponding azimuth counters.

(3) A time counter placed between the internal azimuth and site counters is solenoid-operated, advancing one unit for each operation. The solenoid is operated indirectly by the time interval device at a frequency normally once per second. The time counter may be advanced manually using a small screw driver in the fitting by the

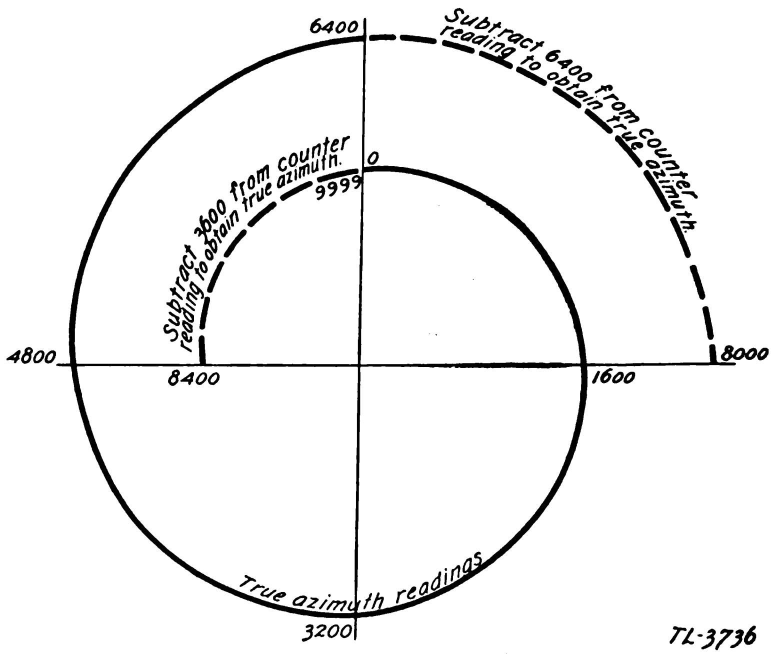

FIGURE 25.—Corrections for azimuth readings.

traversing handwheel (fig. 3) or reset to zero with the reset knob by the site handwheel (fig. 4). Detailed operation will be discussed under electrical connections.

e. Optical systems.—Three optical systems are used in the theodolite. Figure 26 illustrates their respective uses. They are discussed individually below:

(1) The tracking optical system consists of an elbow type 8-power telescope with a field of view of 156 mils, fixed to the camera prism mount which rotates about a horizontal axis for determination of site angles. A reticle having cross hairs is placed in the telescope so that the target being followed can be kept at the center of the field

of view of the telescope. This telescope has one adjustment, the focusing of the eyepiece on the reticle.

(2) The camera optical system of the theodolite PH-BC-33 consists of a right angle prism fixed on the rotating camera prism mount and a 6-inch focal length lens focused permanently at infinity. Parallel rays of light enter the optical system, are bent 90°, and focused on the film in the camera aperture. Three orienting indicator projections on the camera aperture, two vertical and one horizontal, cast shadows on the film. The center of the camera optical system is focused on the intersection of two imaginary lines, one between the upper and lower vertical indicators and a second from the horizontal indicator mark perpendicular to the vertical indicator line. In addition the field of view between the horizontal portions of the vertical indicators is 100 mils. The presence of the prism in the

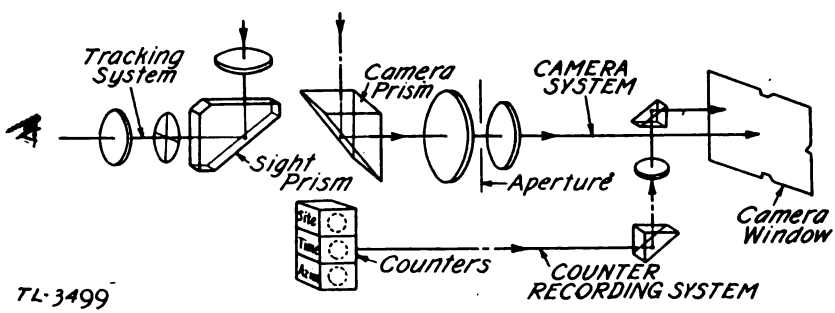

FIGURE 26.—Camera optical systems.

camera optical system reverses rights and lefts on the picture but has no effect in the vertical direction.

(3) The counter recording system consists of two right angle prisms and a lens which focuses the image of the illuminated internal counters on one edge of the film in the camera aperture. This system is mounted entirely inside of the theodolite frame. Light rays reflected from the counters are bent by the first prism, pass through the lens and are bent by the second prism to focus on the film in the camera aperture. This system serves to photograph the site, azimuth, and time counters and the theodolite serial number which is placed on the time counter.

f. Electrical system.—Each theodolite obtains its power from a 12-volt storage battery. The cord CD-407 connects the battery to the junction box and two leads of the four-conductor cable complete the connection to the theodolite. The schematic wiring diagram of the theodolite is shown in figure 27. Detailed operation of the individual electrical components of the theodolite is given below:

(1) The signal switch closes the circuit of the relay on the rear of the control panel. This relay receives intermittent operating battery from the time interval device through the two remaining leads of the four-conductor cable and the two-conductor field wire connected from the terminals on the junction box to the time interval device. The relay closes the 12-volt operating circuit to the time counter solenoid and the signal lamp. Normally the relay is operated once each second by the time interval device.

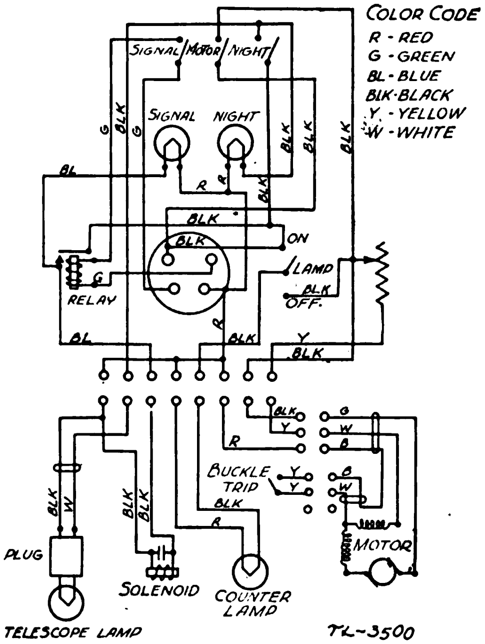

FIGURE 27.—Schematic wiring diagram of theodolite PH-BC-33.

(2) The motor switch closes the 12-volt operating circuit of the counter lamp and camera motor. The counter lamp illuminates the internal counters for photographing, and may be turned on with the lamp switch for reading the counters through the window (fig. 4). The motor speed is controlled by the rheostat at the lower left corner of the control panel and a buckle trip switch in the camera opens to stop the motor if the film jams. Two external three-conductor leads with plugs connected to the motor may be disconnected if the motor is removed from the camera.

(3) The night switch closes the 12-volt operating circuit of the night and telescope lamps. The night lamp on the back of the

control panel illuminates a small mirror in the theodolite which reflects the light to the back of the camera lens. Part of this light is reflected from the camera lens to the film in the camera aperture, "fogging" it slightly so that the indicator marks will show on the film for night photography. The telescope lamp illuminates the cross hairs in the reticle of the telescope so that they can be seen when used at night. The flexible cable connecting the telescope lamp can be unplugged when taking the telescope cover off. These lamps are used only for night photography.

g. Recording system.—The recording system consists of a motor-driven motion picture camera, the speed of operation of which may be varied from 10 to 20 frames per second. Figure 19 illustrates the film feed and safety mechanisms of the camera. A tachometer indicates the speed of operation and corresponding exposure time or shutter speed. The film magazine holds 200 feet of 35-millimeter film, the amount used being indicated on a Veeder counter film footage indicator.

(1) The film feeds from the upper reel on the magazine through a felt-lined slit to the film feed sprocket which rotates counterclockwise. The film is held against the sprocket by two rollers so that the teeth on the sprocket engage the perforations of the film. These rollers are moved by rotation of a knurled head for threading the film in the camera mechanism. Pins on the two knurled heads in the camera prevent the camera door from being closed unless the rollers are properly seated on the sprocket. From the drive sprocket the film passes through a film guide past the camera aperature and back to the lower side of the film feed sprocket and is held in place against the sprocket by another set of rollers similar to those described above. From the lower side of the film feed sprocket the exposed film passes through another felt-lined slit to the belt-driven lower (take-up) reel in the magazine. This reel rolls up the exposed film. To prevent the film from jamming, a buckle trip lever, pin, and switch are so placed that they will trip to stop the camera if the take-up reel fails to roll up the exposed film as fast as it is used. Figure 19 shows the position of the buckle trip lever, which releases the buckle trip pin, actuating a switch to stop the camera motor.

(2) The film feed sprocket provides for steady movement of film in and out of the camera, but the movement of the film past the camera aperature must be intermittent and synchronized with the opening and closing of the camera shutter. Upper and lower film loops provide the slack film between the steady movement of the film at the sprocket and the intermittent movement at the camera aperature. The film fits snugly between the film guides and is moved down by

the pull down claws (fig. 19). These claws, cam-operated, move toward the film, engage in the perforations, pull the film down the width of one "frame" and move away from the film. During the time the pull down claws are moving up to engage the film a rotary shutter allows the focused image from the camera lens system to strike the film at the camera aperature. The shutter closes the aperture just before the pull down claws start to move the film down again, keeping it closed until the film has been moved down and then opening the aperture to expose the next frame on the film. Thus the film has a series of "still" pictures on it, taken at a rate of from 10 to 20 per second, depending on the speed of operation of the camera.

32. Theodolite PH-BD-33.—*a. Support and leveling mechanism.*—This is identical in operation with that of theodolite PH-BC-33 (par. 31*a*).

b. Azimuth tracking mechanism.—This is identical in operation with that of theodolite PH-BC-33 (par. 31*b*). Figure 5 illustrates the traversing handwheel.

c. Site tracking mechanism.—This is identical in operation with that of theodolite PH-BC-33 (par. 31*c*). Figure 6 illustrates the site handwheel.

d. Counter mechanism.—This is identical in operation with that of theodolite PH-BC-33 (par. 31*d*). Figure 6 illustrates the window through which the internal counters are observed.

e. Optical systems.—Three optical systems are used in the theodolite PH-BD-33. Figure 26 illustrates their respective uses. They are discussed individually below.

(1) The tracking optical system is identical in operation with that of theodolite PH-BC-33 (par. 31*e*(1)).

(2) The camera optical system of the theodolite PH-BD-33 consists of a 12-inch focal length lens focused permanently at infinity, and a mirror. Parallel rays of light enter the optical system, are focused by the lens, and bent 90° by the mirror to the film in the camera aperture. Three orienting indicator projections on the camera aperture, two vertical and one horizontal, cast shadows on the film. The center of the camera optical system is focused on the intersection of two imaginary lines, one between the upper and lower vertical indicators and a second from the horizontal indicator mark perpendicular to the vertical indicator line. In addition, the field of view between the horizontal portions of the vertical indicators is 50 mils. The presence of the mirror in the camera optical system reverses rights and lefts on the picture but has no effect in the vertical direction.

(3) The counter recording system is identical in operation with that of theodolite PH-BC-33 (par. 31*e*(3)).

f. Electrical system.—Each theodolite obtains its power from a 12-volt storage battery BB-46. The cord CD-407 connects the battery to the junction box and two leads of the four-conductor cable complete the connection to the theodolite. The wiring of the theodolite is similar to that of theodolite PH-BC-33 (fig. 27), with the exception that there is no rheostat for motor speed control, as the camera motor speed is governor-controlled and the connecting cable terminals are wired differently. Detailed operation of the individual electrical components of the theodolite is given below.

(1) The signal switch closes the circuit of the relay in the theodolite. This relay receives intermittent operating impulses from the time interval device through the remaining two leads of the four-conductor cable and the two-conductor field wire connected from the terminals on the junction box to the time interval device. The relay closes the 12-volt operating circuit to the time counter solenoid and the signal lamp. Normally the relay is operated once each second by the time interval device.

(2) The motor switch closes the 12-volt operating circuit of the counter lamp and camera motor. The counter lamp illuminates the internal counters for photographing, and may be turned on with the lamp switch for reading the counters through the window (fig. 6). The motor speed is controlled by a governor on the top of the motor (fig. 6). A film trip switch inside the camera stops the motor if the film jams and does not feed properly onto the take-up spool.

(3) The night switch closes the 12-volt operating circuit of the night and telescope lamps. The night lamp by the camera aperture illuminates the mirror in the camera optical system. This light is reflected from the mirror to the film in the camera aperture, "fogging" it slightly so that the indicator marks will show on the film for night photography.

g. Recording system.—The recording system consists of a motor-driven motion picture camera, the speed of operation of which may be varied from 10 to 20 frames per second. Figure 20 illustrates the film feed and safety mechanisms of the camera. A tachometer indicates the speed of operation and corresponding exposure time or shutter speed. The film magazine holds 200 feet of 35-mm film, the amount used being indicated on a Veeder counter film footage indicator (fig. 6).

(1) The film feeds from the upper reel on the magazine through a double roller slit to the film feed sprocket which rotates clockwise. The film is held against the sprocket by a sprocket film guide so that

the teeth on the sprocket engage the perforations of the film. This guide is moved away from the sprocket by pressing down on the pin handle, for threading the film in the camera mechanism. The pin handle prevents the camera door from being closed until the sprocket film guide has been properly placed to hold the film. From the drive sprocket the film passes through a film guide past the camera aperture and back to the lower take-up sprocket, and is held in place against the sprocket by the same sprocket film guide. From the take-up sprocket the exposed film passes through another roller slit to the belt-driven lower (take-up) reel in the magazine. This reel rolls up the exposed film. As a means to prevent the film from jamming, a trip switch between the take-up sprocket and the film magazine will stop the camera motor if the film jams in the camera. The motor cannot be started until the slight jam of film is cleared and the trip switch is released. Unlike the buckle trip mechanisms on the theodolite PH-BC-33, it is not necessary to reset the trip switch of this camera.

(2) The film feed and take-up sprockets provide for steady movement of film in and out of the camera, but the movement of the film past the camera aperture must be intermittent and synchronized with the opening and closing of the camera shutter. Upper and lower film loops provide the slack film between the steady movement of the film at the sprockets and the intermittent movement at the camera aperture. The film fits snugly between the film guides and is moved down by the pull down claws (fig. 20). These claws, cam-operated, move toward the film, engage in the perforations, pull the film down the width of one "frame," and move away from the film. During the time the pull down claws are moving up to reengage the film a rotary shutter allows the focused image from the camera lens system to strike the film at the camera aperture plate. The shutter closes the aperture just before the pull down claws start to move the film down again, keeping it closed until the film has been moved down and then opening the aperture to expose the next frame on the film. Thus the film has a series of "still" pictures on it, taken at a rate of from 10 to 20 per second, depending on the speed of operation of the camera.

33. Theodolite PH-BE-33.—*a. Support and leveling mechanism.*—This is identical in operation with that of theodolite PH-BC-33 (par. 31*a*).

b. Azimuth tracking mechanism.—This is identical in operation with that of theodolite PH-BC-33 (par. 31*b*).

c. Site tracking mechanism.—This is identical in operation with that of theodolite PH-BC-33 (par. 31*c*).

d. Counter mechanism.—This is identical in operation with that of theodolite PH–BC–33 (par. 31*d*).

e. Optical systems.—Three optical systems are used in the theodolite PH–BE–33. Figure 26 illustrates their respective uses. They are discussed individually below.

(1) The tracking optical system is identical in operation with that of theodolite PH–BC–33 (par. 31*e*(1)).

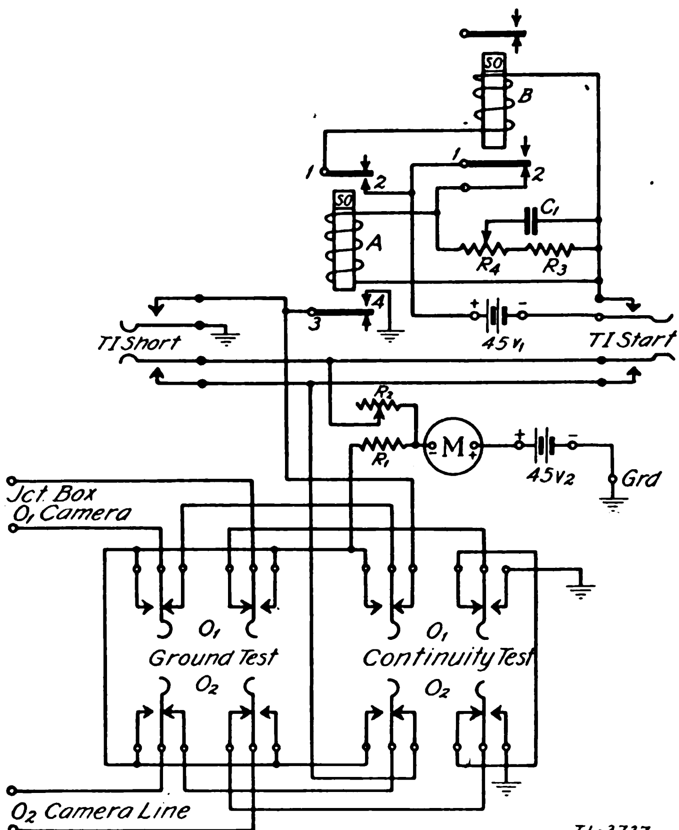

FIGURE 28.—Circuit diagram, time interval device PH–103.

(2) The camera optical system is identical in operation with that of theodolite PH–BD–33, discussed in paragraph 32*e*(2)).

(3) The counter recording system is identical in operation with that of theodolite PH–BC–33 (par. 31*e*(3)).

f. Electrical system.—The electrical system is identical in operation with that of theodolite PH–BC–33 (par. 31*f*).

g. Recording system.—The recording system is identical in operation with that of theodolite PH–BC–33 (par. 31*g*).

34. Time interval device PH-103.—This time interval device circuit (fig. 28) consists basically of a relay pulsing circuit for supplying periodic direct current pulses on external lines, and test circuits for testing the lines. It is permanently mounted in a carrying case which also has space for the two batteries BA-26 required for its operation. One battery supplies power for the operation of the relays and the other for the external circuit and test circuits. If only one battery is available it may be used to supply both circuits in an emergency. The function of the time interval device is to supply periodic direct current pulses on the lines to the O_1 and O_2 theodolites and the time interval multiplier, for time measurement. Functionally, the operation of the time interval device may be considered under the four separate phases discussed individually below:

a. Time interval circuit.—This portion of the time interval device circuit, shown by the heavy lines in figure 29①, consists of two slow operating relays A and B, resistor R_3, potentiometer R_4, capacitor C_1 and one contact of the T. I. start switch, and draws power for operation from the battery V_1. When the T. I. start switch is closed relay A operates through contacts 1 and 2 on relay B. As soon as relay A has operated, relay B operates through contacts 1 and 2 on relay A, and causes relay A to release. Releasing of relay A opens the operating circuit of relay B and it releases. This completes the cycle of operation; both relays are released and relay A again operates to repeat the cycle. The contacts 3 and 4 on relay A are connected to the theodolite circuit. The time interval is controlled by use of the resistor R_3, potentiometer R_4, and capacitor C_1. While relay B is in a nonoperated condition the capacitor C_1 is being charged, the rate of charge controlled by the setting of the potentiometer R_4. When relay B operates the capacitor stops charging and starts discharging through two paths, one path through the resistor R_3 and a part of potentiometer R_4, and the other path through the remainder of the potentiometer and relay A. Relay A will not release until the voltage impressed by the capacitor C_1 drops below the "hold" value of the voltage for the relay. This delay in the releasing time of relay A lengthens the time per cycle of operation of the two relays and thus controls the time interval. This circuit is designed to provide an adjustable range in pulsing rate of one cycle per second plus or minus 20 percent.

b. Theodolite circuit.—This portion of the time interval device circuit, shown by the heavy lines in figure 29②, consists of one contact of the T. I. start switch, a T. I. short switch, rheostate R_2, meter M (common to several circuits), 45-volt battery V_2, and contacts 3 and 4 of relay A. With the T. I. start switch closed, each time relay A operates contacts 3 and 4 close the circuit containing the rheostat R_2, meter **M**, the two theodolite circuits, and V_2. The current in this circuit is adjusted with the rheostat. Pressing the T. I. short switch will close this circuit and hold it closed as long as the switch is pressed, regardless of the position of the T. I. start switch or the operated or nonoperated condition of relay A. With the signal switches of both theodolites closed their signal lamps will light and the time counters will advance one unit each time this switch is pressed or each time relay A operates during normal operation. This switch is used to close the circuit for adjusting line current to 25 to 30 milliamperes.

c. Continuity test circuit.—The basic function of this portion of the

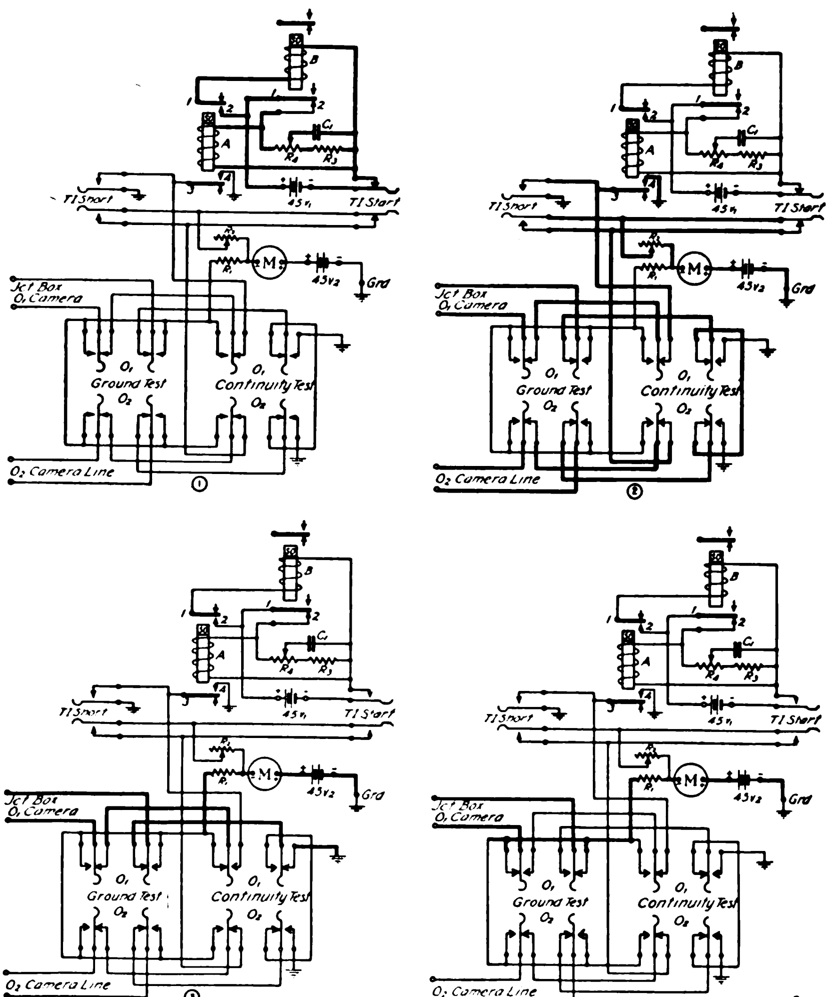

FIGURE 29.—Functional diagrams for time interval device PH-103.

time interval device circuit, shown by the heavy lines in figure 29③, is to place the battery V_2 in series with meter M, resistor R_1, and each theodolite line, one at a time. This is done by operating the continuity test key to the "O_1" or "O_2" position to test either the O_1 or O_2 lines. Either line may be tested at any time, but the signal switch of the theodolite whose line is being tested must be closed at the time the test is being made. Each time the key is operated the signal lamp of the theodolite on the line being tested will light and its time counter will advance one unit. Figure 29③ shows the circuit (heavy lines) for testing the O_1 line.

d. Ground test circuit.—The basic function of this portion of the time interval device circuit, shown by the heavy lines in figure 29④, is to place both sides, paralleled, of either the O_1 or O_2 line in series

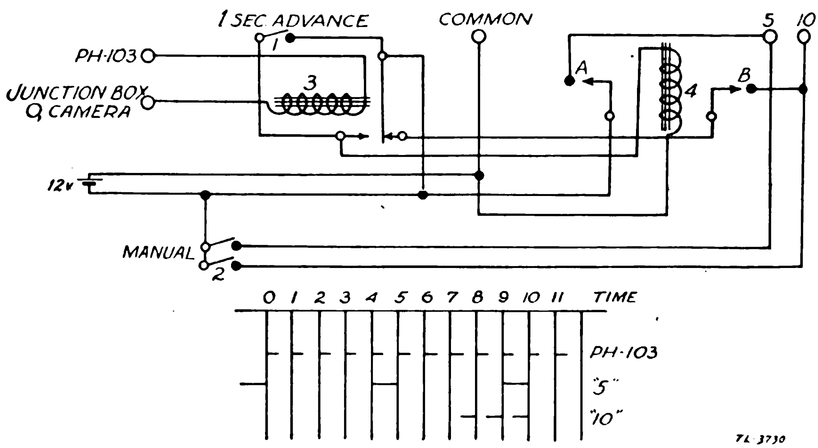

FIGURE 30.—Circuit diagram, time interval multiplier PH–264–( ).

with the resistor R_1, meter M, V_2, and ground. The ground connection is supplied by a ground rod connected to a ground terminal at the lower left corner of the panel. It is not necessary for the signal switches on the theodolites to be closed for this test. Figure 29④ shows the circuit (heavy lines) for testing the O_1 line.

35. Time interval multiplier PH–264–( ).—Figure 30 shows the multiplier circuit, which consists of two relays and two nonlocking push button type keys. In use, the winding of relay 3 is in series with the line from the time interval device to the O_1 theodolite junction box, so this relay is operated once each second by the time interval device. Relay 4 has two contacts, moved by two cams on a shaft with a 10-tooth ratchet wheel. The driving pawl is the armature of relay 4. Contacts A are closed by the A cam once for each of two diametrically opposite teeth on the ratchet. Each operation of relay 3 causes relay 4 to be energized, advancing the ratchet wheel one tooth. As the cams rotate the contacts A will be closed by the two projections on the A cam once every five operations of relays 3 and 4. Each time contacts A are closed 12-volt battery appears between the "common" terminal and the terminal marked "5" until the ratchet is advanced again, opening contacts A. This will occur every fifth second. Contacts B are closed once each 10 seconds continuously for three consecutive teeth on the ratchet, closing the path from terminal "10" to the back contact of relay 3. When relay 3 releases after having operated, 12-volt battery appears between the "common" terminal and the terminal marked "10." Contact B will remain closed for two more operations of relays 3 and 4 so that three battery pulses will appear between terminals "common" and "10." The time chart shown in figure 30 illustrates the sequence of battery pulses obtained. Pressing the manual key impresses battery between the "common" and both the "5" and "10" terminals. The "1 sec. advance" key operates the stepping relay 4 once each time the key is pressed.

36. Line connector unit EE–87.—This unit (circuit shown in fig. 31) receives direct current pulses from the time interval multiplier and delivers tone pulses over 1 or 6 telephone lines. It is powered by the same 12-volt battery BB–46 used for the multiplier. The seven-contact relay is energized by the direct current pulses from the time interval multiplier. One contact of this relay closes the primary circuit of the push-pull type 1,000-cycle hummer (of which there are two) in use, causing it to start humming. The physically coupled vibrator type receiver and carbon button microphone combination is mechanically tuned to a frequency of approximately 1,000 cycles. Tone induced in the secondary circuit of the hummer in use is supplied to the primaries of the six-line-coupling transformers in series through a key-resistor combination affording three degrees of loudness of the signal. Introduction of resistance decreases the signal loudness. The remaining six contacts of the relay connect the secondaries of the line coupling transformers through 0.1-microfarad capacitors to the line terminal binding posts for connection to the lines. These six connections are broken to prevent inductive coupling of the telephone lines when tone is not being supplied. For each pulse of direct current from the time interval multiplier, the relay operates, starting a hummer (either one may be selected by a key on the panel) and connecting the line coupling transformers to the line terminals and thus supplying a tone pulse to each of the connected telephone lines.

37. Time interval signal BE–65.—This signal (circuit shown in fig. 32) receives direct current pulses from the time interval multiplier which control a vibrator type horn which is powered by local batteries.

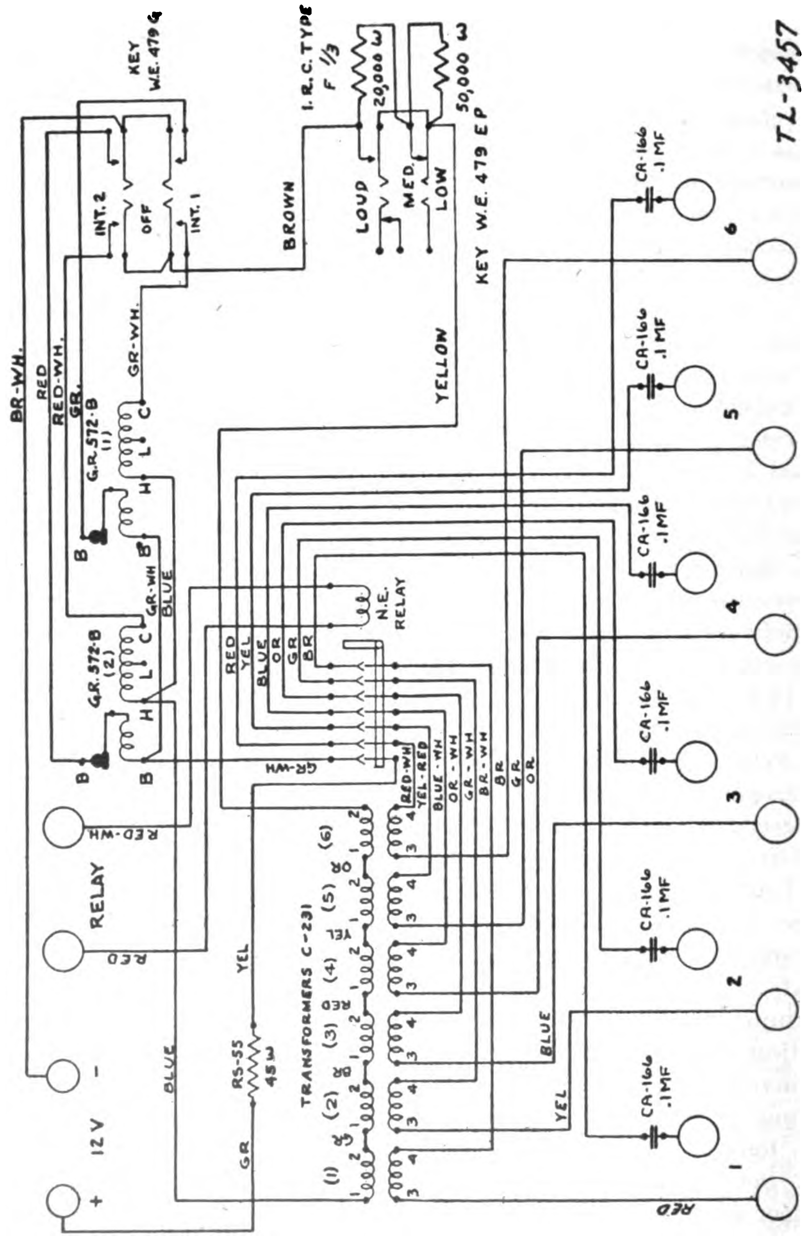

Figure 31.—Circuit diagram, line connector unit EE-87.

The relay is energized by the direct current pulses from the time interval multiplier and the contact of the relay closes the horn magnet circuit. The operation of the horn is fundamentally the same as that of the simple buzzer. The electromagnet attracts the armature whose movement opens a contact on the battery supply circuit. The armature then falls back to close the contact and repeat the cycle. In the horn the armature is connected to a diaphragm, the vibration of which emits more sound than the simple armature of the buzzer. A capacitor

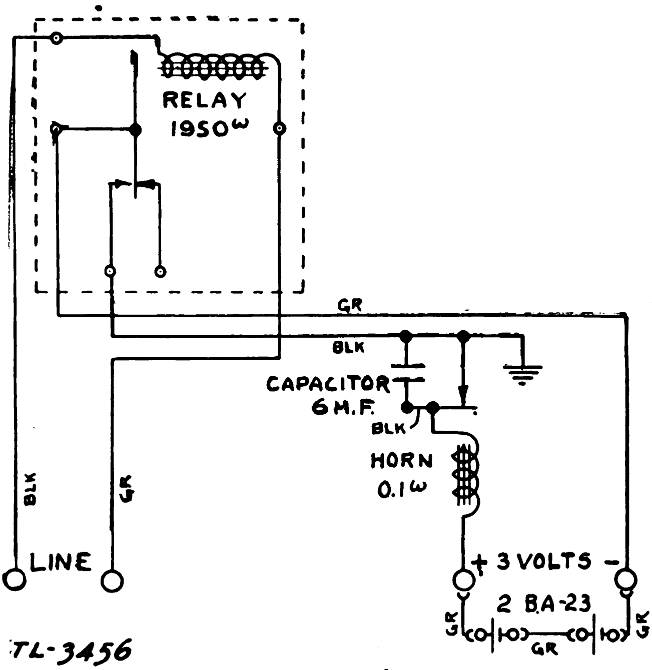

FIGURE 32.—Circuit diagram, time interval signal BE-65.

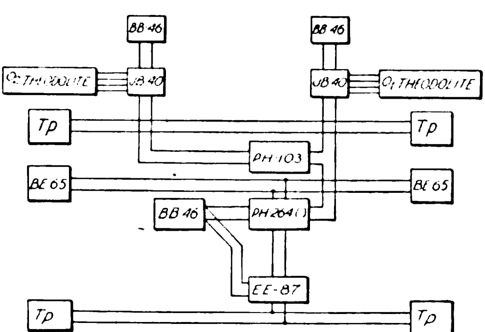

FIGURE 33.—Wiring of spotting set PH-32-B.

is supplied for reducing the arcing at the horn vibrator points. For each pulse of direct current from the time interval multiplier the relay will operate and the horn will emit a blast of sound.

38. Combined electrical circuits.—Figure 33 shows a block diagram of the wiring of the spotting set. Each theodolite receives power for operation from its own storage battery BB–46. The time relays of the two theodolites and relay 3 of the time interval multiplier are operated by the time interval device. For each operation of the time interval device the signal lamps on the theodolites light and their time counters advance one unit. The time interval multiplier operates the line connector unit and the time interval signals. The line connector unit impresses periodic tone signals on the connected telephone lines.

39. Exposure meters PH–77–B and PH–252–A.—These meters are of the photoelectric type, containing a photoelectric cell, meter, and a set of concentric disks used in determining the aperture setting of a camera for light intensities as measured by the photoelectric cell and meter.

a. Light striking the face of the photoelectric cell causes the cell to generate a voltage which is measured on the associated meter in relative brightness units. The voltage and corresponding relative brightness reading are proportional to the amount of light striking the face of the photoelectric cell.

b. The concentric disks serve as calculators for determining camera aperture settings for different light strengths.

(1) The type camera dial is adjusted to type A or B, depending on the exposure time for normal 16 frame per second operation of the camera.

(*a*) Type A camera normal exposure time is approximately 1/30 second.

(*b*) Type B camera normal exposure time is approximately 1/40 second.

(2) The emulsion speed setting made with the inner dial considers the emulsion speed of the film, light absorption or filter factor of the filter used.

(3) The middle dial is adjusted to the camera speed used, in frames per second.

c. With the dials properly set for type of camera, emulsion speed and filters, and camera operating speed the meters become direct reading instruments. The relative brightness reading obtained on the meter scale appears on the outer row of figures on the dials. Opposite this reading on the middle dial appears the correct "f" setting for the camera aperture under the existing conditions. The dials must be changed when either camera speed, filter, or type of film is changed.

40. Filters.—The four filters supplied as a part of the theodolite equipment are used to increase the contrast between the shell-burst and background in the photograph. Each filter absorbs light of one or more colors, depending on its own color. Chart I referred to in paragraph 20 furnishes the information necessary for selection of the filter for use with the theodolites.

41. Film viewer PH-97-A.—The motor-driven film viewer, shown in figure 13, consists basically of two parts, one of which provides for moving the film intermittently past a lighted aperture. The second part is a viewing attachment PH-98-A comprising a microscope with a circular reticle for viewing the film as it moves past the lighted aperture.

a. The film is carried on two reels on the viewer, winding from either one to the other through the film guide past the lighted aperture, as the viewer is operated either forward or backward. A film feed sprocket, motor-driven, provides for continuous motion of the film to and away from the film guide and intermittent sprocket. Two sets of rollers hold the film against the film feed sprocket so that its teeth will engage in the perforations in the film. These rollers may be moved away from the sprocket to allow sliding the film from the side over (or under) the sprocket when threading the film in the viewer. The sprocket pulls the film from the supply reel and the take-up reel is driven by a friction clutch to wind up the film as it leaves the sprocket. An intermittent sprocket at the upper end of the film guide moves the film one "frame" at a time through the film guide past the lighted aperture. Loops of film between the film feed sprocket and intermittent sprocket supply slack to allow for the steady and intermittent film movement. The film guide cover is hinged and may be unlatched and swung toward the operator's left for placing the film in the film guide, adjusting the upper loop, and engaging the teeth of the intermittent sprocket in the film perforations.

b. The viewing attachment screws into a mount on the film guide cover. This mount may be moved parallel to the film guide by a vertical framing lever for moving the viewing attachment so that the microscope is in line with a "frame" on the film. A horizontal framing screw in the viewing attachment moves the microscope perpendicular to the film for adjustments to line the reticle with the indicator marks on the film. The microscope has two adjustments, one a sliding lens barrel (with clamping screws) for focusing the eyepiece on the reticle and the other a screw-operated magnification adjustment (with clamping screw) for adjusting the magnification to make the horizontal portions of the vertical indicators tangent to the circular reticle. Double rubber eyecups are fixed to the eyepiece for using the viewer in daylight.

c. The switch panel has three switches, one for the light which is housed in the frame of the viewer just below the aperture, a second for choosing the forward or backward operation of the viewer, and the third for turning on the motor. A rheostat on the left side of the viewer controls the motor speed. A cord-connected foot-operated speed controller is connected parallel to the motor on-off switch for pedal control of the speed. The viewer draws a current of 2 amperes from a 110-volt d-c or 110-volt 25-60 cycle a-c supply.

42. Developing equipment PH-41 and drying rack PH-42.—This equipment was designed specifically for developing 35-mm film in lengths under 200 feet. The film is wound without slack on the Stineman reel, emulsion side out to hold it in a position where the processing solutions will have free access to the emulsion side of the film and the emulsion side will not be scratched during the processing. The film and reel are first immersed in a tank of developing solution (Eastman D-11) for a given time dependent on the temperature of the solution, then removed from the developer and rinsed in a tank of clear water, after which they were immersed in a tank of fixing (hypo) solution for 10 to 15 minutes. When the fixing is completed the film is washed in a tank of clear water by immersing and moving the reel up and down in the water for 15 to 20 seconds through 5 to 8 changes of water. At the completion of the washing process the film ends are loosened in the reel and it is immersed in water upside down and agitated to free the film from it and then the reel is removed from the water. The film is then wound into a compact roll under water, taken from the water, carefully wiped with a viscose sponge and wound emulsion side out on the collapsible drying reel. Each of the three nesting tanks is used for one particular solution and the order of use corresponds with the order of removal from the carrying chest with the exception that the intermediate-sized tank is used twice, both times with water. Tank uses are:

Developer: small-sized tank.
Water rinse: intermediate-sized tank.
Fixing solution: large tank.
Water wash: intermediate-sized tank.

Section IV

SERVICE AND REPAIR

43. General instructions.—Only the general servicing and checking as described in paragraphs 43 to 48, inclusive, are to be done by using personnel. *Adjustment and repairs described in paragraphs 49 to 58, inclusive, must be done only in an authorized depot or by the manufacturer.*

44. Lubrication.—*a. Theodolite PH-BC-33.*—(1) Oil the working parts of the camera at the beginning of each day's practice and each time you change magazines, using a good grade of light spindle oil, stock number 6G1315A or equal.

(*a*) Turn the camera mechanism until the semicircular cut in the cam washer lines up with the upper right-hand corner of the cam yoke as in figure 13 and put 1 drop of oil on the cam.

(*b*) Put 1 drop of oil on the pull-down arm toggle bearing, which pivots the rear end of the pull-down arm.

(*c*) Put 1 drop of oil in each of the two oil cups protruding into the camera case from the motor side of the camera.

(2) Using the oil cups provided, put 1 drop of medium weight high-grade machine oil, stock number 6G1320 or equal, in each cup to lubricate the traversing and elevating shafts and worm gears. Oil at beginning of each day of use.

b. Theodolite PH-BD-33.—(1) Oil the working parts of the camera at the beginning of each day's use and each time you change magazines, using 1 drop of oil at each oiling point. Use a good grade of light spindle oil, stock number 6G1315A or equal.

(2) Three oil cups are provided on the frame of the theodolite: one for the azimuth gear, one for the site gear, and one for the barrel carrying the lens mount. Put 1 drop of medium weight high-grade machine oil, stock number 6G1320 or equal, in each cup. Oil at beginning of each day of use.

c. Theodolite PH-BE-33.—(See *a* above.) This theodolite is lubricated the same as theodolite PH-BC-33.

d. Film viewer PH-97-A.—(1) At the beginning of each day's use oil as follows with light oil, stock number 6G1315A or equal:

(*a*) One drop in each of the oil holes on the spindles.

(*b*) One drop in each of the four oil cups provided. One cup is for the film feed sprocket, one is for the intermittent sprocket, one is for the main drive shaft, and the last is for the reel belt drive shaft.

(2) Keep the intermittent movement case about half full of lubricating grease, checking every 3 months. Lay the viewer on the belt side when removing the cover to the intermittent movement.

45. Cleaning.—*a. Theodolites.*—(1) Keep dirt and grit cleaned off all parts of the theodolite.

(2) Keep the telescope cover, camera lens cover, and magazine cover on the theodolite at all times when it is not in use. Clean surfaces of lenses, prisms, or filters with camel's-hair brush or by rubbing lightly with lens tissue, a linen cloth, or absorbent cotton. *Do not use a cotton cloth* as it will leave lint.

b. Film viewer PH-97-A.—(1) Keep the parts of the machine coming in contact with the film especially free from wax and dirt, using a soft cloth.

(2) Use lens tissue, a soft linen cloth, or a pad of absorbent cotton rolled on the end of a match stick to clean the exposed surfaces of the optical system. Do not dismantle the viewing attachment to clean unexposed surfaces.

c. Time interval device PH-103.—Keep dirt and grit out of the time interval device and no other cleaning will be necessary.

46. Replacing lamps.—*a. Theodolite PH-BC-33.*—(1) To replace either the night lamp or signal lamp, remove the control panel by taking out the eight screws holding it and pulling it forward, tilting to get it past the oil cup on the theodolite frame. Remove the lamp cover from the back of the control panel and replace the burned-out lamp. The signal lamp shows light only through the red bull's-eye on the front of the control panel. Light shines from the night lamp through a slot in the lamp housing onto a small reflector, from the reflector to the lens, and from the lens to the camera aperture. After replacing this lamp and the lamp cover put the control panel back on the theodolite and fasten it in place with two screws. Turn on the night lamp. Release the camera aperture pressure plate by rotating the spring holder toward the camera door and take out the pressure plate. Using a small mirror to look into the camera aperture, check the illumination to see that the light has equal brightness at all corners of the aperture. If it does not, adjust by reversing the night lamp in the socket, by moving the slit in the lamp cover sideways, by bending the small reflector, or by any necessary combination of the above adjustments. If fogging is too dense, cover the top part of the reflector and if it is too light put in a lamp which burns brighter. Place all screws in control panel and tighten them.

(2) To replace the counter illuminating lamp remove the counter lamp cover plate (fig. 4) and the lamp and socket. Replace the lamp

and socket, lining up the contact springs with the contact screws, and reassemble.

(3) To replace the telescope lamp, first disconnect the lamp cable by unplugging and then remove the telescope cover which is held in place by three screws. Unscrew the lamp socket from the lamp housing, replace the lamp, and screw the socket back into the housing. Replace the telescope cover and reconnect the lamp cable. If the illumination of the telescope cross hairs is not correct you can adjust it at night by moving the lamp housing on the telescope. Disconnect the lamp cable, remove the telescope cover, and reconnect the lamp cable. Loosen the two screws clamping the housing to the telescope, turn on the night lamps, and adjust the illumination of the cross hairs by sliding the lamp housing on the telescope body. When it is correct, tighten the clamping screws and reassemble, making sure that the lamp housing does not touch the telescope cover, for if it does the telescope will be thrown out of alinement.

b. Theodolite PH-BD-33.—(1) To replace the signal lamp, open the small door on the control panel, remove the burned-out lamp, and replace it with a new one.

(2) To replace either the counter illuminating lamp or the night lamp, remove the control panel and the azimuth handwheel. Use the special wrench to unscrew the handwheel set screws about three turns each.

(*a*) The bracket supporting the counter illuminating lamp socket is fastened to the frame of the theodolite by one screw just below and to the left of the camera door. Remove this screw and swing the bracket, socket, and lamp out so that you can replace the lamp. Replace and fasten the bracket and replace and secure the control panel and handwheel.

(*b*) To replace the night lamp, remove the control panel and handwheel and swing the counter lamp socket bracket out as above. The night lamp and socket are pushed through a barrel mount up to a position by the camera aperture near the front of the theodolite, and are locked in place by a setscrew on the front of the theodolite. The lead wires to the socket pass up the barrel. Loosen the setscrew, take hold of the wires, and carefully pull the socket down and out of the barrel. Replace the burned-out lamp and put the new lamp and socket in the barrel, pushing them up as far as they can be easily pushed. Tighten the holding setscrew, replace the counter lamp bracket and the control panel, and turn on the night lamp. Release the camera aperture pressure plate by rotating the spring holder toward the camera door and take out the pressure plate. Using a small mirror to look into the camera aperture, check the illumination to see that the light has equal brightness at all corners of the aperture. If it does not, remove the control panel, loosen the holding setscrew, rotate the lamp slightly, replace the control panel, and recheck the illumination. Rotating the lamp and socket changes the illumination slightly. When the illumination is correct tighten the holding setscrew and replace the azimuth handwheel.

(3) To replace the telescope lamp, loosen the thumbscrew on the telescope cover and carefully pull the lamp socket out of the mounting hole. Replace the lamp, reinsert the socket, and reclamp. Two adjustments may be used to adjust the cross hair illumination. Move the socket in and out of the mounting hole to change the illumination. If this does not give enough change in illumination remove the rubber eyecap and telescope cover (fastened with four screws) and rotate the diffusion ring on the eyepiece so that more or less light (as needed) may pass through the window to the cross hairs. Replace the telescope cover and rubber eyepiece, make a final adjustment of illumination with the lamp socket movement, and clamp the socket.

c. *Theodolite PH-BE-33.*—Refer to *a* above. Lamps are changed in the same manner as for theodolite PH-BC-33.

d. *Film viewer PH-97-A.*—Remove the four knurled-head screws (fig. 13) holding the film transportation assembly, and lift the assembly from the viewer, which will enable you to replace the 25-watt lamp in the viewer. After replacing the lamp reassemble the viewer, tightening the screws with your fingers only.

47. Adjusting and replacing belts.—*a. Theodolite PH-BC-33.*—There is no belt tightener in the theodolite. To shorten the belt, disjoint it at the connection, cut off a very short piece, and rejoin the ends. To remove the belt, disjoint it and pull on the end having the coupling left on it. The belt will pull out. To replace, feed the end without the coupling into one of the two belt holes in the camera casting until it comes out the other hole. Recouple the belt.

b. *Theodolite PH-BD-33.*—The belt on this theodolite is a continuous V-type belt. The following procedure is used in replacing the belt:

(1) Remove camera motor mounting plate secured by four screws.

(2) Turn the pulley until you can see the pulley setscrew, insert the setscrew wrench, and loosen the setscrew about three turns.

(3) Pull out the pulley shaft far enough to allow the pulley to be removed and remove the pulley and belt.

(4) Put a new belt on the pulley and (using the belt to hold the pulley) place the pulley back into position and push the shaft back into place. Line up the flat on the shaft and the pulley setscrew

so that when tightened the screw will seat on the flat, and tighten the setscrew. This will prevent burring of the round portion of the shaft, which would make later shaft pulling difficult.

(5) The belt shaft is driven by a friction fitting on the drive gear. To tighten this friction fitting, turn the split nut down on the spring pressing against the fiber friction plate.

(6) Replace the motor mounting plate.

c. Theodolite PH-BE-33.—Refer to *a* above. Belts are changed in the same manner as for theodolite PH-BC-33.

d. Film viewer PH-97-A.—(1) The motor drive belt tension is adjusted by moving the motor in the frame. Loosen the four screws (two on each side of the viewer) which hold the motor, move the motor to a position giving the proper belt tension, and tighten the holding screws. To remove the belt, loosen it enough so that you can slip it off one of the pulleys.

(2) Reel-drive belt tension is adjusted by swinging the reel spindles on their mounts. Loosen the thumb nut on the left or belt side of the viewer, rotate the spindle mount to give a slight tension, and tighten the thumb nut.

(3) Spindle clutch tension is maintained by spring pressure. To change this pressure, release the lock nut on the rear end of the spindle, tighten the lower nut on the spring, and relock with the lock nut. Adjust this tension so that a full reel will just be positively driven.

48. Batteries.—*a. Battery BA-23.*—These 1½-volt batteries, used on the time interval signal, should be replaced when the tone of the signal becomes erratic.

b. Battery BA-26.—These 45-volt batteries, used in the time interval device, should be replaced when the voltage *under load* drops to 35 volts.

c. Battery BB-46.—Keep these batteries properly filled with distilled water and charged as prescribed in TM 11-430.

49. Theodolite PH-BC-33.—*a. Adjusting light baffle.*—If there is evidence of light from the counter system fogging the target portion of the film, or that from the camera lens system fogging the counter portion, correct this by the following procedure:

(1) Unplug the motor connecting cord from the theodolite frame.

(2) Carefully remove the camera from the theodolite frame.

(3) If counter portion of film is fogged, bend the baffle on the theodolite frame (in the camera aperture opening) *slightly* toward the front of the theodolite. If the target portion is fogged bend the baffle *slightly* toward the rear of the theodolite.

b. Adjusting levels.—(1) Remove the control panel from the theodolite.

(2) Place the theodolite on a rigid base.

(3) Rotate the azimuth handwheel to make the levels lie parallel to the leveling screws.

(4) Level the theodolite without making leveling screws too tight.

(5) Rotate the theodolite carefully through 3,200 mils with the azimuth handwheel. Do not move the theodolite on the rigid base.

(6) If the bubbles are not centered, turn the level adjusting screws to move the level bubbles halfway to center.

(7) Relevel the theodolite, rotate it back to the original setting, and check the bubbles again. If they are not now centered repeat the half-centering and releveling, rotating, and checking until the bubbles stay at the center through one complete rotation of the theodolite.

c. Adjusting zero position of camera prism.—(1) Prepare a "target" on a sheet of white paper, consisting of four vertical lines, the central ones 9$\frac{3}{16}$ inches apart, the outer lines 9$\frac{3}{8}$ inches outside the inner pair, and one horizontal line bisecting the vertical lines, all lines to be about ½ inch wide. Label the vertical lines from left to right: T, C, C′, and T′.

(2) Mount the theodolite in the normal manner (see par. 16).

(3) Place the target at least 200 feet from the theodolite and as near as possible at the same height. Remove the camera aperture pressure plate as in paragraph 46*a*(1) and insert a piece of ground film in the film gate over the camera aperture.

(4) Traverse and elevate or depress the theodolite, using the azimuth and site handwheels until the image of the horizontal target line coincides with the horizontal indicator mark in the camera aperture. Note the site counter reading and "dump" the theodolite (traverse and site through 3,200 mils).

(5) If the image of the horizontal target line does not coincide with the horizontal indicator, rotate the site handwheel to move the image halfway to the indicator and then move the target vertically until its horizontal line image and the horizontal indicator coincide. Note the site reading and "dump" the theodolite again and repeat the check. When the image of the horizontal target line coincides with the horizontal indicator mark in both the direct and "dumped" positions the target is at the same level as the theodolite.

(6) With the camera "set" on the horizontal target line as above (telescope pointed away from the front side of the theodolite) check the site counter readings. If the site counters do not read zero make the following adjustments:

(*a*) Drive out the taper pin holding the site handwheel to the shaft.

(*b*) Unscrew the counter gear cover plate directly in back of the elevating handwheel.

(*c*) Line up the holes in the elevation counter gear with the three thrust bearing screws. Remove these screws.

(*d*) Mark the mating teeth of counter gears with a pencil before unmeshing these gears.

(*e*) Withdraw the elevation worm shaft and thrust bearing just enough so that the gears do not mesh and set the site counters, both internal and external, to zero. Remesh the gears to the nearest tooth and replace the thrust bearing screws, cover plate, and handwheel.

d. Setting prism perpendicular to axis.—With the camera "set" on the horizontal target line as above (telescope pointed away from the front side of the theodolite) make the following tests and adjustments:

(1) Traverse the theodolite so that the image of target line C falls on the line of the two vertical indicators in the camera aperture.

(2) Note the azimuth setting and "dump" the theodolite. If the image of target line C′ falls on the line of the two vertical indicators, no adjustment is necessary. If it does not, first remove the telescope mounting plate from the theodolite (held by three screws) and then turn the hexagonal-head screw at the base of the prism to move the image of line C′ halfway to the vertical indicator line and by traversing bring the image of line C′ to coincide with the line of the two vertical indicators.

(3) Note the azimuth reading and "dump" the theodolite, checking on line C. If the image of line C coincides with the vertical indicator line, the adjustment is complete. If it is not, repeat the halving process and recheck.

e. Alining sight.—(1) Remove the dowel pin from the telescope mounting bracket and remount the telescope on the theodolite.

(2) Having made the adjustments described under *b*, *c*, and *d* above, set the theodolite at zero elevation with the camera horizontal indicator on the horizontal target line and the camera vertical indicator on target line C, and loosen the three locking screws on the telescope bracket so that you can just move the telescope by hand.

(3) Rotate the telescope by hand so that the image of the horizontal target line coincides with the horizontal cross hair of the telescope. Check to see whether or not the vertical cross hair of the telescope coincides with the target line T. If it does not, adjust the position of the telescope by using shims under either the rear leg of the mount or both front legs until this vertical cross hair does coincide with the target line T. When the telescope is adjusted so that both the horizontal target line and target line T coincide with the cross hairs on the telescope, tighten the holding screws.

(4) "Dump" the theodolite. If all adjustments have been properly made the horizontal target line and target line T′ will coincide with

the telescope horizontal and vertical cross hairs. If you find this to be true, redowel the telescope bracket to the mounting plate, using a slightly larger dowel if necessary.

f. Counters.—(1) The counters are permanently mounted on the elevating mechanism and it must be removed to gain access to the counters. The following steps, in the order described, are employed to remove this mechanism:

(*a*) Remove the time counter advance fitting (fig. 3) by removing the three screws, the guide, and then the slotted fitting. This is important.

(*b*) Unplug the telescope lamp connecting cable.

(*c*) Remove the screws holding the elevating mechanism to the theodolite frame. These are below the telescope.

(*d*) With an assistant holding the frame of the theodolite, pull the elevating mechanism away from the frame of the theodolite. Pull straight out from the frame to prevent binding.

(*e*) The counters are readily accessible on the removed elevating mechanism.

(2) Replacing the elevating mechanism is the reverse of the above procedure. Place the slot in the counter reset shaft in a horizontal position before you replace the elevating mechanism.

50. Theodolite PH-BD-33.—*a. Adjusting light baffle.*—If there is evidence of light from the counter system fogging the target portion of the film or that from the camera lens system fogging the counter portion, correct this by the following procedure:

(1) Remove the camera motor mounting plate (secured by four screws) from the camera.

(2) Remove the camera from the theodolite frame (secured by three bolts, two in the gear box and one in the camera movement chamber).

(3) Loosen the setscrew holding the counter optical system in position. This setscrew is on the rear of the theodolite, extending through the frame to press on the barrel mount of the counter optical system.

(4) If the counter portion of the film is fogged, rotate the barrel mount to move the end of the baffle *slightly* toward the front of the theodolite. If the target portion is fogged, rotate to move the end of the baffle *slightly* toward the rear of the theodolite. Tighten the setscrew.

(5) Set the baffle so that it does not protrude beyond the theodolite frame more than $\frac{1}{32}$ inch.

(6) Replace the camera and camera motor mounting plate.

b. Adjusting levels.—(1) Place the theodolite on a rigid base.

(2) Rotate the azimuth handwheel to make the levels lie parallel to the leveling screws.

(3) Level the theodolite without making leveling screws too tight.

(4) Rotate the theodolite carefully through 3,200 mils with the azimuth handwheel. Do not move the theodolite on the rigid base.

(5) If the bubbles are not centered, turn the level adjusting screws (using the small capstan wrench in the tool kit) to move the level bubbles halfway to center.

(6) Relevel the theodolite, rotate it back again to the original setting, and check the bubbles again. If they are not now centered repeat the half-centering and releveling, rotating, and checking until the bubbles stay at the center through one complete rotation of the theodolite.

c. Adjusting camera optical system (site).—(1) Prepare a "target" on a sheet of white paper, consisting of four vertical lines, the central ones 6¾ inches apart and the outer ones 7¾ inches outside the inner pair, and one horizontal line bisecting the vertical lines, all lines to be about ½ inch wide. Label the vertical lines from left to right: T, C, C′, and T′.

(2) Mount the theodolite in the normal manner (see par. 16).

(3) Place the target at least 200 feet from the theodolite and as near as possible at the same height. Remove the camera aperture pressure plate as in paragraph 46*b*(2)(*b*) and insert a piece of ground film in the film gate over the camera aperture. It may be desirable to remove the sprocket film guide and upper sprocket from the camera, and close the camera door with the camera magazine opening cover removed. This will shield the light from the ground film and it will be easier to line up the target lines with the camera aperture indicators on the ground film.

(4) Traverse and elevate or depress the theodolite, using the azimuth and site handwheels, until the image of the horizontal target line coincides with the horizontal indicator mark in the camera aperture. Note the site counter reading and "dump" the theodolite (traverse and site through 3,200 mils).

(5) If the image of the horizontal target line does not coincide with the horizontal indicator, rotate the site handwheel to move the image halfway to the indicator and then move the target vertically until its horizontal line image and the horizontal indicator coincide. Note the site reading, "dump" the theodolite again, and repeat the check. When the image of the horizontal target line coincides with the horizontal indicator mark in both the direct and "dumped" positions the target is at the same level as the theodolite.

(6) With the camera "set" on the horizontal target line as above (telescope pointed away from the front side of the theodolite), check

the site counter readings. If the site counters do not read zero make the following adjustments:

(*a*) Remove the site handwheel by taking out the wafer-headed screw in the end of the shaft and loosening the setscrew about three turns.

(*b*) Remove the azimuth counter drive release unit by loosening the setscrew in the brass sleeve about three turns and squeezing the release levers while you unscrew the release unit off the shaft.

(*c*) Remove the counter dust cover to gain access to the counter unit.

(*d*) Remove the three screws holding the counter unit and pull it out of the theodolite frame just far enough to unmesh the site gears. Rotate the site counters by means of the site counter idler gear (at the right side of the counter unit) to make the site counters read zero, replace the counter unit in the theodolite frame, meshing the site gears to the nearest tooth, and replace the screws holding the counter unit in place. Adjust the unit so that gears mesh tightly but do not bind before tightening the three screws.

(*e*) Replace the counter dust cover.

(*f*) Replace the azimuth counter drive release unit by screwing it on the shaft (with the levers squeezed together) until the distance between the inside of the ends of the released levers is 5/16 inch. Tighten the setscrew in the brass ring to secure the release unit in place.

(*g*) Replace the site handwheel, lining up the flat on the shaft with the setscrew before tightening.

d. Adjusting camera optical system (azimuth).—(1) With the camera "set" on the horizontal target line as in *c*(5) above (telescope pointed away from the front of the theodolite), rotate the theodolite with the azimuth handwheel to bring the image of the target line C′ in line with the vertical indicators in the camera aperture, note the azimuth and site counter readings, and "dump" the theodolite (azimuth and site through 3,200 mils).

(2) If the target line C′ is now in line with the vertical indicators no adjustment is necessary.

(3) If the target line C′ is not in line with the vertical indicators make the following adjustments:

(*a*) Loosen the four screws on the slide mount for the camera lens barrel so that it is free to slide.

(*b*) Loosen the two screws clamping the end stop screw for the slide mount.

(*c*) While exerting pressure on the camera lens barrel at its base to hold it against the end stop screw, turn this screw to move the image of the target line C′ half the distance to the vertical indicators in the camera aperture. Tighten the four screws on the slide mount.

(*d*) Using the azimuth handwheel, rotate the theodolite to bring the image of target line C′ in line with the vertical indicators, note the azimuth and site counter readings, and "dump" the theodolite.

(*e*) If the target line C is now in line with the vertical indicators the adjustment is complete and the two screws which clamp the end stop screw may be tightened. If it does not, repeat the adjustments described in (*a*), (*c*), and (*d*) above until the target lines C and C′ line up with the vertical indicators of the camera aperture with the theodolite in the direct and "dumped" positions. When this condition is reached you have this adjustment completed and may tighten the four screws on the slide mount and the two screws clamping the end stop screw for the slide mount.

e. Alining the sight.—(1) After the camera optical system adjustments in *d* above have been made, adjust the theodolite so that (with the telescope pointed away from the front side of the theodolite) the target horizontal and C lines are lined up with the horizontal and vertical indicators of the camera aperture.

(2) Focus the telescope on the target. If the image of the horizontal target line does not coincide with the horizontal cross hair in the telescope, make the following adjustments:

(*a*) Loosen the six screws holding the telescope mount to the site gear. Using a screw driver, dig out the wax over the two, screws securing the telescope mount dowel pin fitting and loosen the screws.

(*b*) Rotate the telescope mount on the site gear until the horizontal cross hair and the horizontal target line coincide and tighten the six screws. Tighten and rewax the two screws holding the dowel pin fitting.

(3) If the target line T does not coincide with the vertical cross hair of the telescope, make the following adjustments:

(*a*) Remove the telescope cover held in place by four screws.

(*b*) With a screw driver loosen the prism movement locking screw on the bottom of the telescope.

(*c*) With the capstan wrench turn the capstan screw until the target line T coincides with the vertical cross hair in the telescope and tighten the prism movement locking screw.

(*d*) "Dump" the theodolite. If all previous adjustments have been correctly made, the target horizontal and T′ lines will coincide with the telescope cross hairs. Replace the telescope cover.

(*e*) Remove the ground film from the camera and replace the camera aperture pressure plate (and the film guide and upper sprocket, if they had been removed to obtain a better view of the ground film).

f. Counter.—(1) The counter assembly is removed from the theodolite by the following procedure:

(*a*) Remove the control panel and unplug the electrical connection to the counter assembly.

(*b*) Remove the site handwheel by taking out the wafer-headed screw in the end of the shaft and loosening the setscrew about three turns.

(*c*) Remove the azimuth counter drive release unit by loosening the setscrew in the brass sleeve about three turns and squeezing the release levers while you unscrew the release unit off the shaft.

(*d*) Remove the counter dust cover to gain access to the counter unit.

(*e*) Mark mating teeth in the site counter gears and note the site counter reading.

(*f*) Remove the three screws holding the counter unit and pull it out of the theodolite frame. The azimuth counter idler gear with the knurled hub for manual rotation of the azimuth counters will come off its shaft as the counter assembly is pulled out. Adjustments to the counter assembly or its components may be made while it is removed from the theodolite frame.

(2) Replacing the counter assembly in the theodolite is the reverse of the foregoing removal procedure, with the following precautions to be taken:

(*a*) When replacing the counter assembly, put the azimuth counter idler gear on its shaft as the counter assembly is placed in the frame. This is necessary because the gear fits into the side of the counter assembly.

(*b*) Set the site counter reading to the value noted before the counter assembly was removed and mesh the marked mating teeth so that the site counter readings will be correct after the theodolite is reassembled.

(*c*) Before tightening the three screws which hold the counter assembly in place, adjust its position so that the gears mesh tightly but do not bind.

(*d*) When replacing the azimuth counter drive release unit squeeze the levers together and screw it on the shaft until the distance between the inside of the ends of the released levers is $5/16$ inch. Then tighten the set screw in the brass ring to secure the release unit in place.

(*e*) Line up the flat on the shaft with the setscrew in the site handwheel before tightening the setscrew.

51. Theodolite PH–BE–33 (see par. 49).—Adjustments on this theodolite are, with one exception, made in the same manner as for theodolite PH–BC–33. Theodolite PH–BE–33 has a mirror in the camera optical system and the prism adjustment in theodolite PH-BC-33 will be a mirror adjustment for the PH-BE-33.

52. Time interval device PH-103.—*a. Erratic timing.*—If, with fresh batteries, the timing becomes erratic the trouble is probably caused by a defective capacitor. Replace the capacitor with one of the two spares and check for regular operation.

b. Contacts.—Clean contacts of keys and relays when necessary with crocus cloth, never with emery cloth.

53. Time interval multiplier PH-264-( ).—*a.* Adjust relay 3 so that its action is positive on both operate and release with 20 milliampere coil current.

b. Adjust stepping relay 4 for positive advance of ratchet wheel through a complete cycle (10 operations) with 12-volt battery source.

c. Clean relay contacts with crocus cloth when necessary.

54. Line connector unit EE-87.—*a.* The contact springs of the multiple contact relay may be adjusted by bending the top springs with a pair of longnose pliers. Key contact springs are adjusted in the same manner. Bend springs near the base to prevent introduction of bows in the springs. They should be kept as nearly straight as possible.

b. The vibrators of the hummers may be adjusted for spacing and stable operation with the small screw adjustment.

55. Time interval signal BE-65.—*a.* Relay adjustment is made by changing spring tension and adjustment of the screw stops.

b. Three vibrator adjustments are provided for the horn.

(1) The stop of the contact spring of the vibrator must be adjusted so that the contact will make and break properly under the action of the armature and post attached to it. This adjusment may be made in the field.

(2) The post is also adjustable, being screwed into the center of the armature and secured with a lock nut. To adjust, loosen the post lock nut, screw the post in or out as needed, and tighten the lock nut. The post must be in such a position that the stop for the vibrator contact will break the contacts when the armature is pulled to the magnet.

(3) The arch mounted on the base casting by means of heavy screws and lock nuts must be parallel to the base casting. The movement of this arch adjusts the air gap in the horn magnet system. Use a socket wrench to make this adjustment.

56. Developing equipment PH-41 and drying rack PH-42.—This equipment, if properly used, should not require repair. Tank leaks may be soldered from the outside, using care to wash off all flux.

57. Exposure meters PH-77-B and PH-252-A.—These meters, when damaged, must be returned to the Signal Corps depot for repair or forwarded to the factory for repair and recalibration.

58. Film viewer PH-97-A.—*a. Mechanical parts.*—With proper servicing the viewer will require little repair. The intermittent movement is most likely to become worn through use, and repair will consist of replacing worn parts. Parts secured to shafts with taper pins are furnished without holes for the pins. Fit the parts properly on the shafts and then drill the hole for the taper pin through both the new part and the shaft together, taking care to miss the old taper pin hole in the shaft. Taper ream the hole and fit the pin securely. Bearing bushings will be supplied undersize in bore and without oil holes. Press the new bushing into place, drill oil holes, and ream the bushing to fit the shaft.

b. Optical system.—(1) *Centering reticle.*—This requires two small screw drivers. Place a piece of film with a fine cross scratched on it in the film guide, under the viewing attachment. Focus the eyepiece on the reticle and the objective on the film scratch. Adjust the viewing attachment so that the crossed scratches coincide with the center of the reticle. Rotate the reticle 180° with the knurled ring. If the reticle is centered properly there will be no apparent movement of the intersection of the crossed scratches with respect to the center of the reticle. If there is apparent movement, note the amount and rotate the reticle until the small screws appear through the screw holes in the bearing housing (just below the knurled ring). Engage screw drivers in opposite screws and turn the screws simultaneously to move the center of the reticle about one-half the apparent movement distance in the direction toward the intersection of the crossed scratches. Repeat with the other pair of screws, check, and repeat the centering process until no relative movement is observed on rotation of the reticle. The reticle is now centered.

(2) *Magnification of objective.*—The mil graduations on the reticle grid indicate correctly only when the magnification of the objective is so adjusted that the outer circle of the reticle is accurately inscribed in the vertical and horizontal indicators as shown in figure 24. The distance between the two vertical indicators should be 0.588 inches. Place a piece of film having this dimension correct in the viewer when checking the magnification. If the reticle is not perfectly inscribed in the horizontal and vertical indicators, the image of the reticle plane should be enlarged or reduced by slightly shifting the objective and the tube in which it is mounted. Remove the three mounting screws

in the reticle bearing housing, and lift this from the viewing attachment. This provides access to the tube in which the objective is mounted and the setscrew holding the tube. Loosen the setscrew, slide the objective tube towards the film to increase the size of the image or away from the film to decrease the size, and tighten the setscrew. Replace the upper portion of the viewing attachment; carefully focus the eyepiece on the reticle and the objective on the film so that there is no parallax. If there is no apparent motion of the reticle with respect to the film, when you move your eye from side to side when looking through the eyepiece, there is no parallax. Check the magnification and if it is correct replace the screws holding the upper portion of the viewing attachment. If it is not, remove the upper portion and readjust the objective as above. Remove all dust particles from the optical system before reassembling the attachment.

(3) *Inspection and lubrication of moving parts of viewing attachment PH-98-A.*—The fit of the cross motion slide is adjusted by means of three setscrews in the base. Tighten these with a number 5 Bristo setscrew wrench. To lubricate, remove the body tube of the viewing attachment, the top, and end plates of the base, and disassemble the slide, clean thoroughly, and lubricate with Alcoa Thread Lubricant. Lubricate the cross slide adjusting screw with a good grade of light spindle oil, stock number 6G1315A or equal. Remove body tube rotational shake by tightening the adjusting screw just below the focusing clamp screw. Lubricate the body tube slide with a mixture of one part beeswax, two parts paraffin, and three parts petroleum jelly. Use this same mixture to lubricate the cone-bearing of the reticle mount, in the tongue and groove dust trap on the knurled reticle rotating ring, and on the sliding tube of the eyepiece assembly.

SECTION V

LIST OF PARTS

59. Spotting set PH-32-B.—*a.* The following is a list of the component parts of this equipment:

Quantity	Stock No.	Article	Specification or Drawing No.
1	6H227A	Axle RL-27-A	71-655.
8	3A23	Battery BA-23; 4 in use, 4 spare	70-21.
4	3A26	Battery BA-26; 2 in use, 2 spare	70-21.
6	3B46	Battery BB-46; 3 in use, 3 spare	70-33.
2	8A3733.3-0	Book, Instruction, for Theodolite PH-BC-33 and Associated Equipment[1], or Book, Instruction, for Theodolite PH-BD-33 and Associated Equipment[1], or Book, Instruction, for Theodolite PH-BE-33 and Associated Equipment [1].	
2	8A109 7( )-4	Book, Instruction, for Film Viewer PH-97-A.	
2	8A3837-1	Book, Instruction, for Time Interval Device PH-103.	
2 bottles	8A790.1	Cement, film splicing, suitable for nitrate film, in 4-oz bottles, Eastman Kodak Co., or equal.	Commercial.
2	3E1407	Cord CD-407	75-32.
1	8A941	Developing Equipment PH-41	75-36.
1	8A982	Drying Rack PH-42	75-36.
2	8A1057B 8A1058A	Exposure Meter PH-77-B or PH-252-A.	75-77.
10 rolls	None	Film, 200′ rolls, negative 35-mm, SMPE Standard, perforated; panchromatic type having speed of 64 on Weston scale as published by Weston Electrical Instrument Corp., Newark, N. J., or equal.	Commercial.
1	8A1097-( )	Film viewer PH-97-A	75-82.
2	None	Junction Box JB-40	75-32.
1	4H1187	Line Connector Unit EE-87	71-967.
40 pkgs	8A802-35	Powder, acid, fixing, Eastman Kodak Co., in 1-lb packages, or equal.	Commercial.
10 cans	None	Powder, developing, Eastman Kodak Co., D-11, or equal (each can to make 5 gallons of developer solution).	Commercial.
1	8A3292	Rewinder PH-92	Commercial.
1	8A3691	Splicer PH-91	Commercial.
2	8A3733.3	Theodolite PH-BC-33, or	75-32.
2		Theodolite PH-BD-33, or	75-32.

[1] Instruction book for theodolite supplied.

Quantity	Stock No.	Article	Specification or Drawing No.
2		Theodolite PH-BE-33	75-32.
1	8A3837	Time Interval Device PH-103	75-81.
1	None	Time Interval Multiplier PH-264-( ).	75-101.
2	4H5005	Time Interval Signal BE-65	71-965.
3 miles	1B110B	Wire W-110-B on Reels DR-4	71-478.

b. The following abbreviations of names of manufacturers will be used in subsequent paragraphs and lists:

Abbreviation	*Meaning*
NH	Norma Hoffman.
MR	Micro-switch Corporation, Freeport, Ill.
VR	Veeder-Root, Incorporated, Hartford, Conn.
H&H	Hart & Hegeman, Hartford, Conn.
HBJ	Howard B. Jones, Chicago, Ill.
WECo	Western Electric Company.
WESTON	Weston Electrical Instrument Corporation, Newark, N. J.
CD	Cornall-Dubilier Electric Corporation.
Guar	Guardian Manufacturing Company.
AE Co	Automatic Electric Company.
SD	Struthers Dunn, Incorporated.
GR	General Radio Company.
IRC	International Resistance Company, Philadelphia, Pa.

60. Developing equipment PH-41 and drying rack PH-42.

Manufacturer's reference No.	Stock No.	Name of part	Description	Function	Specification or drawing No.	
					Manufacturer	Signal Corps
	8A941	Developing equipment PH-41 Changing bag.	200′ capacity, cloth	For loading magazines.	The Stineman System.	75-36.
21		Developing reel	200′ capacity	Processing film		
17		Tank	Developer, 200′ capacity.	Developing film		
17		Tank	Washing, 200′ capacity	Washing film		
28		Tank	Hypo, 200′ capacity	Fixing film		
23		Screen	Wire screen			
		Winding device				
		Chest	Carrying chest			SC-D-1595G.
	8A982	Drying rack PH-42	200′ capacity	Drying film		75-36.
		Rack	Collapsible, wooden			
		Chest	Carrying chest			SC-D-1596B.

61. **Film viewer PH-97-A.**—See figures 34 to 38, inclusive, for identification of parts.

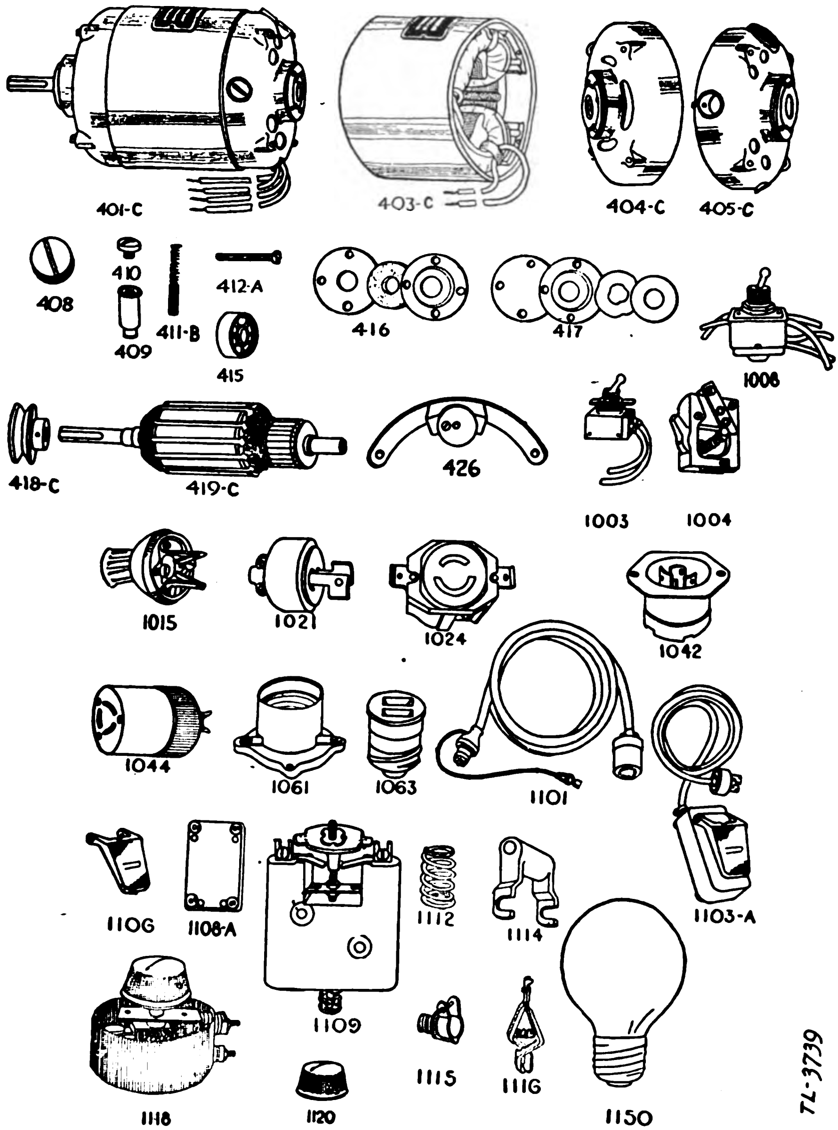

FIGURE 34.—Parts identification for film viewer PH-97-A.

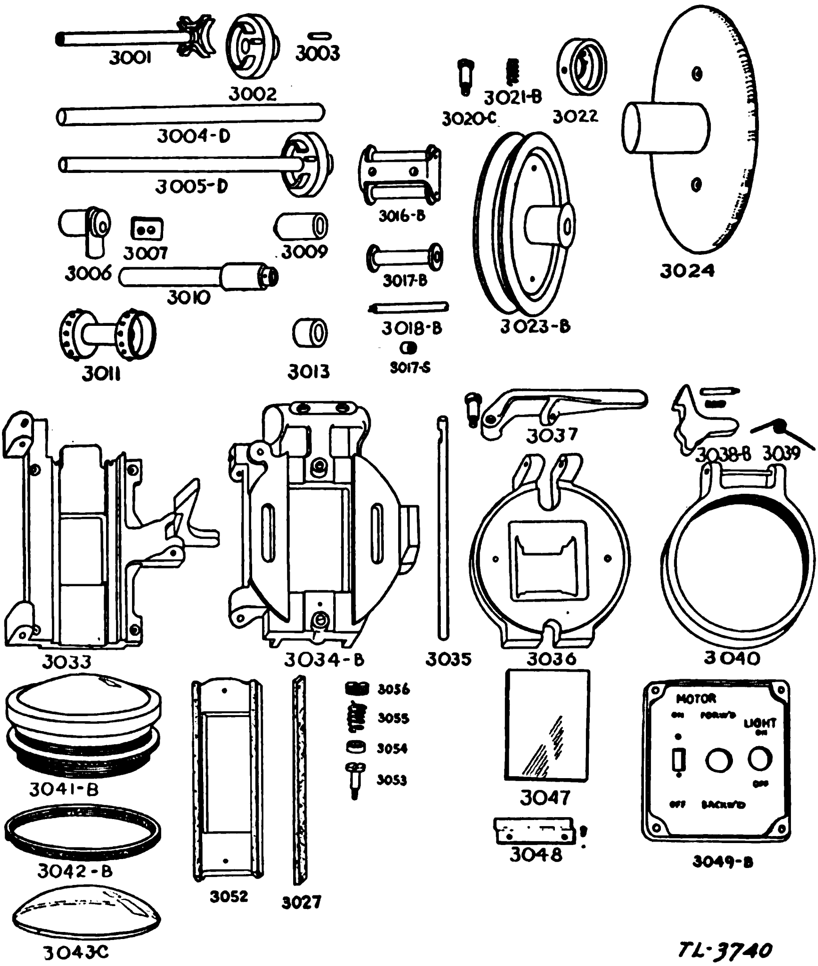

FIGURE 35.—Parts identification for film viewer PH-97-A.

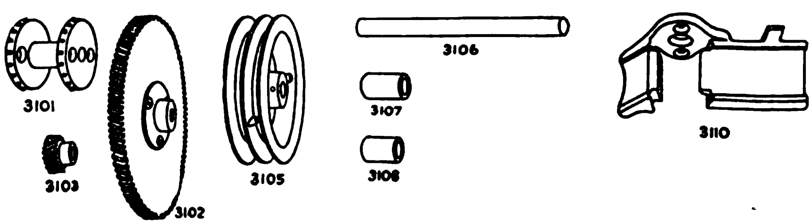

FIGURE 36.—Parts identification for film viewer PH-97-A.

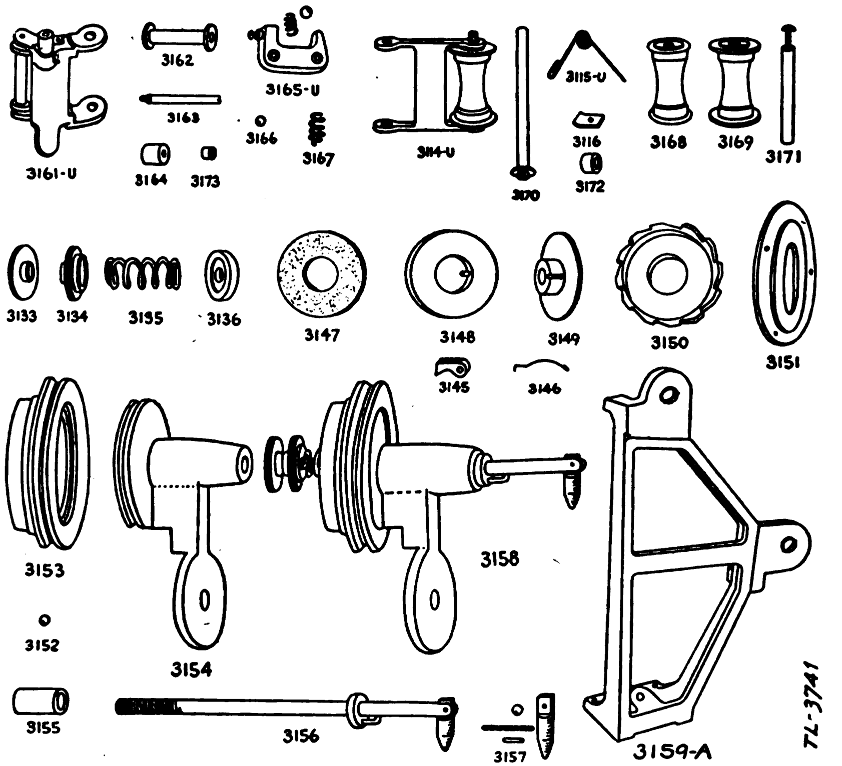

Figure 36.—Parts identification for film viewer PH–97–A—Continued.

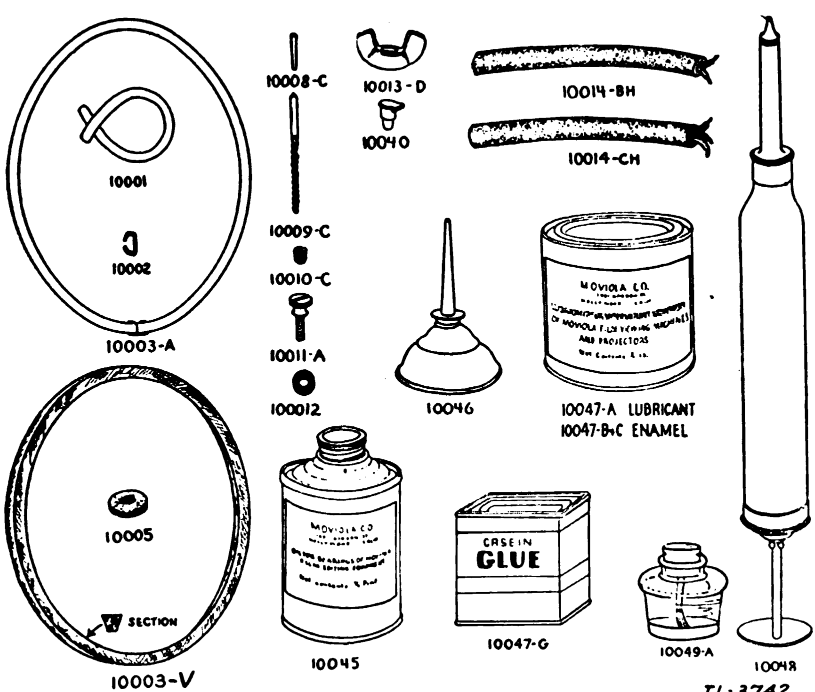

Figure 37.—Parts identification for film viewer PH–97–A.

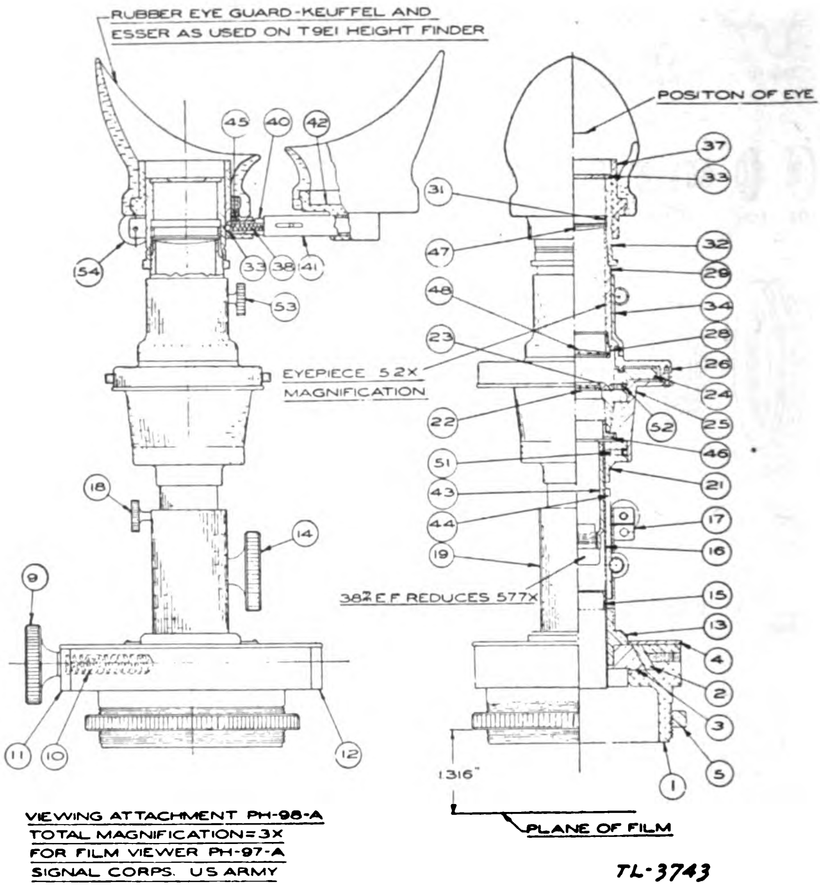

FIGURE 38.—Parts identification for viewing attachment PH-98-A.

Reference No.	Stock No.	Name of part	Description	Specification or drawing No., Signal Corps
	8A1097-( )	Film viewer PH-97-A	Motor-driven 35-mm, Moviola model D	75-82.
401-C		Motor	Ventilated, with cylindrical body, for mounting with resilient mounting lugs, part No. 426, with ball bearings, complete but without pulley or mounting lugs.	
403-C		Field frame assembly	With coils, for motor with cylindrical body	
404-C		End shield	For shaft extension end of ventilated, ball bearing motor, without the ball bearing and its retainer.	
405-C		do	For commutator end of ventilated, ball bearing motor, without brush holders, ball bearing, and its retainer.	
408		Inspection hole plug		
409		Brush holder		
410		do	Cap screw	
411-B		Carbon brush	⅛″ x ¼″, and spring	
412-A		End shield screw	1⅛″ under head	
415		Ball bearing		
416		Ball bearing retainer	For shaft extension end of ball bearing motors, consisting of: end plate, felt washer, and felt retaining cup.	
417		do	For commutator end of ball bearing motors, consisting of: flat end plate, cupped plate, steel spring washer and steel spacing washer.	
418-C		Pulley	1″ outside diam., for V-belt, with set screw	
419-C		Armature	For motor with ball bearings	
426		Resilient mounting lug	With washer attached	
1003		Switch	Single pole canopy switch	
1004		do	Single pole, bakelite, trigger switch; small (for models C and D).	

Reference No.	Stock No.	Name of part	Description	Specification or drawing No., Signal Corps
1008		Switch	Motor reversing switch, canopy type; small, used for variable speed motors.	
1015		Cord connector cap	2-wire spring action, rubber	
1021		do	2-wire TL rubber	
1024		Receptacle	2-wire TL flush black porcelain	
1042		Plug base	3-wire small TL flush attachment	
1044		Cord connector body	3-wire small TL	
1061		Viewing lamp receptacle	Bakelite	
1063		Plug body	Standard Edison screw base	
1101		Attachment cord	Standard, 3-wire, 10′ long, with No. 1015, 1044, 1063 and 1116.	
1103-A		Foot controller	Model AB, complete with 6 feet of cord, cord connector cap No. 1021 and 4 rubber bumpers, No. 10005 underneath.	
1106		Treadle	For foot controller model AB	
1108-A		Bottom plate	With 4 rubber bumpers No. 10005, for foot controller No. 1103-A.	
1109		Resistance unit	For foot controller model AB	
1112		Spring	For treadle of foot controller model AB	
1114		Treadle arm	For foot controller model AB	
1115		Squeeze connector	For attaching cord	
1116		Ground clamp		
1118		Rheostat	2½″ diam., with knob for operation of variable speed motors.	
1120		Knob	1½″ diam., for operating rheostats	
1150		Lamp	115-volt, 25-watt, medium screw base	

3001		Star and 9/32-inch diameter shaft, combined.	
3002		Cam	1¼″ diam., with .116″ diam. pin
3003		Pin	.116″ diam., for cam No. 3002
3004–D		Cam shaft	5/16″ diam., 6⅝″ long, for model D
3005–D		Cam	With pin, No. 3002 and shaft No. 3004–D
3006		Eccentric bushing	With 9/32″ hole and flange, for star shaft, not reamed
3007		Retainer	For flange of eccentric bushing, with screw
3009		Bushing	¾″ long, for flywheel end of cam shaft of model D
3010		do	2⅞″ long (including sleeve), for cam end of cam shaft of model C or model D.
3011		Sprocket	16-tooth, with 9/32″ hole, plain, for intermittent movement.
3013		Spacer sleeve	With 9/32″ hole, used on star shaft between intermittent sprocket and eccentric bushing at star end.
3016–B		Sprocket shoe	With two rollers
3017–B		Roller	With oilite bearing bushings for No. 3016–B
3017–S		"Oilite" bearing bushing	For roller No. 3017–B
3018–B		Axle	3/16″ diam., for roller No. 3017–B
3020–C		Shoulder screw	3/16″ diam. x ⅜″ grip, for parts Nos. 3016–B and 3036
3021–A		Spring, coil	For use on shoulder screw No. 3020–C, when attached to part No. 3016–B.
3021–B		do	For use on shoulder screw No. 3020–C when attached to part No. 3036.
3022		Oil guard	With screw
3023–B		Flywheel	Grooved for V-belt
3024		Flange for flywheel	With hub for winding film, with two screws for attaching.
3027		Felt shoe	To be cemented into one of the grooves of felt shoe holder No. 3052 with casein glue No. 10047–G.

NOTE.—"TL" means "Twist Lock."

Reference No.	Stock No.	Name of part	Description	Specification or drawing No., Signal Corps
3033		Film slide plate	Bronze, with catch assembled and with four screws for attaching.	
3034-B		Gate	Without sprocket shoe and felt shoe holder	
3035		Hinge pin	For gate No. 3034-B, with set screw	
3036		Framing carriage		
3037		Framing lever	With shoulder screw for fulcrum	
3038-B		Catch (not drilled)	With screw and spring, for film slide plate No. 3033	
3039		Spring	For raising gate	
3040		Hinged ring	For support of viewing lens assembly, with hinge pin	
3041-B		Viewing lens assembly	Consisting of one lens of 3'' diam. and one lens of 2½'' diam. in mounting, complete with lock nut.	
3042-B		Locknut	For viewing lens assembly No. 3041-B	
3043-B		Viewing lens	2½'' diam	
3043-C		do	3'' diam	
3047		Opal glass pane		
3048		Retainer	For opal glass pane, with two screws	
3049-B		Switch plate		
3052		Felt shoe holder	Cast aluminum, with two felt shoes No. 3027	
3053		Shoulder screw	$\frac{9}{64}$'' diam. x $\frac{3}{16}$'' grip, for support of felt shoe holder No. 3052.	
3054		Cup for spring	For support of felt shoe holder No. 3052	
3055		Spring	For felt shoe holder No. 3052	
3056		Adjusting screw	For support of felt shoe holder No. 3052	
3101		Sprocket	24-tooth, for film feeding device	
3102		Gear	Phenolite, helical, with 120 teeth, 4'' pitch diam., right hand, with metal hub.	
3103		Pinion	Brass, helical, with 20 teeth, 2-3'' pitch diam., left hand	

3105		Pulley	Double, 3″ diam., for driving take-up devices
3106		Shaft	3-8″ diam., for sprocket No. 3101, gear No. 3102 and double pulley No. 3105.
3107		Bushing	¾″ long, for shaft No. 3106, at sprocket end
3108		do	5-8″ long, for shaft No. 3106, at double pulley end
3110		Film guide	With two screws
3114-U		Upper frame and roller	For jerk absorbing device
3114-L		Lower frame and roller	do
3115-U		Spring for upper frame	No. 3114-U
3115-L		Spring for lower frame	No. 3114-L
3116		Retainer	For spring No. 3115, with screw
3133		Locknut	For adjusting nut No. 3134
3134		Adjusting nut	For tension of spring No. 3135
3135		Spring	Steel, coil, for friction of take-up and hold back device
3136		Socket	For spring No. 3135
3145		Pawl	
3146		Spring for pawl	One right hand and one left hand
3147		Washer	Felt, 1¾″ diam. x $\frac{1}{16}$″
3148		Sliding collar	1¾″ diam
3149		Spindle collar	With slot and flange, 1¾″ diam
3150		Ratchet	Aluminum
3151		Cover plate	
3152		Bearing, ball	$\frac{3}{16}$″ diam., set of 44 balls
3153		Pulley	With bronze ball race, complete, including detachable, flanged section of ball race.
3154		Reel spindle bearing	With cast-in bronze ball race and two bearing bushings No. 3155.
3155		Bearing bushing	For reel spindle (two required for each reel spindle)
3156		Reel spindle	Complete with collar, key, and toggle
3157		Toggle	Pin, ball, and spring for reel spindle
3158		Hinged reel spindle	With ball bearing, complete assembly

Reference No.	Stock No.	Name of part	Description	Specification or drawing No., Signal Corps
3159-A		Reel bracket	For 10-in. diam., 1,000 ft. capacity reels	
3161-U		Roller clamp	Upper pressure, with 2 pressure rollers and guide roller	
3161-L		do	Lower pressure, with 2 pressure rollers and guide roller	
3162		Pressure roller	With Oilite bearing bushings for No. 3161	
3163		Axle	3/16" diam., for roller No. 3162	
3164		Guide roller	For No. 3161	
3165-U		Roller clamp holder	Upper pressure, with stop screw and nut, ball, spring, and 2 screws.	
3165-L		do	Lower pressure, with stop screw and nut, ball, spring, and 2 screws.	
3166		Ball	9/32" diam., for No. 3165	
3167		Spring	For No. 3165	
3168		Roller	With 7/8" diam. flanges and Oilite bushings, for use on axle No. 3170.	
3169		do	With 1" diam. flanges and Oilite bushings, for use in frame No. 3114, for jerk absorbing device.	
3170		Axle	1/4" diam., for roller No. 3168 and hinge pin for clamp No. 3161 and frame No. 3114, with washer and screw.	
3171		do	1/4" diam., for roller No. 3169, with screw	
3172		Bearing bushing	Oilite for rollers Nos. 3168 and 3169	
3173		do	Oilite for roller No. 3162	
10001		Belting	Leather, 3/16" diam	
10002		Belt hook		
10003-A		Belt	Leather, 3/16" diam., endless, length 28 inches, for driving take-up device for model D.	
10003-V		do	Size No. 22330, vulcanized rubber, V-section, for motor drive of model D.	

10005		Rubber bumper	(Ring type)
10008-C		Taper pin	Size 000 x ¾″, used for Nos. 3023, 3101, 3102, 3105, and other parts.
10008-D		do	Size 0000 x ¾″, used on model SD and DX and other places.
10008-E		do	Size 00000 x ½″, used for Nos. 3001, 3002, 3103, and other places.
10009-C		Taper pin reamer	For size 000
10009-D		do	For size 0000
10009-E		do	For size 00000
10010-C		Set screw	Size No. 8-32 x ¼″ long, for small motor pulleys, securing hinge pins, etc.
10010-D		do	Size ¼″-20 x ¼″ long, for large motor pulleys, etc
10011-A		Thumbscrew	Size No. 10-24 x ½″ under head
10011-B		do	Size No. 10-24 x 9/32″ under head
10012		Washer	Flexible fiber, for use with thumbscrew No. 10011-B, when used for closing grease holes in movement case.
10013-B		Wing nut	Size ¼″-20, for attaching exciter lamp sockets, etc
10013-D		do	Size ⅜″-16, for attaching reel brackets, reel spindle bearings, etc.
10014-BH		Rubber-covered cable	Two-conductor, heavy type, 13/32″ outside diam
10014-CH		do	Three-conductor, heavy type, 7/16″ outside diam
10040		Oil cup and cover	For 3/16″ diam. hole
10045		Lubricating oil	½ pint in can
10046		Oiler	
10047-A		Lubricant (grease)	For intermittent movement, ½ lb, in can
10047-B		Enamel	Black satin finish, for baking or air drying, 1 qt, in can
10047-C		do	Crystal finish, for baking or air drying, 1 qt, in can
10047-D		Lubricant (grease)	For ball bearings, 1 lb, in can
10047-G		Glue, casein	For cementing felt shoes to felt shoe holders, 1½ oz, in can.

Reference No.	Stock No.	Name of part	Description	Specification or drawing No., Signal Corps
10048		Grease gun	For putting lubricant in intermittent movement case	
10049-A		Film cement	¾ oz, in bottle with cork and quill	
10049-B		Cork and quill only	For bottle No. 10049-A	
10049-C		Film cement	In can, ½ pt, 1 pt, 1 qt	
		Viewing attachment PH-98-A.	Attachment for film viewer	75-82.
1		Base		
2		Gib		
3		Slide		
4		Base cover		
5		Lock ring		
6		Cross motion screw		
7		Shoulder ring		
8		Shoulder bushing		
9		Knurled head—cross motion.		
10		Spring—cross motion slide.		
11		End plate—spring		
12		End plate—plain		
13		Lower bearing—draw tube.		
14		Pinion assembly		
15		Diaphragm—draw tube		
16		Draw tube		
17		Clamp lug		
18		Clamp screw		

19		Body tube	
20		Upper bearing—body tube.	
21		Flange—draw tube	
22		Reticle	
23		Reticle mounting	
24		Reticle mounting circle	
25		Reticle housing base	
26		Reticle housing cover	
28		Field lens mounting—eyepiece.	
29		Eyepiece tube	
31		Spring ring—eyepiece	
32		Eyepiece tube	
33		Eyepiece diaphragm	
34		Eyepiece adapter tube	
35		Clamp lug	
36		Knurled screw	
37		Eyerest—support tube	
38		Spring—detent—eyerest	
39		Ball—detent—eyerest	
40		Adjusting arm—blank eye guard.	
41		Eye adjustment sleeve	
42		Support—blank eyerest	
43		Objective mounting tube name plate.	
44		Rack	
45		Fiber shoe	
46		Lock ring	
47		Eye lens—eyepiece	

Reference No.	Stock No.	Name of part	Description	Specification or drawing No., Signal Corps
48		Field lens—eyepiece		
50		Objective		
51		Set screw—objective tube		
52		Set screw—reticle centering.		
53		Clamp screw—eyepiece		
54		Clamp screw—eyerest assembly		

62. Junction box JB-40.—See figure 39 for identification of parts.

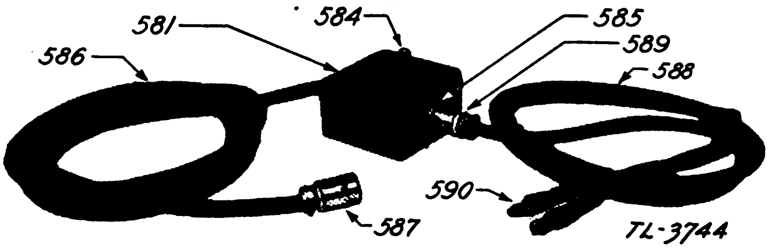

FIGURE 39.—Parts identification for junction box JB-40.

Reference No.	Name of part	Description	Specification or drawing number, Signal Corps
	Junction box JB-40		75-32.
581	Junction box casting		SC-D-1023.
582	Junction box cable clamp		SC-D-1023.
583	Junction box panel		SC-D-1024.
584	Binding posts	No. 14-G Sergeant, Eby Co.	
585	Socket SO-56		SC-D-457.
586	Cord		SC-D-1026.
587	Cable plug M-155		SC-D-1460.
588	Battery cord assembly		SC-D-1025.
589	Battery cord plug M-156		SC-D-1460.
590	Battery clips	No. 27 Clip, Meuller Co.	
591	Battery clip insulators	Mueller No. 47, modified	
592	Large insulator	Mueller No. 49, modified	
593	P. G. rubber tubing	3/16″ inside diameter x 1/16″ wall.	

63. Line connector unit EE-87.—See figures 9 and 31 for identification of parts.

Stock No.	Name of part	Description	Specification or Drawing number	
			Manufacturer's	Signal Corps
4H1187	Line connector unit EE-87.			SC-D-3719-C.
	Relay	Multiple, 7-contact 10-12 v., North.	400-Z	SC-D-3719-C.
	Hummer	Microphone hummer type 572-B, G. R.		SC-D-3719-C.
	Washer	Countersunk, brass, No. C-145, nickel finish, Simpson.		SC-D-3719-C.

Stock No.	Name of part	Description	Specification or Drawing number: Manufacturer's	Specification or Drawing number: Signal Corps
3Z9936	Terminal	TM-36, eye clip, oval, brass (tinned).		10701-B-1.
3Z4455	Resistor	RS-55, 45 ohms ±5% porcelain tube.		RL-D-6223.
	Washer	Phenolic plate, ⅝" outside diameter x 13/64", inside diameter x 3/32" thick.		SC-D-3719-C.
•	Circuit plate	Gothic type on 1/16" graphic lamicoid, 8" x 11½".		SC-D-3718-C.
	Transformer	Type C-231		SC-D-1614-C.
	Box	Birch, 14 17/32" x 11 7/32" x 4 1/32" high		SC-D-3720-B. SC-D-3721-C. SC-D-3722-B.
	Plate	XXX black phenolic plate, 13 9/16" x 10¼" x 3/16".		SC-D-3723-B.
	Binding post	TM-195, brass, dull white finish, knurled cap, provides connection to line circuits.		SC-D-1132.
3Z209	do	TM-109, bakelite, knurled cap and base, provides connection for battery leads.		SC-D-530.
3D166	Capacitor	CA-166, 0.1 µf fixed, paper, 200-v d-c, Tobe.		SC-D-512.
3Z9913	Terminal	TM-13, eye clip, oval, brass (tinned), for binding posts for battery leads.		RL-A-320.
	Key	3-position, No. 479EP, W. E. Co.		SC-D-3723-B.
	do	3-position, No. 479G, W. E. Co.		SC-D-3723-B.
	Resistor	Type F-⅓, 20,000 ohm, ⅓ w, IRC.		SC-D-3723-B.
	do	Type F-⅓, 50,000 ohm, ⅓ w, IRC.		SC-D-3723-B.

64. Theodolite PH-BC-33.—See figures 40 to 43, inclusive, for identification of parts.

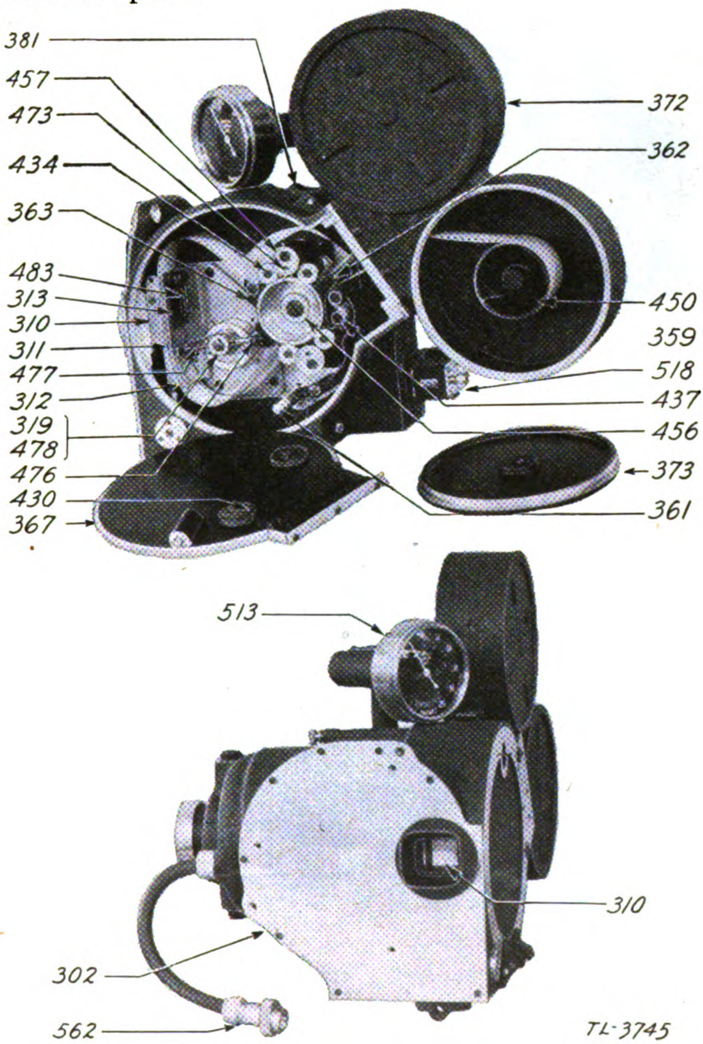

FIGURE 40.—Parts identification for theodolite PH-BC-33.

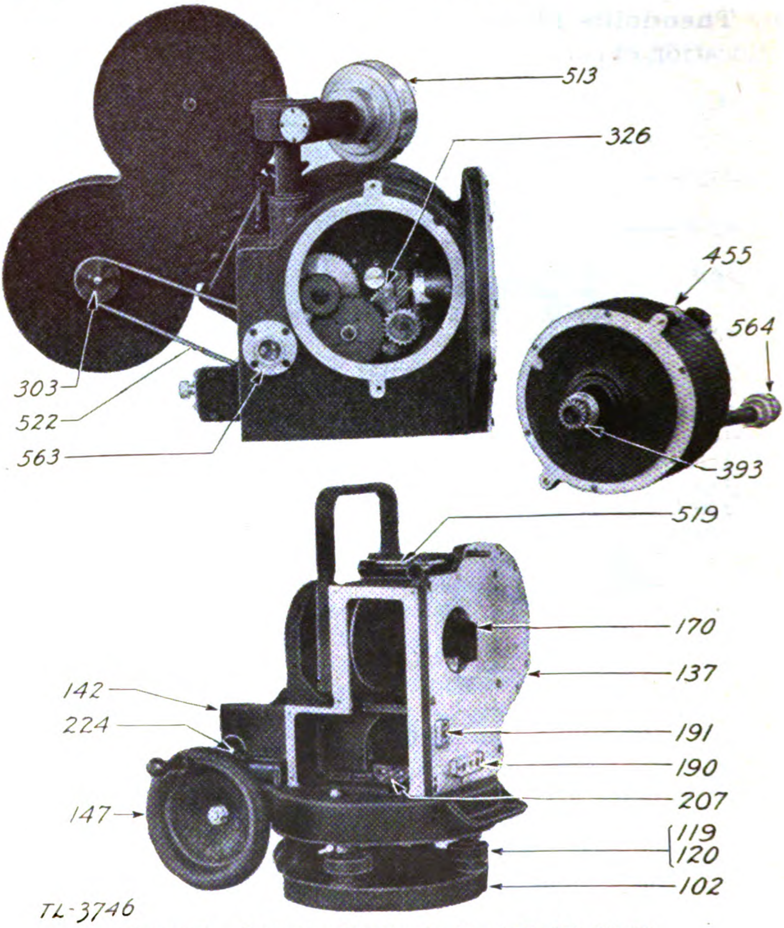

FIGURE 41.—Parts identification for theodolite PH-BC-33.

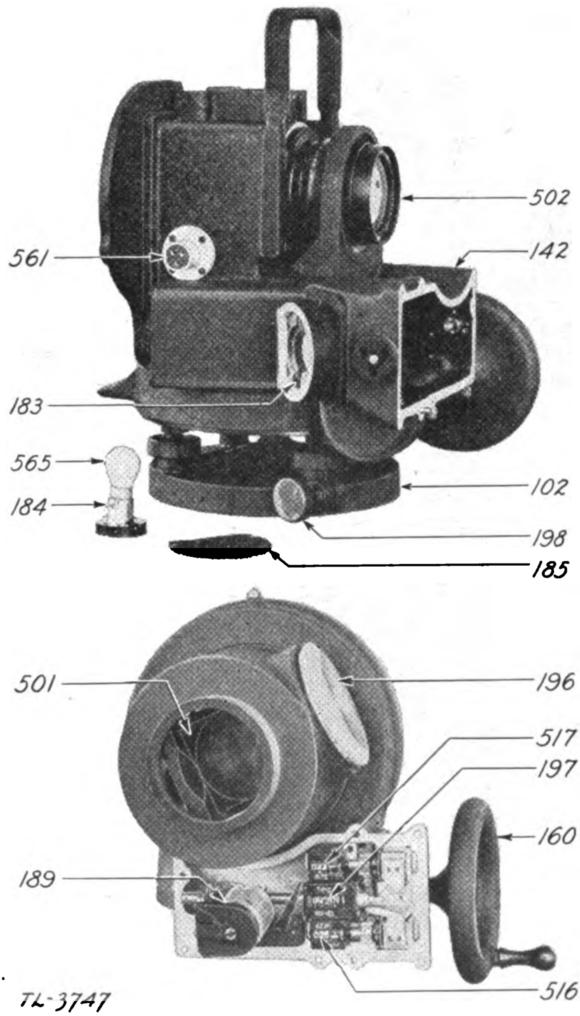

FIGURE 42.—Parts identification for theodolite PH-BC-33.

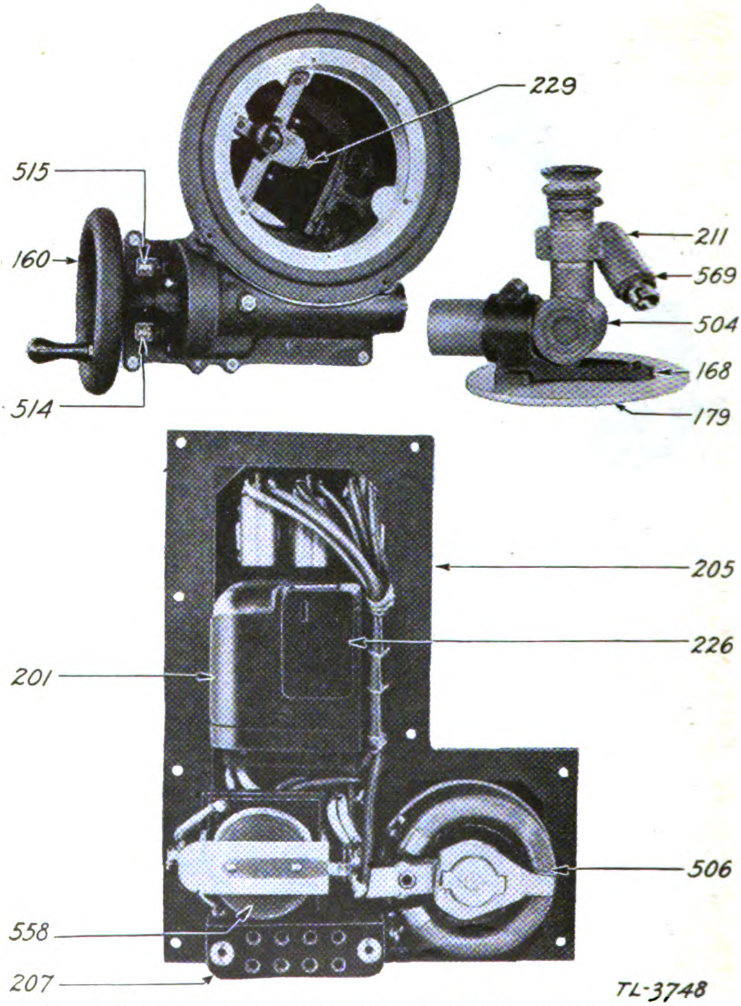

FIGURE 43.—Parts identification for theodolite PH-BC-33.

Reference No.	Stock No.	Name of part	Description	Specification or drawing No. — Manufacturer's	Specification or drawing No. — Signal Corps
	8A3733.3	Theodolite PH-BC-33			75-32.
101		Base		T-101	
102		Turntable		T-102A	
103		Azimuth gear, lower half		T-103	
104		Azimuth gear, upper half		T-104	
105		Lower gear retaining ring		T-105	
106		Backlash spring block		T-106	
107		2½" prism bracket		T-107	
108		2½" prism box		T-108	
109		Elevation worm gear		T-109	
110		1" prism bracket		T-110A	
111		50-mm lens mount		T-111	
112		1¼" prism stop		T-112	
113		1¼" prism spring block		T-113	
114		1" prism		T-114	
115		1¼" prism		T-115	
116		Diaphragm for 50-mm lens		T-116	
117		1¼" prism hold down button.		T-117	
118		Worm for azimuth and site		T-118	
119		Leveling screw handle		T-119	
120		Leveling screw		T-120	
121		Leveling screw cup		T-121	
122		Turntable ball thrust		T-122	
123		King pin		T-123	
124		2½" prism spring bar		T-124	
125		2½" prism top spring		T-125	
126		2½" prism side spring		T-126	
127		1" and 1¼" prism hold down spring.		T-127	
128		2½" prism bottom spring		T-128	
129		2½" prism top hold down button.		T-129	
130		2½" prism side hold down button.		T-130	
131		2½" prism back stop		T-131	
132		2½" prism round head screw.		T-132	
133		2½" prism ball head screw		T-133	
134		2½" prism house		T-134	
135		Outboard bearing for 2½" prism house.		T-135	
136		Elevation gear thrust collar.		T-136	
137		Theodolite cover		T-137	
138		Filter holder		T-138	
139		Filter frame		T-139	
140		Filter frame nut		T-140	
141		Backlash spring		T-141	
142		Theodolite box		T-142	
143		Elevation gear housing		T-143A	
144		Solenoid bracket		T-144A	
145		Lens setting ring		T-145	
146		Lens setting nut		T-146	
147		Azimuth hand wheel		T-147	
148		Counter ratchet shaft		T-148A	
149		Counter ratchet pin		T-149A	
150		Elevation worm thrust bearing.		T-150	

Reference No.	Stock No.	Name of part	Description	Specification or drawing No.	
				Manufacturer's	Signal Corps
151		Elevation worm bearing		T-151	
152		Elevation counter gear		T-152	
153		Elevation counter idler gear bracket.		T-153	
154		Elevation counter idler gear.		T-154	
155		Elevation worm shaft		T-155	
156		Elevation counter gear cover.		T-156	
157		Elevation counter gear bearing.		T-157	
158		Elevation and azimuth worm washer.		T-158	
159		Counter coupling pinion		T-159	
160		Elevation hand wheel		T-147	
161		Counter dial		T-161	
162		Azimuth worm bearing		T-162	
163		Counter bracket		T-163A	
164		Azimuth worm shaft		T-164	
165		Azimuth worm thrust bearing.		T-165	
166		Hand wheel handle		T-166	
167		Hand wheel handle shaft		T-167	
168		Telescope bracket		T-168A	
169		Top spring for 2½" prism		T-169	
170		6" lens baffle		T-170	
171		Reset counter shaft extension.		T-171	
172		Counter window frame		T-172A	
173		Counter window		T-173A	
174		Reset counter knob		T-174	
175		Counter reset bushing		T-175	
176		Elevation worm cover		T-176	
179		Telescope base plate		T-179A	
180		Theodolite handle		T-180A	
181		Lamp house		T-181A	
182		Light reflector insulator		T-182A	
183		Light reflector contact		T-183	
184		Light socket	No. 20 double contact bayonet receptacle, modified, F. W. Morse, Boston.		
185		Cover for light reflector		T-185A	
187		Solenoid spring		T-187A	
188		Ball thrust disk		T-188	
189		Solenoid	Type 5035, 12-v, d-c, 7 ohms, Leach Relay Co.		
190		Lower gib		T-190	
191		Side gib		T-191	
193		Telescope guard		T-193A	
194		Felt ring		T-194	
195		Counter spiral marker plate		T-195A	
196		Dust cap		T-196	
197		Interval counter	No. AT28, ratchet counter, Veeder-Root Co.		
198		Turn table screw		T-198A	
199		Turn table screw washer		T-199	
200		Fillister head screw		T-200	
201		Fog lamp cover		T-201A	

Reference No.	Stock No.	Name of part	Description	Specification or drawing No. Manufacturer's	Signal Corps
202		Fog lamp support		T-202A	
203		Counter window		T-203	
204		Counter window washer		T-204	
205		Panel		T-205	
206		Panel knob		T-206	
207		Panel strip switch, 8 prong		T-207	
208		Cable clamp		T-208	
209		Oil can clamp, theodolite box.		T-209	
210		Sight		T-210	
211		Telescope reticle illuminator.		T-211	
212		Lamp housing end cover		T-212	
213		Bracket pin, theodolite box.		T-213	
214		Eye bolt, theodolite box		T-214A	
215		Eye bolt bracket, theodolite box.		T-215	
216		Hold down bracket, theodolite box.		T-216A	
217		Right level guard		T-217	
218		Left level guard		T-218	
219		Cushion support, theodolite box.		T-219	
220		Cushion block, theodolite box.		T-220	
221		Level washer		T-221	
222		Center block, theodolite box.		T-222	
223		Center felt, theodolite box		T-223	
224		Manual counter set		T-224	
225		Manual counter set bearing.		T-225	
226		Cover plate for T-201A		T-226	
227		Switch box spacer		T-227	
228		Solenoid wire insulator		T-228	
229		Adjusting screw for 2½" prism.		T-229	
230		Relay insulator		T-230	
231		Relay spacer		T-231	
232		Relay insulator nut		T-232	
234		Washer for hold down bracket.		T-234A	
236		Oiler spacer		T-236	
237		Azimuth thrust washer		T-237	
242		do		T-242	
254		Solenoid bracket attachment.		T-254	
301		Camera box		TC-1	
302		Shutter cover		TC-2	
303		Magazine pulley		TC-3	
304		Magazine catch		TC-4	
305		Shutter		TC-5	
306		Shutter counterweight		TC-6	
307		Movement gate bushing		TC-7	
308		Movement gate pin		TC-8	
309		Movement spring		TC-9	
310		Aperture plate		TC-10A	
311		Register plate		TC-11	

Reference No.	Stock No.	Name of part	Description	Specification or drawing No. Manufacturer's	Signal Corps
312		Gate		TC-12	
313		Pressure plate		TC-13	
314		Base plate		TC-14	
315		Hold down arm toggle bearing.		TC-15	
316		Bearing housing		TC-16	
317		Movement bearing large spacer.		TC-17	
318		Movement bearing small spacer.		TC-18	
319		Cam shaft		TC-19A	
320		Movement bearing nut		TC-20	
321		Aperture field indicator top.		TC-21	
322		Aperture field indicator side.		TC-22	
323		Aperture field indicator bottom.		TC-23	
324		Counter aperture fence		TC-24	
325		Shutter drive gear		TC-25	
326		Movement gear		TC-26	
327		Magazine feed pin		TC-27	
328		Intermediate gear		TC-28A	
329		Intermediate pinion		TC-29A	
330		Sprocket gear		TC-30	
331		Tachometer gear on sprocket shaft.		TC-31	
332		Tachometer lower gear		TC-32	
333		Tachometer gear		TC-33	
334		Tachometer pinion		TC-34	
335		Magazine drive pulley		TC-35A	
336		Magazine pulley pinion		TC-36A	
337		Counter gear		TC-37	
338		Shutter shaft gear		TC-38	
339		Intermediate gear washer		TC-39	
340		Magazine pulley shaft		TC-40A	
341		Sprocket bearing housing		TC-41	
342		Sprocket bearing spacer, large.		TC-42	
343		Sprocket bearing spacer, small.		TC-43	
344		Sprocket shaft washer		TC-44	
345		Sprocket shaft		TC-45	
347		Shutter shaft inner race spacer.		TC-47	
348		Shutter shaft bearing housing.		TC-48	
349		Shutter shaft		TC-49	
350		Shutter hub		TC-50	
351		Lower box screw		TC-51	
353		Counter bracket		TC-53	
354		Tachometer housing		TC-54	
355		Tachometer drive shaft		TC-55	
356		Tachometer gear box cover		TC-56	
358		Trip apron bearing		TC-58	
359		Trip apron		TC-59	
360		Trip plunger bearing		TC-60	
361		Trip plunger knob		TC-61	
362		Stripper, take up side		TC-62	

Reference No.	Stock No.	Name of part	Description	Specification or drawing No. Manufacturer's	Signal Corps
363		Stripper, feed side		TC-63	
364		Sprocket film guide base		TC-64	
365		Idler roller pin		TC-65	
366		Counter drive shaft		TC-66	
367		Door		TC-67	
368		Door light trap		TC-68	
369		Door light trap insert		TC-69	
370		Magazine stop		TC-70	
371		Door, magazine light trap		TC-71	
372		Magazine		TC-72	
373		Magazine cover		TC-73	
374		Lower box tie		TC-74A	
375		Magazine hold down shaft		TC-75	
376		Magazine hold down spring arm.		TC-76	
377		Camera door hinge, inboard.		TC-77A	
378		Camera door hinge, outboard.		TC-78	
379		Magazine latch spring		TC-79	
380		Hinge pin		TC-80	
381		Magazine hold down		TC-81	
382		Magazine idler spool		TC-82	
383		Lock washer screw		TC-83	
385		Threading knob		TC-85	
386		Rotor shaft felt seal		TC-86	
387		Needle bearing screw		TC-87	
388		Felt seal washer		TC-88	
389		Camera cover, motor side		TC-89A	
390		Motor end bell		TC-90A	
391		Motor brush end bell		TC-91B	
392		12v motor armature		TC-92	
393		Motor drive gear		TC-93	
394		12v motor field		TC-94A	
395		Trip plunger		TC-95	
396		Door catch		TC-96	
397		Tachometer housing cover plate.		TC-97	
398		Movement gate spring clip		TC-98	
399		Movement gate spring post.		TC-99	
401		Tachometer drive pin		TC-101	
402		Motor grommet cap		TC-102	
403		Motor grommet plug		TC-103	
404		Magazine spring post		TC-104	
405		Magazine hole cover		TC-105	
406		Movement gear hub		TC-106	
407		Movement gear ring		TC-107	
408		Aperture plate screw		TC-108	
409		Counter		TC-109	
411		Box lock screw		TC-111	
412		Box lock nut		TC-112	
413		Magazine pulley shaft		TC-113	
414		Washer		TC-114	
415		Gear retaining ring		TC-115	
416		Gear retaining ring		TC-116	
417		Baffle plate		TC-117	
430		Sprocket film guide, safety bushing.		AA-1-10	

Reference No.	Stock No.	Name of part	Description	Specification or drawing No. Manufacturer's	Signal Corps
431		Door latch stop		AA-21-2	
432		Door latch knob		AA-21-3	
433		Door latch spring		AA-21-5	
434		Sprocket film guide roll		AF-14-12A	
435		Sprocket film guide pin, short.		AF-14-13A	
436		Sprocket film guide pin, long.		AF-14-14A	
437		Idler roller		AF-14-17	
438		Idler roller shaft screw		AF-14-19	
439		Sprocket film guide spring		AF-14-23	
440		End roller, magazine		AI-23-2	
441		Magazine center roller		AI-23-3	
442		Center roll bushing, magazine.		AI-23-5	
443		Magazine roll spring		AI-23-6	
444		Magazine light trap plate		AI-23-7A	
445		Magazine spindle		AI-23-10	
446		Magazine roll screw		AI-23-11	
447		Magazine spindle bushing housing.		AI-24-3	
448		Magazine cover spring housing.		AI-24-4	
449		Magazine spool tension spring.		AI-24-5	
450		Contractible spool assembly.			
451		Contractible spool frame		CMS-1	
452		Contractible spool trigger		CMS-2	
453		Contractible spool shell		CMS-3	
454		Oilless bearing		LM-3A	
455		Screw		MOA-14	
456		Sprocket		NC-57C	
457		Eccentric		NC-174A	
458		Eccentric shaft		NC-175	
459		Buckle trip switch assembly.			
460		Switch contact bar separator.		NC-225	
461		Trip switch top plate		NC-226	
462		Tungsten point		NC-227	
463		Tungsten point		NC-228	
464		Trip switch contact bar		NC-229B	
465		Trip switch bottom plate		NC-230	
466		Trip switch push plate		NC-232	
467		Buckle trip switch shaft		NC-234	
468		Spacer		NC-237	
469		Buckle trip switch spring		NC-239	
470		Sprocket film guide swivel casting.		NC-268	
471		Buckle trip spring		NC-304	
472		Buckle strip spring post		NC-305	
473		Door stop pin		NC-337A	
474		Sprocket shaft roller pin		NC-481	
476		Swivel bearing		S-9	
477		Pull-down arm		S-22	
478		Cam washer		S-23	
479		Cam hook washer		S-25A	
480		Pressure plate rail		S-27B	

Reference No.	Stock No.	Name of part	Description	Specification or drawing No. Manufacturer's	Specification or drawing No. Signal Corps
481		Pressure plate roller		S 28	
482		Clamp arm spring		S 30A	
483		Pressure plate clamp arm		S 45	
484		Clamp arm spacer		S 46	
501		Prism	45°, 2½" face, B & L Co.		
502		Photographic lens	152-mm, f.2.7, Baltar, B & L Co.		
503		do	50-mm, f.3.5, Tessar, B & L Co.		
504		Elbow telescope	Ordnance Dept. M-2, B & L Co.		
505		Photographic filter	Wratten No. 5N5		
506		do	Wratten No. 25 A		
507		do	Wratten No. 29 F		
508		do	Wratten No. 39		
509		Needle bearing	B-610, Torrington Co.		
510		Ball bearing	Felt seal No. 200TT, Fafnir Co.		
511		do	Felt seal No. 200T, Fafnir Co.		
512		do	Felt seal No. 37T, Fafnir Co.		
513		Tachometer	757N, special dial, Stewart-Warner Co.		
514		Azimuth visual counter	P-56, Veeder-Root Co		
515		Site visual counter	P-56, Veeder-Root Co		
516		Azimuth photographic counter.	P-31, modified, Veeder-Root Co.		
517		Site photographic counter	P-31, modified, Veeder-Root Co.		
518		Footage counter	AQ-48, Veeder-Root Co		
519		Level	1" side transit, 2$\frac{5}{16}$" x ⅝, C. Berger Co., Boston.		
520		Oil cup	No. 53-ON Empress		
521		do	No. 54-21K Empress		
522		Belt	⅛" leather, 15⅞" long		
523		Carrying case			
551		Signal switch	No. 20994 SPST toggle switch, H. & H. Co.		
552		Motor switch	No. 20994 SPST toggle switch, H. & H. Co.		
553		Night switch	No. 20994 SPST toggle switch, H. & H. Co.		
554		Lamp switch	No. 21350-A SPDT toggle switch, H. & H. Co.		
555		Bayonet receptacle	No. 12 double contact, modified, F. W. Morse, Boston.		
556		Signal lamp	No. 68 double contact mazda, G. E. Co.		
557		Night lamp	No. 68 double contact mazda, G. E. Co.		
558		Relay	Type 1010-22½-v d-c Leach Relay Co.		
559		Socket SO 54			SC D-457.
560		Rheostat	Model J No. 0321, 150 ohms, Ohmite Co.		

Reference No.	Stock No.	Name of part	Description	Specification or drawing No. — Manufacturer's	Specification or drawing No. — Signal Corps
561	....	Connector	No. ATR-17-3, female connector, Aero Elect. Products.	....	
562	....	do	No. ATR-12-3G, male connector, Aero Elect. Products.	....	
563	....	do	No. ATR-18-3, male connector, Aero Elect. Products.	....	
564	....	do	No. ATR-11-3G, female connector, Aero Elect. Products.	....	
565	....	Counter lamp	No. 94 double contact mazda, G. E. Co.	....	
566	....	Bayonet plug	No. 148 double contact, F. W. Morse, Boston.	....	
567	....	Condenser	TP 428, 0.10 mf., 400-v, Mallory Co.	....	
568	....	Pilot light jewel	No. 311, red, Yaxley Co	....	
569	....	Socket assembly	Ordnance Department B16301.	....	
570	....	Reticle lamp	No. 68 double contact mazda, G. E. Co.	....	

65. Theodolite PH-BD-33.—See figures 44 and 45 for identification of parts.

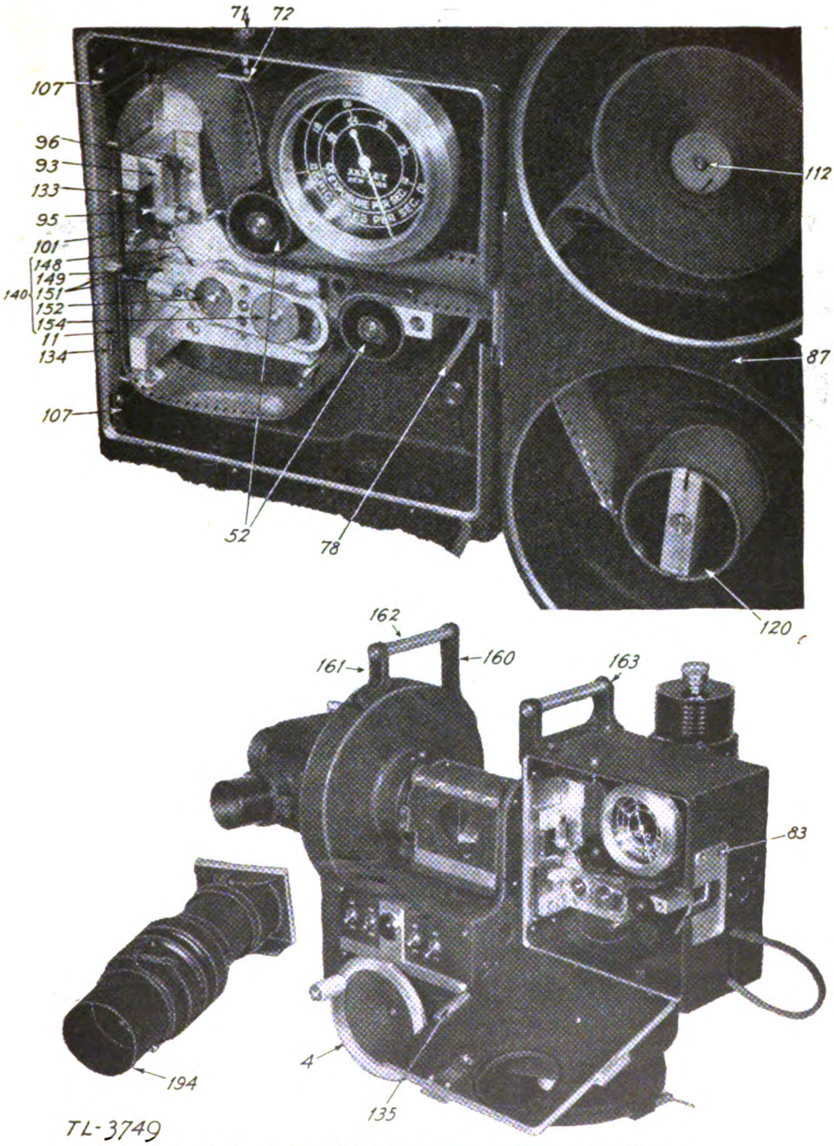

FIGURE 44.—Parts identification for theodolite PH-BD-33.

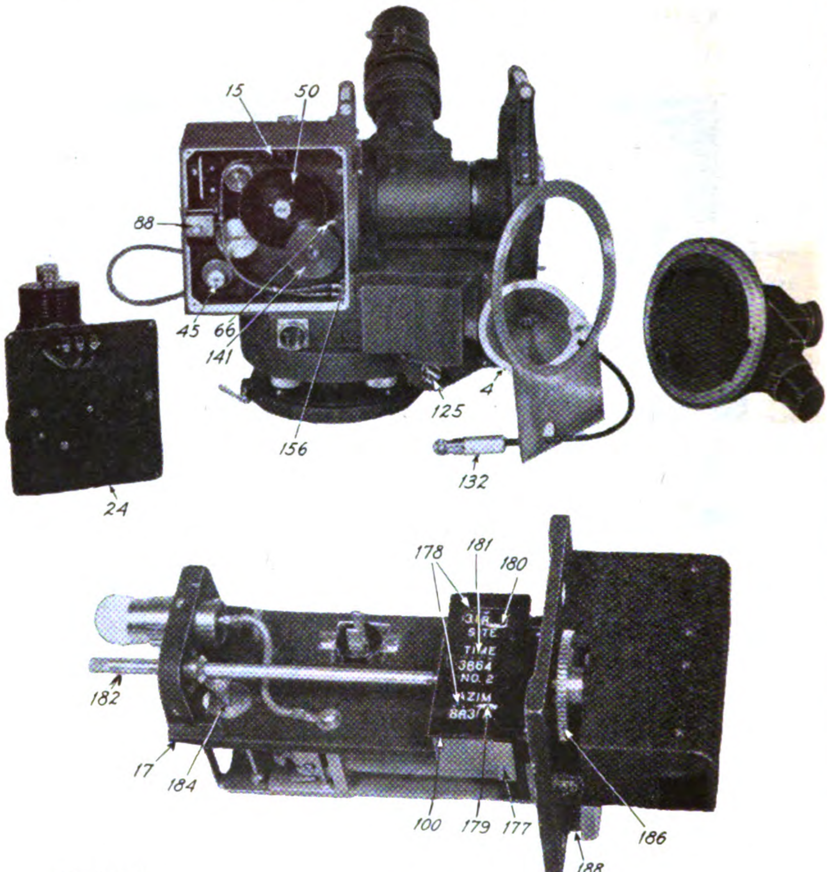

FIGURE 45.—Parts identification for theodolite PH-BD-33.

Reference No.	Name of part	Description	Specification or drawing number: Manufacturer's	Specification or drawing number: Signal Corps
1	Magazine roller unit case		1	
2	Roller unit film guide		2	
3	Hinge for camera door end		3	
4	Handwheel for azimuth/elevation gears.		4	
5	Shaft for film safety trip		5	
6	Counter drive shaft		6	
7	Bearing for hold-back sprocket (No. 16).		7	
8	Film sprocket guide screw		8	
9	Idler gear screw		9	
10	32-mm lens barrel for theodolite		10	
11	Film gate for theodolite		11	
15	Camera switch block		15	
16	Feed sprocket bearing (No. 7)		16	
17	Counter unit frame		17	
19	Camera shutter		19	
20	Split ball bearing retainer for theodolite.		20	
23	Camera door		23	
24	Motor mounting plate for theodolite camera.		24	
25	Motor mounting casting for theodolite camera.		25	
26	Ball bearing retainer for motor mounting.		26	
27	Motor knob for camera drive clutch unit.		27	
28	Shaft for camera drive clutch unit.		28	
29	Hub for camera drive clutch unit.		29	
30	Tension washer for camera drive clutch unit.		30	
31	Washer for camera drive clutch unit.		31	
34	Filter mount		34	
35	Ring for filter mount		35	
36	Spiral drive gear for camera drive clutch unit.		36	
37	Camera drive clutch unit assembly.		37	
38	Shaft for take-up shaft assembly		38	
39	Gear hub for take-up shaft assembly.		39	
40	Gear for take-up shaft assembly		40	
41	Pressure plate for take-up shaft assembly.		41	
42	Pressure spring for take-up shaft assembly.		42	
43	Adjusting nut for take-up shaft assembly.		43	
44	Pulley for take-up shaft assembly.		44	
45	Take-up shaft assembly		45	
46	Elevation bearing sleeve		46	
47	Shaft for feed sprocket shaft assembly.		47	

Reference No.	Name of part	Description	Specification or drawing number — Manufacturer's	Signal Corps
48	Spiral gear for feed sprocket shaft assembly.		48	
49	Medium gear for feed sprocket shaft assembly.		49	
50	Large gear for feed sprocket shaft assembly.		50	
51	Film guide. Stop washer		51	
52	Feed sprocket and hold-back sprocket.		52	
53	Feed sprocket shaft assembly		53	
54	Hold-back sprocket shaft assembly.		54	
55	Shaft for hold-back sprocket assembly.		55	
56	Gear for hold-back sprocket assembly.		56	
57	Tachometer assembly		57	
58	Drive shaft end of tachometer for tachometer assembly.		58	
59	Ball bearing adapter for tachometer assembly.		59	
60	Drive shaft for tachometer assembly.		60	
61	Drive shaft collar for tachometer assembly.		61	
62	Gear for tachometer assembly		62	
64	Light trap ring for tachometer assembly.		64	
65	Shutter shaft assembly		65	
66	Shaft for shutter shaft assembly		66	
67	Ball bearing retainer shutter shaft assembly.		67	
68	Collar retainer shutter shaft assembly.		68	
69	Counterweight retainer shutter shaft assembly.		69	
71	Push button for door lock assembly.		71	
72	Lock spring for door lock assembly.		72	
73	Pressure spring for door lock assembly.		73	
74	Catch for door lock assembly		74	
75	Lip for door lock assembly		75	
76	Film safety trip assembly		76	
77	Cam block for film safety trip assembly.		77	
78	Plate for film safety trip assembly.		78	
80	Light trap for camera door		80	
81	Film magazine light trap for camera door.		81	
82	Cover plate for film magazine opening.		82	
83	Film magazine retaining block		83	
84	Hold-back sprocket stripper block.		84	
85	Idler gear assembly		85	

Reference No.	Name of part	Description	Specification or drawing number: Manufacturer's	Specification or drawing number: Signal Corps
86	Gear for idler gear assembly		86	
87	Film magazine for theodolite camera.		87	
88	Film footage reset counter unit		88	
89	Gear for reset counter unit		89	
90	Shaft for reset counter unit		90	
92	Retaining arm assembly for film pressure plate.		92	
93	Arm for retaining arm assembly.		93	
94	Spring for retaining arm assembly.		94	
95	Plunger for retaining arm assembly.		95	
96	Screw for retaining arm assembly.		96	
97	Film guide post for retaining arm assembly.		97	
99	Inner film gate		99	
100	Mask for theodolite counter unit.		100	
101	Film pressure plate assembly		101	
102	Plate for pressure plate assembly.		102	
103	Roller for pressure plate assembly.		103	
104	Roller shaft for pressure plate assembly.		104	
105	Retaining plate for pressure plate assembly.		105	
106	Cover for film magazine		106	
107	Track for film gate		107	
108	Azimuth and elevation worm gears.		108	
109	Small hinge for theodolite chest		109	
110	Catch hinge for theodolite chest		110	
111	Film magazine assembly for theodolite camera.		111	
112	Feed spool shaft for film magazine.		112	
113	Large roller for roller unit case		113	
114	Small roller for roller unit case		114	
115	Shaft roller for roller unit case		115	
116	Bearing for spool shaft assembly.		116	
117	Nut for spool shaft assembly		117	
118	Shaft for spool shaft assembly		118	
119	Pulley for spool shaft assembly		119	
120	Take-up spool assembly for film magazine.		120	
121	Shell for take-up spool assembly		121	
122	Cross piece for take-up spool assembly.		122	
123	Plunger for take-up spool assembly.		123	
124	Spring for take-up spool assembly.		124	
125	Azimuth counter drive release unit.		125	

Reference No.	Name of part	Description	Specification or drawing number: Manufacturer's	Signal Corps
126	Body for azimuth counter drive release.		126	
127	Shell for azimuth counter drive release.		127	
128	Spring for azimuth counter drive release.		128	
129	Lever cam for azimuth counter drive release.		129	
130	Cam follower for azimuth counter drive release.		130	
131	Plug for azimuth counter drive release.		131	
132	Socket holder for theodolite fogging lamp.		132	
133	Guide for camera film gate		133	
134	Retaining spring for camera film gate.		134	
135	Side pressure shoe assembly for film gate.		135	
136	Retaining block for side pressure shoe.		136	
137	Shoe for side pressure shoe		137	
138	Spring for side pressure shoe		138	
140	Film movement assembly for theodolite camera.		140	
141	Flywheel for film movement assembly.		141	
142	Coupling gear for film movement assembly.		142	
143	Cam shaft for film movement assembly.		143	
144	Spacing washer for film movement assembly.		144	
145	Cam stud for film movement assembly.		145	
146	Cam for film movement assembly.		146	
147	Cam bearing for film movement assembly.		147	
148	Arm for film movement assembly.		148	
149	Cross-arm for film movement assembly.		149	
150	Spring for film movement assembly.		150	
151	{Inner and outer Needles for film movement assembly.		151	
152	Cam washer for film movement assembly.		152	
153	Bearing post for film movement assembly.		153	
154	Post washer for film movement assembly.		154	
155	Film guide for theodolite camera		155	
156	Motor connection unit for theodolite camera.		156	
157	Jack retainer for motor connection.		157	

Reference No.	Name of part	Description	Specification or drawing number: Manufacturer's	Specification or drawing number: Signal Corps
158	Jack for motor connection		158	
159	Plug retainer for motor connection.		159	
160	Long arm for theodolite carry bracket.		160	
161	Short arm for theodolite carry bracket.		161	
162	Handle for theodolite carry bracket.		162	
163	Carrying bracket for theodolite camera.		163	
164	Connecting plug assembly for theodolite camera.		164	
165	Terminal for camera switch block.		165	
166	Pin for camera switch block		166	
167	Connecting jack for motor mounting plate.		167	
169	Positioning key for theodolite camera.		169	
170	Camera assembly for type PH-BD-33 theodolite.		170	
171	Counter unit assembly for theodolite.		171	
172	Cover for counter unit assembly		172	
173	Indicator for counter unit assembly.		173	
174	Dial for counter unit assembly		174	
175	Site and azimuth pinion gear for counter unit assembly.		175	
176	Reflector for counter unit assembly.		176	
177	Bracket for counter unit assembly.		177	
178	Site and azimuth counters for counter unit assembly.		178	
179	Azimuth sawtooth indicator for counter unit assembly.		179	
180	Site and time sawtooth indicator for counter unit assembly.		180	
181	Time counter for counter unit assembly.		181	
182	Time counter shaft for counter unit assembly.		182	
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Reference No.	Name of part	Description	Specification or drawing number: Manufacturer's	Signal Corps
191	Diffusion ring for theodolite sight illumination.		191	
193	Thrust ring for theodolite sight		193	
194	Sunshade for theodolite lens		194	
195	Sunshade for theodolite sight		195	
196	Oil can for theodolite chest		196	
197	Prism housing for counter optical unit.		197	
198	Housing base for counter optical unit.		198	
199	Light mask for counter optical unit.		199	
200	Adaptor for sight eyepiece		200	
	Oilless bearing	7/16 inch outside diam. x 1/4 inch inside diam. x 15/32 inch long, bearing for take-up shaft.	45	
	Ball bearing	No. S1RPP-NH, bearing for take-up shaft.	NH	
	Ball valve oiler	Catalog No. 520, Gits Bros. Mfg. Co., Oiler for sprocket bearings.	Gits	
	Hardened steel washer	5/16 inch inside diam. x 5/8 inch outside diam. x 1/16 inch thick, Boston Gear Works, washer for sprockets.	53	
	Tachometer	Stewart-Warner No. 721C, special, camera speed indicator.	57, 63	
	Ball bearing	No. S5R-NH, bearing for tachometer drive.	NH	
	do	No. S1R-NH, rear bearing shutter shaft.	NH	
	do	No. S3R-NH, front bearing shutter shaft.	NH	
	Micro-switch	Cat. No. WZ-R15 MR, safety trip switch.	MR	
	Reset counter	No. AQ48 VR, 3 wheels, lever on left, film footage indicator.	VR	
	Switch	D. P. S. T., 6-amp., 250-v, H&H, motor switch.	H&H	
	do	S. P. S. T., 3-amp., 250-v, H&H, signal, night, or lamp switch.	H&H	
	Plug	No. P-302-FHT, HBJ, plug on counter assembly.	HBJ	
	Socket, female	No. S-302-FHT, HBJ, connector to counter assembly.	HBJ	
	Lamp	3 C. P., 12-16-v, Mazda No. 68, double contact, telescope lamp, signal lamp or fogging lamp.	Mazda	
	do	15 C. P., 12-16-v, Mazda No. 94, double contact, counter illuminating lamp.	Mazda	
	Socket	No. 216-14, G. M. Labs., double contact.	G. M. Labs., Inc.	
	do	Double contact bakelite base, socket-counter illuminating lamp.	Sun Radio	

Reference No.	Name of part	Description	Specification or drawing number — Manufacturer's	Signal Corps
	Socket	Type SO-54, cable connection.		SC-D-457.
	Capacitor	Catalog No. DA-4100, CD	CD	
	Resistor	Type EPA, 25-ohm, 50-watt, IRC.	IRC	
	Relay	Series 125 contacts A1, DC-12-v, 2,000-ohm, Guar.	Guar	
	Counters	Type P52, VR, external site and azimuth counters.	VR	
	"V" belt	Mould No. 5857, L. H. Gilmer Co.	L.H. Gilmer Co., Phila.	

66. Theodolite PH–BE–33.—Replacement parts for this theodolite, with the exception of those pertaining to the camera optical system, are the same as those listed for theodolite PH–BC–33 in paragraph 64.

67. Time interval device PH–103.—See figure 28.

Stock No.	Name of part	Description	Specification or drawing number — Manufacturer's	Signal Corps
8A3837	Time interval device PH-103.			75-81.
	Box	White pine, carrying case		SC-D-1017-D.
	Circuit label			SC-D-4444-B.
	Relays	Slow-acting, Automatic Elec. Co. type R-1793-A-1.	A. E. Co	
	Capacitor C_1	50-v dry electrolytic capacitor 300-µf capacity +25%, −10% at 20° C. Capacity at −40° C. not less than 50% of that at 20°. Capacity at 55° C. not more than 115% of that at 20°.		SC-D-4444.
	Resistor R_1	Type DG 8-watt with C coating 900 ohms.	IRC	
	Resistor R_2	Potentiometer 2,500 ohms, type No. 214-A.	GR	
	Resistor R_3	Type DO 8-watt with C coating 4,000 ohms.	IRC	
	Resistor R_4	Potentiometer 1,000 ohms		
	Continuity test key	Lever type key, continuity test, code No. 479-C5.	WECo	
	Ground test key	do	WECo	
	T. I. start key	Rotating cam type key, code No. 272-A, T. I. start.	WECo	
	T. I. short key	Push button type key, code No. 188-A, T. I. short.	WECo	
	Meter	Model No. 506, panel mounting 0-50 ma.	Weston	

68. Time interval multiplier PH-264-( ).

Reference No.	Name of part	Description	Specification or drawing number: Manufacturer's	Signal Corps
	Time interval multiplier			75-101.
1	Key	Type 464B or 464H, 1 sec. advance	WECo	
2	do	Type 464H, manual	WECo	
3	Relay	Type SD29S2, line relay	S. D	
4	do	Type CX2918, stepping relays	S. D	
	Binding post	TM-195, terminals		SC-A-4717.
	Box	Mahogany		SC-D-6715
	Cover	do		SC-D-6715
	Panel	Phenolic plate		SC-D-6715
	Terminal	Copper		SC-D-6715
	Spacer	Brass		SC-D-6715
	Cable clamp	do		SC-D-6715
	Cord	Two-conductor, battery connection		SC-D-6716.
	Circuit label	Aluminum		SC-D-6713

69. Time interval signal BE-65.—See figures 10 and 32 for identification of parts.

Stock No.	Name of part	Description	Specification or drawing number Signal Corps
4H-5005	BE-65	Time interval signal BE-65	SC-D-3827-A.
	Capacitor	6 µf, 400-v, FU-748, PC-753, C-D	SC-D-3827-A.
	Relay	Model 2C with coil No. 38, K. E	SC-D-3827-A.
	Terminal	Brass, No. 903, P-M	SC-D-3827-A
	a. Box assembly: Box	SAE 1020, ½", cold rolled steel, 9¾" x 6⅛" x 9½" high.	SC-D-3828-C. SC-D-3829-B. SC-D-3830-B. SC-D-3831-A.
	b. Horn assembly		SC-D-3832-B.
	Base	Brass casting, dull white nickel finish, 5⁷⁄₁₆" diameter x 1".	SC-D-3833-C.
	Diaphragm	Nickel silver, 4⁷⁄₁₆" diameter x No. 19 B&S gage	SC-D-3833-C.
	Cone assembly	2 rings and cone of aluminum alloy welded together to form a horn, 5½" diameter x 5⅞" long (approximately).	SC-D-3833-C.
	Cartridge	Brass, dull white nickel finish, ⅞" x ⅝" diameter.	SC-D-3833-C.
	Stud	Brass, dull white nickel finish, 1⅜" x ⁵⁄₁₆", 32 thread.	SC-D-3833-C.
	Arch	Brass, dull white nickel finish, 5¾" x 1½" x ⅜" x ⅛" thick.	SC-D-3833-C.
	Screw	Brass, dull white nickel finish, 1⅛" x ⅝", 27 thread.	SC-D-3833-C.
	Nut	Brass, dull white nickel finish, ⁵⁄₁₆" thick hex, by ⅝", 27 tap.	SC-D-3833-C.
	Washer	Brass, dull white nickel finish, 1⅛" outside diameter x ⁴¹⁄₆₄" inside diameter x ¹⁄₁₆".	SC-D-3833-C.
	Nut	Brass, dull white nickel finish, ¹³⁄₃₂" long x ⅜", 27 thread x No. 10, 32 tap.	SC-D-3834-C.
	Washer	Brass, dull white nickel finish, ⅝" outside diameter x .377 inside diameter x ³⁄₆₄".	SC-D-3834-C.
	Armature	Steel, ⅛" nickel plate, 1⅞" x ⅝" x ⁷⁄₃₂"	SC-D-3834-C.

Stock No.	Name of part	Description	Specification or drawing number, Signal Corps
	Post	Brass, dull white nickel finish, 2¼" x No. 10-32 thread.	SC-D-3834-C.
	Bumper	XX black phenolic rod, 7/16" x 3/32" diameter	SC-D-3834-C.
	Screw	Brass, dull white nickel finish, slotted, 5/8" x No. 6-40 thread.	SC-D-3834-C.
	Nut	Brass, dull white nickel finish, 3/16" thick x No. 6-40 tap.	SC-D-3834-C.
	Plate	Brass, dull white nickel finish, 31/32" x ¾" x 3/32".	SC-D-3834-C.
	....do	Brass, dull white nickel finish, ¾" x 7/16" x 1/16".	SC-D-3834-C.
	Spring	Beryllium copper, ⅞" x ¾" x 0.020"	SC-D-3834-C.
	Contact spring	Beryllium copper, 1¾" x 1⅛" x 0.030"	SC-D-3834-C.
	Stop	Beryllium copper, 1 1/16" x ¾" x ⅛" x 0.040"	SC-D-3834-C.
	Screw	Nickel silver, 33/64" x 5/32" x No. 6-32 thread	SC-D-3835-A.
	Block	"LE" natural phenolic plate, 1" x ½" x 13/32".	SC-D-3835-A.
	....do	"LE" natural phenolic plate, 1" x ½" x 5/16".	SC-D-3835-A.
	Insulator	XXX natural phenolic plate 25/32" x 15/32" x 0.050".	SC-D-3835-A
	Bushing	XXX natural phenolic tubing 13/64" long x ¼" outside diameter x 0.196" inside diameter.	SC-D-3835-A.
	....do	XXX natural phenolic tubing 9/32" long x ¼" outside diameter x 0.196" inside diameter.	SC-D-3835-A.
	Contact	Palladium, 3/32" diam. x 1/16" long	SC-D-3835-A.
	....do	Palladium, 3/32" diam. x 0.025" thick	SC-D-3835-A.
	Pin	Nickel silver No. 14 (0.064") B & S gage x 1 1/16" long.	SC-D-3832-B.
	c. Horn magnet assembly:		
	Lamination	Steel, 1⅞" x 1¼" x No. 29 U. S. standard gage	SC-D-3836-C.
	Angle	Brass, dull white nickel finish, ¼" x ¼" x 1⅞" long x 1/16" thick.	SC-D-3836-C.
	Clip	Nickel silver, ⅞" x 13/16" x 0.020"	SC-D-3836-C.
	Sleeve	Black "LE" phenolic tubing 1 1/16" square x 23/32" long x 1/32" thick.	SC-D-3836-C.
	Insulator	"LE" phenolic plate, 1 3/16" sq. x 1/64".	SC-D-3836-C.
	Head	"LE" phenolic plate, 1 3/16" sq. x 1/32".	SC-D-3836-C.
	d. Panel assembly:		
	Panel	Lamicoid No. 7025, 5¾" x 1½" x ¼" thick	SC-D-3837-A.
	Spacer	Brass, dull white nickel finish, 1½" x ½" outside diameter x 13/64" inside diameter.	SC-D-3837-A.
3Z252	Binding post	TM-152, composition, knurled cap and base	SC-D-530.
	....do	TM-195, brass, dull white nickel finish, knurled cap.	SC-D-1132.
3Z9936	Terminal	TM-36, eye clip, flat, brass	10701B1.
	....do	No. 4012	SC-D-3837-A.
	e. Battery tray assembly:		
	Plate	1/16" cold formed steel, 9⅝" x 6" x ½"	SC-D-3838-B.
	Battery support	Black molded phenolic compound, XM-3510 black bakelite, 5½" x 1¼" x ¾".	SC-D-3838-B.
	Insert	Brass, knurled, ¼" long x ¼" outside diameter x No. 6-32 tap.	SC-D-3838-B.
	....do	Brass, knurled, ⅜" long x ½" outside diameter x No. 10-32 tap.	SC-D-3838-B.
	Clamp	Brass, dull white nickel finish, 5 5/32" x ½" x ⅜" wide x 1/16".	SC-D-3838-B.
	Post	Brass, dull white nickel finish, 3" x No. 10-32 thread.	SC-D-3838-B.
3Z9929	Terminal	TM-29, spade clip, brass (tinned)	10701B1.
	Wire	No. 18 (.0403") AWG x 6" long; green wire code "ravine."	SC-D-3838-B.

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[A. G. 062.11 (3-17-42).]

BY ORDER OF THE SECRETARY OF WAR:

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WAR DEPARTMENT TECHNICAL MANUAL

PUBLIC ADDRESS EQUIPMENT PA-4-C

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WASHINGTON, 25, D. C., 31 January 1944

TM 11-435, Public Address Equipment PA-4-C is published for the information and guidance of all concerned.

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G. C. MARSHALL,
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Major General,
The Adjutant General

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(For explanation of symbols see FM 21-6.)

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DESTRUCTION NOTICE

WHY —To prevent the enemy from using or salvaging this equipment for his benefit.

WHEN—When ordered by your commander.

HOW —1. Smash—Use sledges, axes, handaxes, pickaxes, hammers, crowbars, heavy tools, etc.

2. Cut—Use axes, handaxes, machete, etc.
3. Burn—Use gasoline, kerosene, oil, flamethrowers, incendiary grenades, etc.
4. Explosives—Use fire arms, grenades, TNT, etc.
5. Disposal—Bury in slit trenches, foxholes, other holes. Throw in streams. Scatter.

USE ANYTHING IMMEDIATELY AVAILABLE FOR DESTRUCTION OF THIS EQUIPMENT.

WHAT—1. Smash—Tubes, amplifier, loudspeaker, microphone, batteries and case.

2. Cut—Cords and shoulder harness.
3. Bend and/or Break—Tripod.
4. Burn—Instruction books, shoulder harness and wire.
5. Bury or scatter—Any or all of the above pieces after breaking.

DESTROY EVERYTHING

SAFETY NOTICE

Plate potential of 135 volts is available in Public Address Equipment PA-4-C. Be careful, when installing "B" batteries, or adjusting or repairing this equipment, to avoid shocks which are always unpleasant and can be dangerous.

Section I
Description

1. GENERAL Public Address Equipment PA-4-C is a light-weight, portable public address system, to be used for the purpose of speech amplification in limited areas for mobile or stationary use. It has an undistorted output of two watts.

2. COMPONENTS

a. The components that make up Public Address Equipment PA-4-C are:

Item	*Quantity*	*Article*	*Dimensions in inches*	*Weight in lbs.*
*1	1	Amplifier BC-641-C	8⅞x8¼x3³⁄₁₆ Overall dimensions	7.0
*2	12	Battery BA-30; 4 installed; 8 spare		
*3	4	Battery BA-51 for Amplifier BC-641-C; 2 installed, 2 spare		
*4	2 Sets	Tubes, vacuum; complete, for Amplifier BC-641-C 1 Set (consisting of 1—1H4G and 1—1J6G) installed; 1 Set spare		
5	1	Case CS-91-C	19¾x10¾x8¾	11.0
6	2	Technical Manual for Public Address Equipment PA-4-C		
*7	1	Loudspeaker LS-6-C	14½ long; 10⅝ bell	6.0
*8	1	Microphone T-36-C		.5
*9	1	Shoulder Harness ST-39		.75
*10	1	Tripod M-230-C	15 long (extended 53½)	1.75

*NOTE: Items 1, 2, 3, 4, 7 and 9 assembled, form a portable public address equipment.
Items 1, 2, 3, 4, 7, 8 and 10 assembled, form a public address equipment for classroom or assembly room use, using Tripod M-230-C for Loudspeaker LS-6-C and Microphone T-36-C. Either one or both microphones may be operated at the same time.

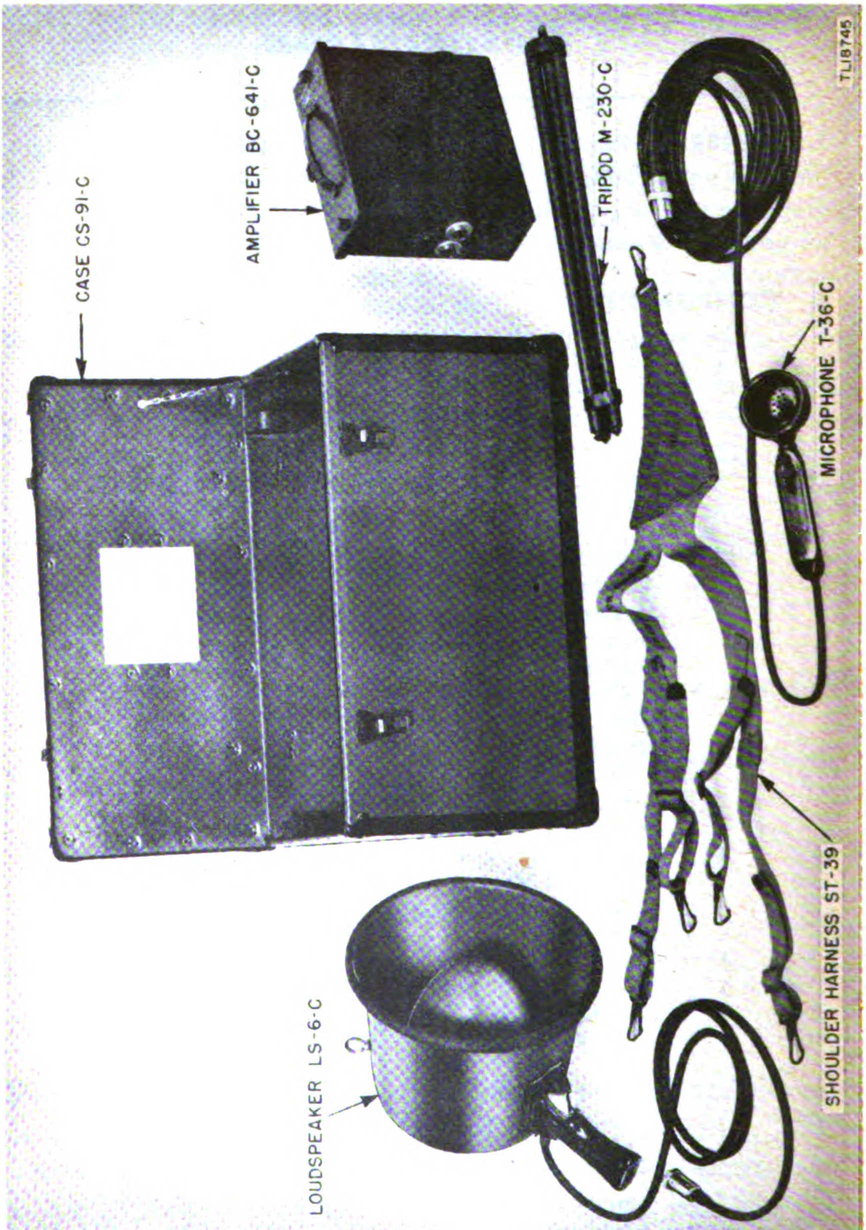


Figure 1. Public Address Equipment PA-4-C, components

b. Amplifier BC-641-C.

(1) Amplifier BC-641-C is a two tube amplifier employing a type 1H4G tube as a preamplifier for the microphone and also to drive the type 1J6G tube which is used as a push-pull, class B power-output stage. It uses a filament supply of 2 to 3 volts and a plate supply of 100 to 135 volts. Output impedance is approximately 3.5 ohms, and the input impedance is approximately 250 ohms for carbon microphone operation.

(2) The amplifier is set at fixed minimum gain, which is sufficiently low to prevent microphone feedback by means of a 2,500 ohm resistor (27) across terminals 8 and 5 of the first stage (see fig. 8). Adjust the volume control on the outside of the case to increase amplifier gain.

(3) No capacitors are used in this circuit. The microphone coupling resistor and the volume control are the only resistors used.

(4) The amplifier employs one tube type 1H4G and one tube type 1J6G.

(5) The volume control can be turned to full volume when using Microphone T-36-C with the amplifier and speaker as shown in (figs. 4 and 5.)

c. Loudspeaker LS-6-C.

Loudspeaker LS-6-C is a combination unit consisting of exponential reflex baffle, permanent magnet dynamic loudspeaker unit, carbon type microphone unit, pistol handle with trigger switch and necessary cable with connector attached. The dynamic loudspeaker unit is of the permanent-magnet moving coil type. The microphone is a waterproof, carbon granule type of special construction. Loudspeaker LS-6-C is operated by pressing the trigger switch (55) and speaking into the microphone (61). The switch (55) is non-locking and the system is inoperative when the switch trigger is released (fig. 3).
A six-foot 4-conductor cord with connector (58) is attached to the handle of Loudspeaker LS-6-C for connecting this unit to Amplifier BC-641-C.

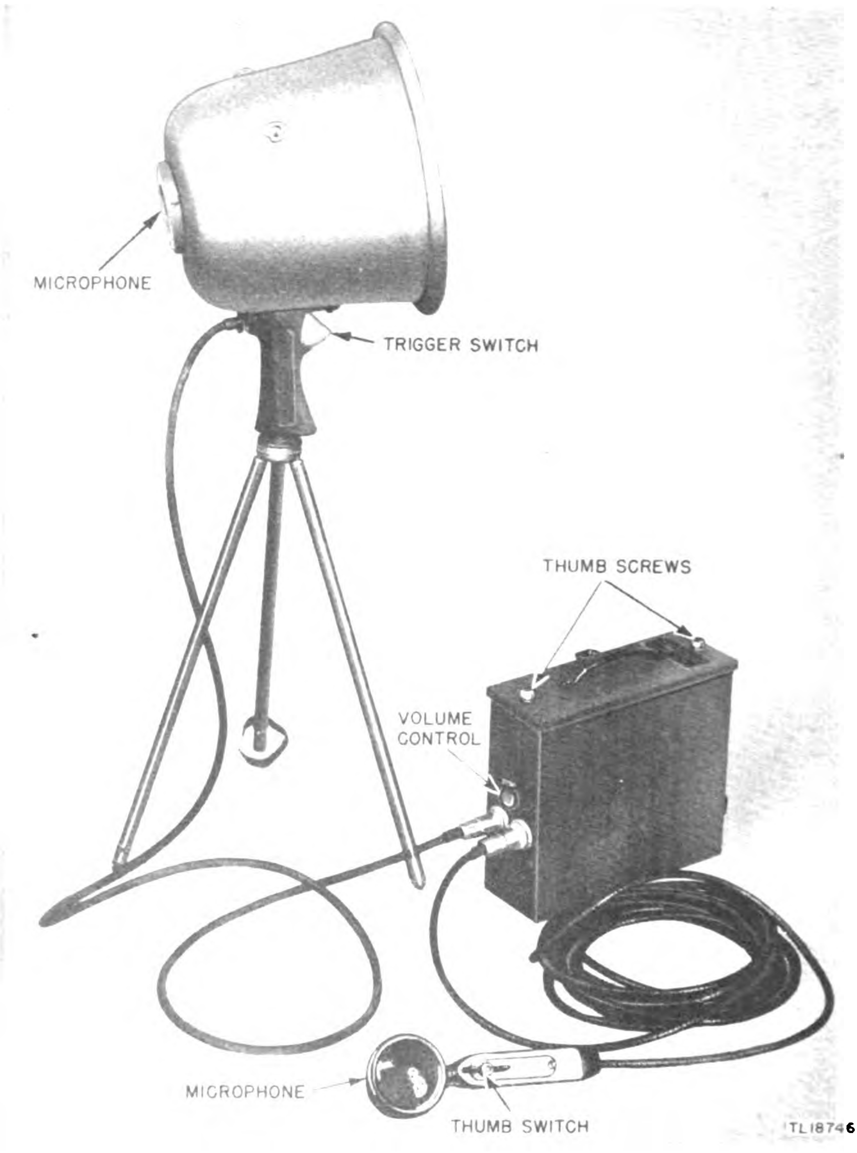


Figure 2. Public Address Equipment PA-4-C, assembled with Tripod M-230 and Microphone T-36-C

d. Microphone T-36-C.
Microphone T-36-C consists of a carbon type microphone unit (same as used in Loudspeaker LS-6-C) assembled in a hand housing fitted with a thumb operated switch (86) (figs. 2 and 4). The operation of Microphone T-36-C is accomplished by moving the switch arm to either the left or the right with the thumb. The system is non-operative when this switch is released. A 24-foot 3-conductor cord with connector (89) is attached to the handle of Microphone T-36-C for connecting this unit to Amplifier BC-641-C.

e. Shoulder Harness ST-39.
Shoulder Harness ST-39 is made of web and duck and can be adjusted to fit the wearer.
The harness is used as shown in Figures 3 and 5 with Amplifier BC-641-C slung on the back of the user and Loudspeaker LS-6-C slung for easy carrying.

f. Tripod M-230-C.
Tripod M-230-C is of the telescope type and can be used at a height of fifteen and 7/8 inches or extended to fifty-three inches.
This tripod is used as a mounting for Loudspeaker LS-6-C by screwing the tripod into the drilled and tapped hole at the bottom of the handle on Loudspeaker LS-6-C (figs. 2 and 4).

Section II
Installation and Operation

3. PREPARATION FOR USE

a. Amplifier BC-641-C is shipped with tubes but less "B" batteries and "A" batteries. The "A" battery component consists of four Batteries BA-30 (flashlight cells). The "B" battery component consists of two Batteries BA-51. Tubes are installed in Amplifier BC-641-C when issued; "A" and "B" batteries are issued separately.

b. To install Batteries:
(1) Remove the cover from Amplifier BC-641-C by unscrewing the two knurled thumb screws, (it is not necessary to remove the knurled thumb screws entirely). (See fig. 2.)
(2) Insert four Batteries BA-30 in the "A" battery compartment as shown in figure 6.

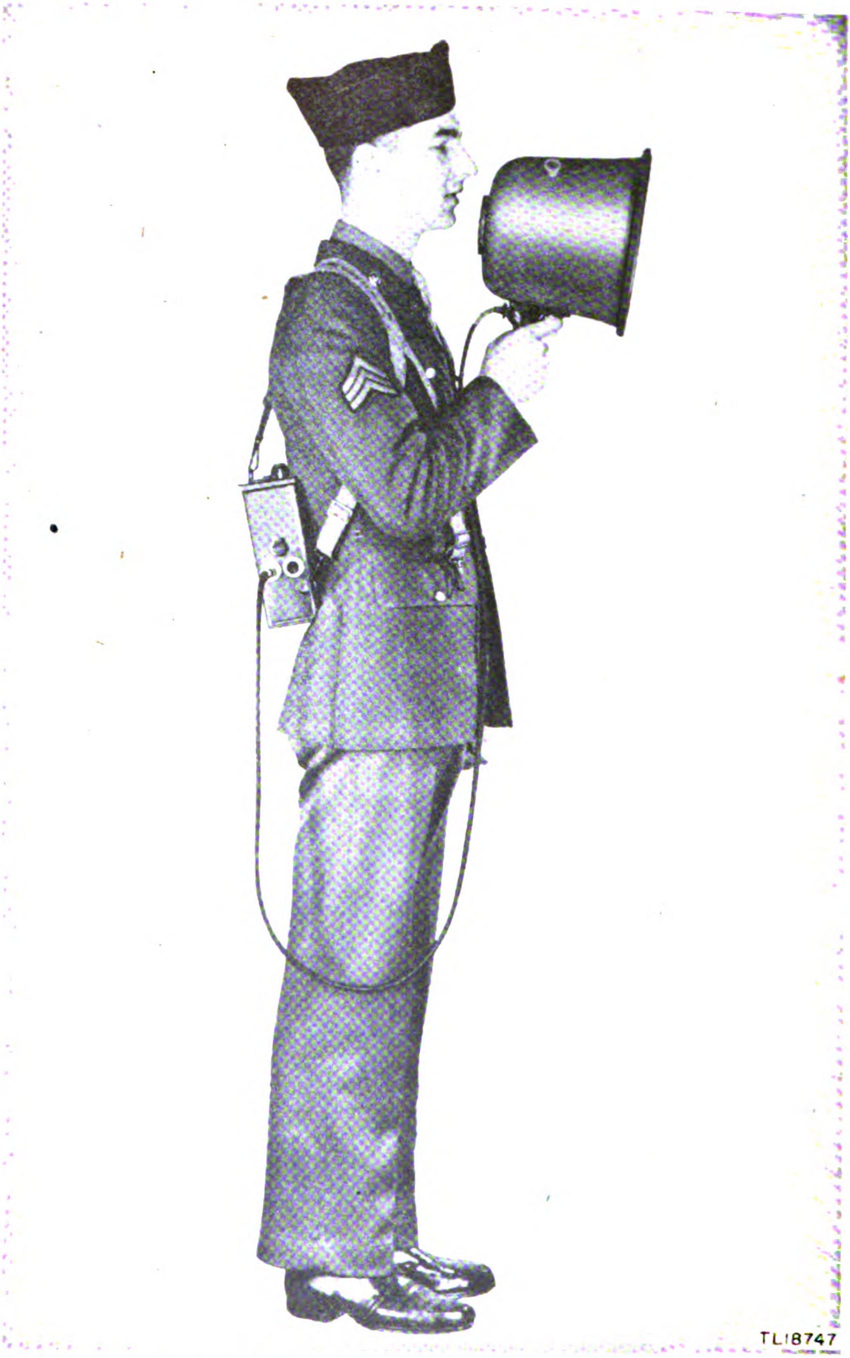


Figure 3. Public Address Equipment PA-4-C, in use as portable equipment

(3) Install two Batteries BA-51 using the connectors (see fig. 6). These connectors are of the polarized type and installation cannot be made incorrectly.

(4) Place the two Batteries BA-51 with connectors attached, on top of the "A" battery compartment.

(5) Place the cover over the amplifier case using the knurled thumb screws to fasten it securely.

(6) Attach connector on the end of the cable of Loudspeaker LS-6-C to the socket on the case of Amplifier BC-641-C (fig. 2) fastening the plug securely with the locking nut on connector.

(7) Shoulder Harness ST-39 is worn as in figures 3 and 5, and is used to carry Amplifier BC-641-C and Loudspeaker LS-6-C.

4. OPERATION

a. Operation is instantaneous. Press the trigger switch (55) (see fig. 2) on the handle of Loudspeaker LS-6-C, and speak into the microphone (61) mounted on the back of Loudspeaker LS-6-C. Best results will be obtained by speaking close to the microphone.

b. To operate Microphone T-36-C attach the connector (see fig. 2) of Microphone T-36-C to the socket on the case of Amplifier BC-641-C. Operation of Microphone T-36-C is instantaneous upon throwing the thumb switch. Both microphones can be used at the same time, or either of them can be used alone.

c. For stationary use, Tripod M-230-C can be attached to Loudspeaker LS-6-C by screwing the tripod into the threaded hole at the bottom of the handle of Loudspeaker LS-6-C. Extend the telescopic leg sections to elevate the loudspeaker. It is generally better to use Microphone T-36-C when the loudspeaker is on tripod.

Section III
Functioning of Parts

5. GENERAL

a. Sound waves created by the voice of the operator strike the diaphragm of Microphone T-36-C (87) or the microphone (61) located on Loudspeaker LS-6-C (fig. 8). The vibration of the diaphragm actuates the carbon granules in the button causing its resistance to fluctuate. A fixed voltage of approximately 3 volts d-c is impressed upon this carbon button through the primary of the input transformer (24). The vibrations from the voice thus create

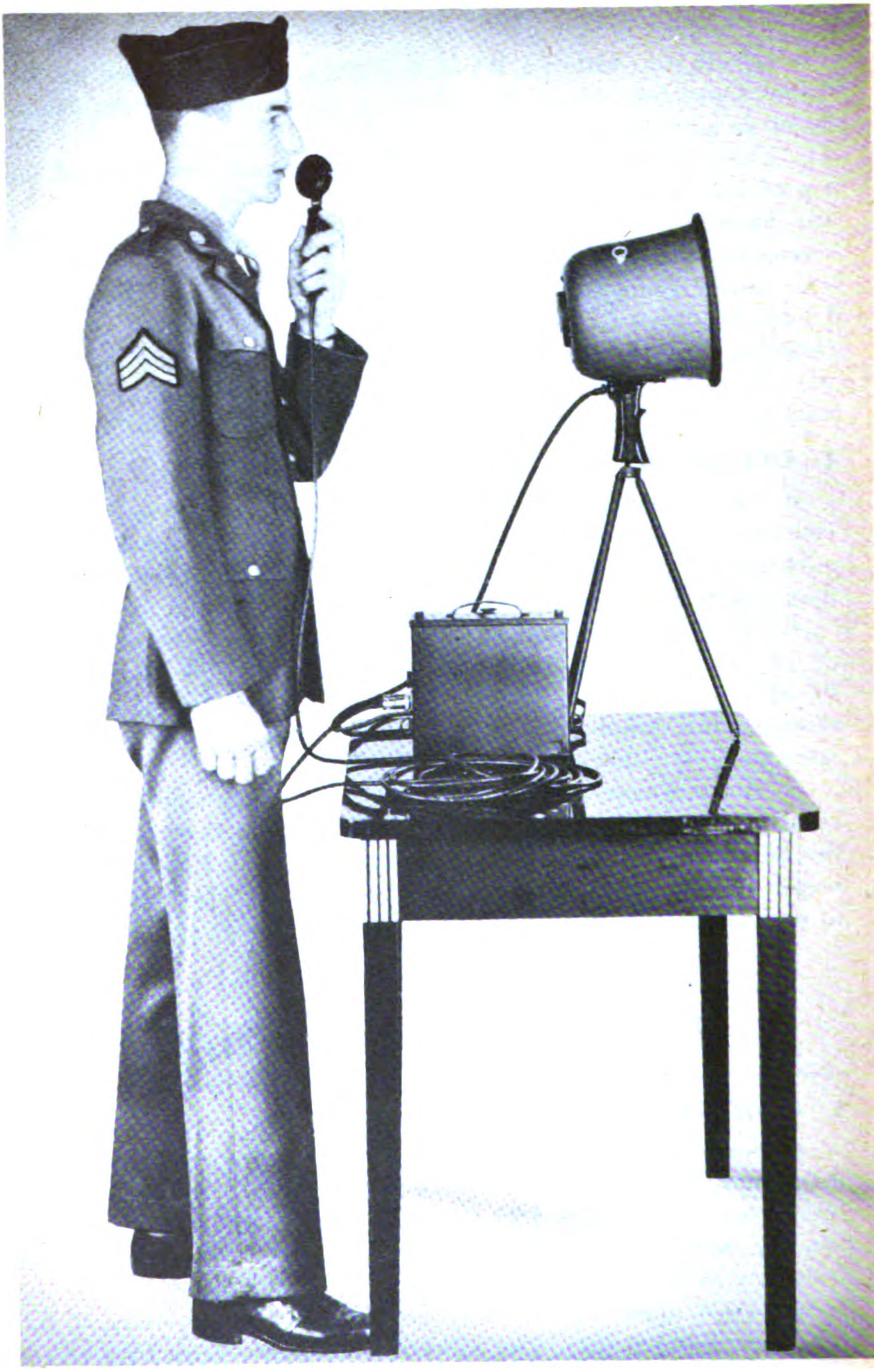


Figure 4. Public Address Equipment PA-4-C, showing Microphone T-36-C in use (auditorium)

a fluctuating direct current in the primary of the input transformer (24). The primary has an impedance of 100 ohms and is correctly designed to match the input impedance.

b. The fluctuating current induces a stepped up a-c voltage in the secondary of the input transformer. The secondary impedance of this transformer is 58,500 ohms and is designed to match the grid impedance of the 1H4G tube. The signal voltage generated is then impressed on the grid (5) of the 1H4G tube.

c. The amount of signal voltage impressed on the grid of this tube is governed by the 2,500 ohms fixed resistor (27) and the 25,000-ohm volume control resistor (36). Rotating this control in a clockwise direction (to the right) increases the power. Rotating the control in a counter-clockwise direction (to the left) decreases the output.

d. The signal voltage impressed on the grid (5) of the 1H4G tube is amplified through the tube and this amplified signal voltage is impressed on the primary of the driver transformer (25). The primary impedance of this transformer is 2,000 ohms and matches the plate impedance of the 1H4G tube.

e. This voltage is transferred by induction to the push-pull secondary of the driver transformer (25). The secondary impedance is 1,750 ohms each side of center tap to correctly match the grid impedance of the 1J6G tube. This voltage is impressed on the two grids (4-5) of the 1J6G (double triode type) tube. The voltage is again amplified in this tube (3-6) and transferred to the push-pull primary of the output transformer (26). The impedance of this primary is 10,000 ohms, plate to plate, to match the plate impedance of the two sections of the tube.

f. This primary voltage is induced into the secondary of the transformer and then impressed (through connectors 32 and 58) across the voice coil of the permanent magnet speaker mounted in Loudspeaker LS-6-C. The output impedance of output transformer (26) is 3½ ohms to correctly match the impedance of the voice coil.

g. The two Batteries BA-51 (67½ volts) connected in series (135 volts) provide the plate voltage for the propér operation of the amplifier. The four Batteries BA-30 (1½ volt flashlight cell) connected in series—parallel (3 volts) provide the proper filament

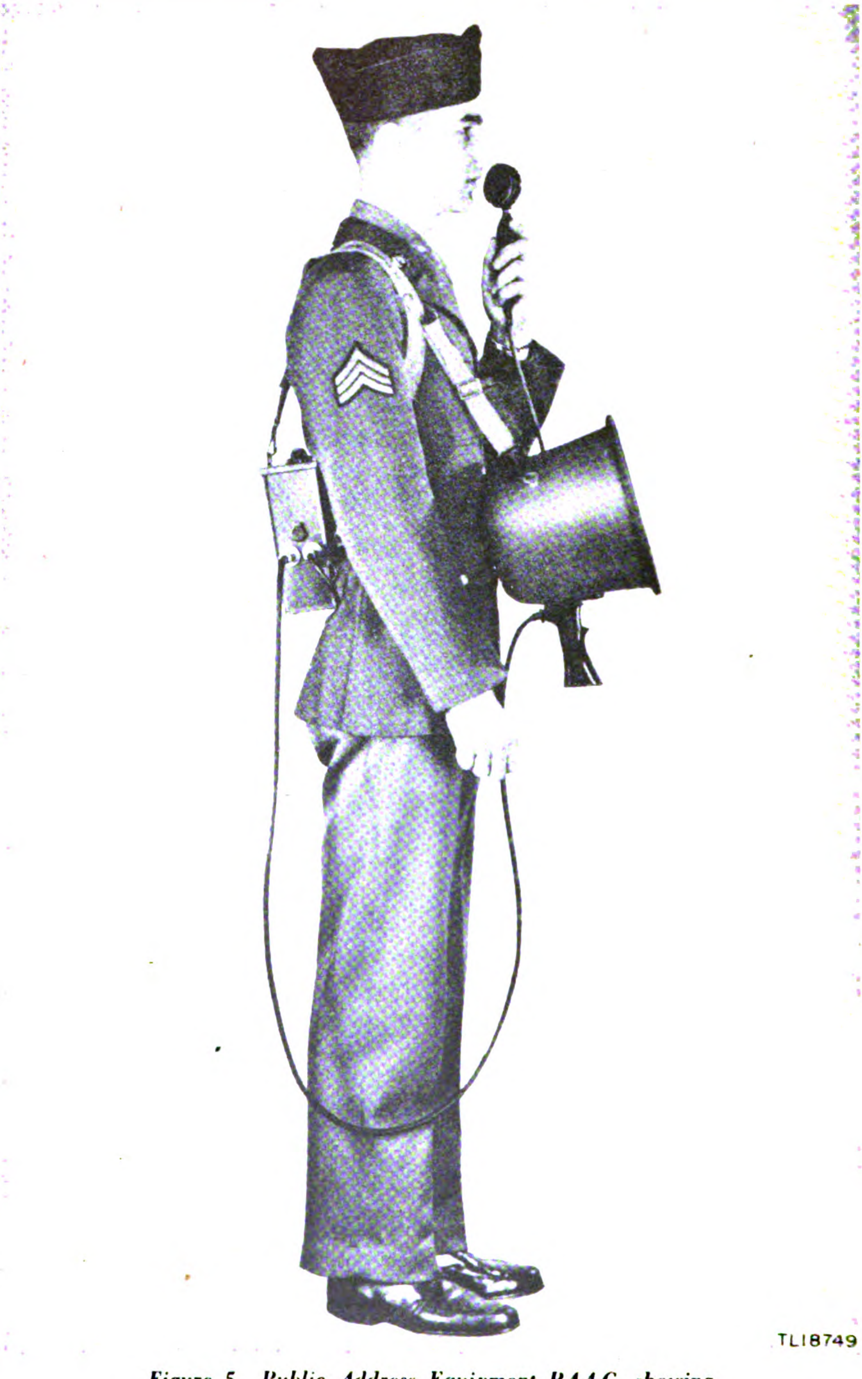


Figure 5. Public Address Equipment PA-4-C, showing Microphone T-36-C in use (field)

voltage for the 1H4G tube and the 1J6G tube and the current to actuate the carbon microphones. The negative side of both battery supplies is wired through connectors (32 and 58) to trigger switch (55) located on handle of Loudspeaker LS-6-C and through connectors (31 and 89) to thumb switch (86) mounted on Microphone T-36-C. Depressing either or both of these two switches completes the negative circuit thereby placing the amplifier in operation.

Section IV
Maintenance

6. GENERAL

a. Test the equipment after each use, by checking both microphones with the loudspeaker connected to Amplifier BC-641-C.

b. Disassemble the equipment and replace it in Case CS-91-C.

c. Batteries should be removed when the equipment will not be used for five days or more.

7. TO REMOVE THE AMPLIFIER CHASSIS

a. Remove the cover.

b. Unfasten "B" battery terminals and remove batteries.

c. Unscrew the four corner screws of the internal dividing plate. The complete chassis with "A" battery compartment can then be removed as a complete unit (fig. 6).

8. TESTS

If equipment does not operate satisfactorily, make the following tests and replace defective parts.

a. Test the "A" Batteries with Microphone T-36-C and Loudspeaker LS-6-C connected and the switch (55) closed. The terminal voltage reading should be 1.8 volts minimum (3 volts normal).

b. Test the "B" Batteries with the microphone and loudspeaker connected, with switches closed. The terminal voltage reading should be 100 volts minimum (135 volts normal).

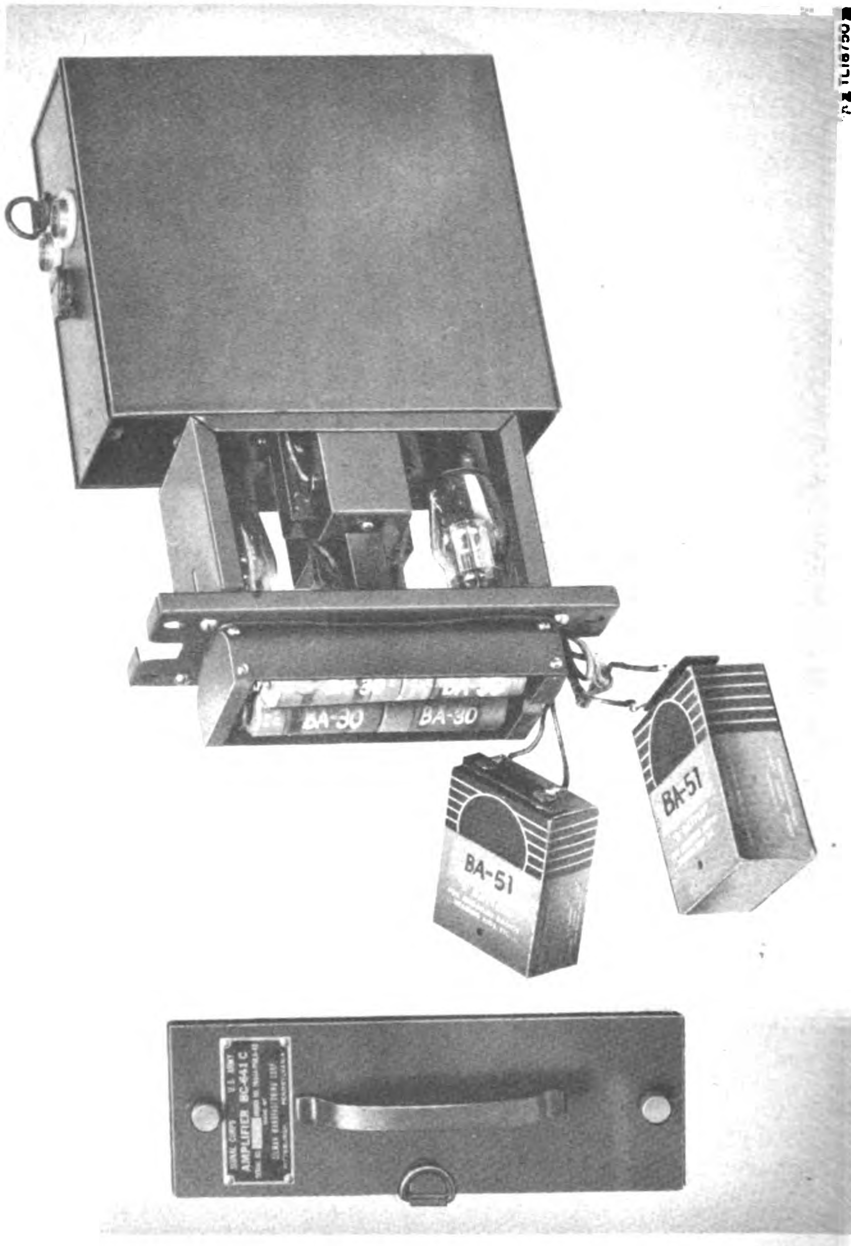


Figure 6. Amplifier BC-641-C, showing chassis and method of connecting Batteries

c. Check the tubes in accordance with the instructions accompanying Test Set I-56-( ) to determine the tube efficiency. Replace poor tubes.

d. To test Amplifier BC-641-C, put a resistance of 30 ohms across the input and a 1-watt 4-ohm resistor across the output. Apply 1,000 c.p.s. at 0.18 volts across the input and measure the output across the 4-ohm load. The output should be at least 1.0 volts with the volume control turned all the way to the right (clockwise).

e. Test the voice coil of Loudspeaker LS-6-C for an open circuit.

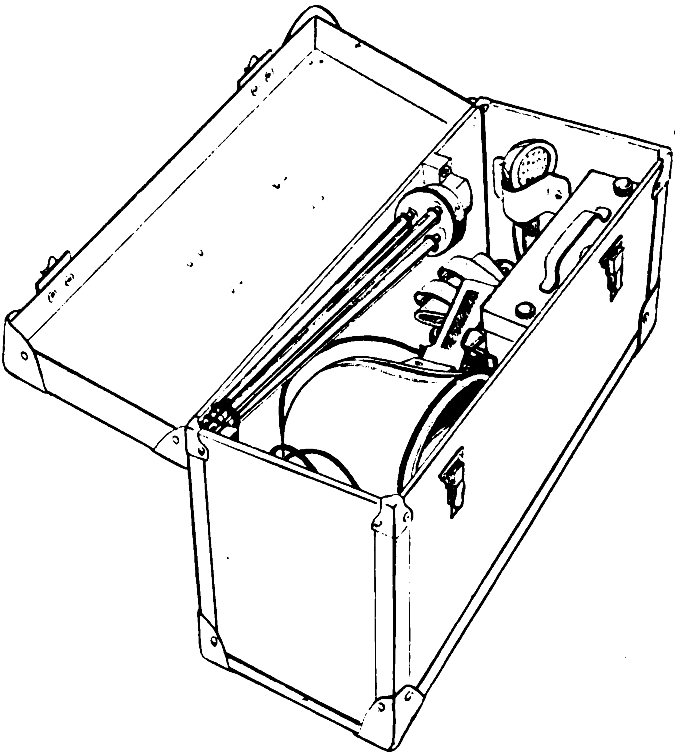
f. Test the switch (55) and connections of Loudspeaker LS-6-C.

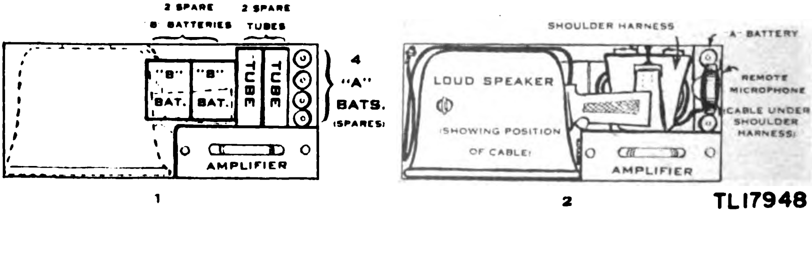
g. Test the terminals of the connector (58).

h. Test the terminal of the microphone (61) and check the resistance of the buttons (250 ohms normal).

i. Test Microphone T-36-C (see *f*, *g* and *h* above).

j. Test all cables for open, or short circuits.





1 2 TL17948

Figure 7. Public Address Equipment PA-4-C in Case CS-91-C

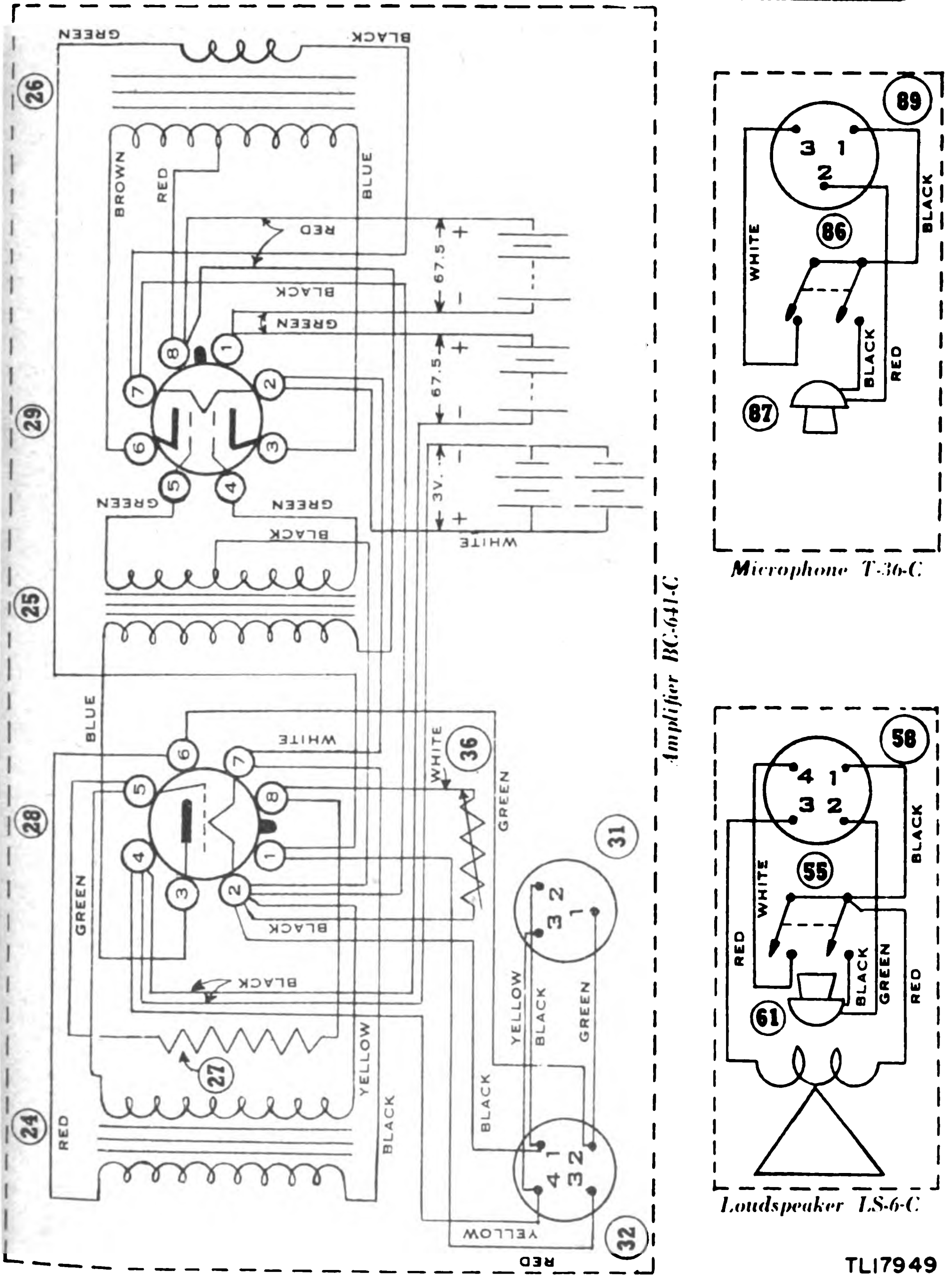


Figure 8. Public Address Equipment PA-4-C, schematic diagram

Section V. Supplementary Data

9. TABLE OF REPLACEABLE PARTS.

NOTE: Order parts by Signal Corps Stock No., name and description.

a. Amplifier BC-641-C. Stock No. 2C241C.

Ref. Symbol	*Total Quantity In Equip.*	*Signal C. Stock No.*	*Name of Part and Description*	*Function*	*Mfr's Code*	*Contr's Dwg. or Part No.*
10	1		Case for amplifier BC-641-C	Housing for amplifier	A	A1509
11	1		Cover for amplifier case	Lid for 10	A	A1509
12	#2	2C241C/S1	Screw, knurled top	Secure lid to case (10)	A	1508
13	1		Dividing Plate	Separate amp. and batts.	A	A1508
14	1		Chassis U frame	Amplifier chassis	A	A1508
15	1		Pad, rubber	Insulates batteries	A	
16	#1	2C241C/C2	Compartment	Holds "A" batteries	A	*ES-D-9223-A
17	2		Side plate, laminated	(+) Section of 16	A	*ES-D-9223-A
18	1		Side plate, laminated	(—) Section of 16	A	*ES-D-9223-A
19	2		Spring, contact, coiled	(—) Contact of 16	A	*ES-D-9223-A
20	1		Retainer plate, nickel-silver	To hold 19	A	*ES-D-9223-A
21	2		Stud, contact, nickel-silver	(+) Contact for 17	A	*ES-D-9223-A
22	1		Plate, bottom of compartment	Bottom of 16	A	*ES-D-9223-A
23	#2	2C241C/C5	Connector, 2 contact, flat fiber	"B" battery connector	A	
24	#1	2Z9969	Transformer, 250 ohms to grid, input	Input stage of amp.	A	A7903
25	#1	2Z9969-1	Transformer, driver, 2000 to 3500 ohms	Driver stage of amp.	A	A6236
26	#1	2Z9969-2	Transformer, output, 10000 to 3½ ohms CT	Output stage of amp.	A	A6235
27	#1	3Z6250-30	Resistor, fixed, 2500 ohms, ½ watt composition	Microphone coupling	C	*SC-D-970
28	1		Tube, Type 1H4G	Input tube	G	
29	1		Tube, Type 1J6G	Output tube	G	
30	#2	2Z8795-12	Socket, 8 prong, type MIP-8	For 28 and 29	B	
31	#1	2Z8799-33	Connector, 3 contact female	Connector for T-36-C	A	
32	#1	2Z8799-220	Connector, 4 contact female	Connector for LS-6-C	A	
33	1		Clamp, steel	Fasten to 10	A	
34	1		Clamp, steel	Fasten to 14	A	
35	#1	2C241C/G1	Grommet, ½" hole	Insulator for 14	A	
36	#1	2Z7262-25M2	Resistor, variable, 25000 ohms Composition, LM type	Microphone control	C	

9. TABLE OF REPLACEABLE PARTS—Continued

Ref. Symbol	Total Quantity In Equip.	Signal C. Stock No.	Name of Part and Description	Function	Mfr's Code	Contr's Dwg. or Part No.
37	1		Cover, steel	To cover 36	A	
38	1		Base, steel	Bottom of 37	A	
39	1		Pin, steel	To connect 37 and 38	A	
40	1		Spring, steel coiled	For 39	A	
41	#1	6Z4049	Gasket, rubber, ⅝" diam.	Insulator for 37	A	
42	2		Gasket, rubber, 1⅛" diam.	Insulator for 31 and 32	A	
43	2		Gasket, thiokol, ½" diam.	Insulator for 12 lid screws	A	

b. Loudspeaker LS-6-C. Stock No. 6C46C.

50	1		Horn, steel	Projector	A	1506
51	1		Baffle, steel	Mounting for 53	A	1504
52	1		Cone, steel	Housing for 53	A	1504
53	1		Speaker assembly unit	Loudspeaker unit	A	
54	1		Handle, bakelite	Attached to 50	A	A1505
55	#1	6C46C/S4	Switch, trigger type, D.P.S.T.	To operate LS-6-C	D	80605
56	1		Strap, steel	Attached to 54 and 55	A	
57	#6 ft.	3E2146	Cordage, 4 conductor, type CO-146	Attached to 54	E	CO-146
58	#1	2Z3096.1	Connector, 4 contact male	Attached to 57	A	
59	1		Clamp, steel	Attached to 54	A	
60	1		Plate, steel	Reenforce 54 mounting	A	
61	#1	6C46C/M1	Transmitter, carbon, single button	Voice operation	F	9811-AS
62	1		Screen, bakelite	Cover for 61	F	9188-AS
63	1		Housing, steel	Housing for 61	A	
64	1		Cover, steel	Cover for 63	A	
65	#1	6C46C/P1	Pad, sponge rubber, 1⅝" diam.	Insulator for 61	A	
66	#1	6C46C/R1	Cushion, sponge rubber, 3⅛" diam.	Insulator for 61	A	
67	#1	6C46C/R2	Ring, sponge rubber, 3⅛" diam.	Insulator for 61	A	
68	#7	6C46C/G1	Grommet, ⅝" hole	Attached to 63	A	
69	1		Lug, terminal	Contact to 61	A	
70	1		Protector, rubber	Attached to 50	A	

9. TABLE OF REPLACEABLE PARTS—Continued

c. Microphone T-36-C. Stock No. 2B1636C.

Ref. Symbol	Total Quantity In Equip.	Signal C. Stock No.	Name of Part and Description	Function	Mfr's Code	Contr's Dwg. or Part No.
80	1		Handle, bakelite	Handle for T-36-C	F	1516
81	1		Housing, bakelite	Housing for 87	F	1516
82	1		Ring, brass	Lock ring for 87	F	1517
83	1		Lock nut, brass	To lock 80	F	
84	1		Spring, contact, copper	(+) Contact to 87	F	1519
85	1		Spring, contact, copper	(—) Contact to 87	F	1519
86	#1	2B1636A/S2	Switch, thumb type, D.P.S.T.	Operate T-36-C	F	SC-D-1055-M
87	#1	2B1109E/3	Transmitter, carbon type, contact terminals	Voice operation	F	9818A
88	#24 ft.	3E2145	Cordage, 3 conductor type CO-145	Attached to 80	E	CO-145
89	#1	2Z3096	Connector, 3 contact male	Attached to 88	A	
90	1		Screen, bakelite	Cover for 87	F	9188-AS
d. Shoulder Harness ST-39.		Stock No. 2Z8539.				SC-D-5685-B
95	4		Buckle, brass	To adjust 39	H	*SC-D-5685-B
96	5		Snap, bronze	Attached to 39	H	*SC-D-5685-B
97	4		End clip, brass	Attached to 39	H	*SC-D-5685-B
e. Tripod M-230-C.		Stock No. 6C330B.				
98	1		Strap assembly, leather with fasteners attached	Attached to leg of M-230-C	A	1514
f. Case CS-91-C.		Stock No. 6C11C.				SC-D-7945-A

Furnished by the contractor as part of maintenance parts groups.

* Indicates Signal Corps drawing.

10. MANUFACTURERS NAMES AND ADDRESSES.

A. Silman Manufacturing Corporation, Pittsburgh, Pa.
B. American Phenolic Corporation, Chicago, Ill.
C. Stackpole Carbon Company, St. Marys, Pa.
D. Arrow-Hart & Hageman Co., Hartford, Conn.
E. Diamond Wire & Cable Co., Chicago, Ill.
F. Connecticut Tel. & Elec. Co., Meriden, Conn.
G. RCA Manufacturing Co., Camden, N. J.
H. North and Judd Manufacturing Company, New Britain, Conn.

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