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CHAPTER 21

Lighted Aids to Navigation—Electric Apparatus

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21-1 GENERAL**21-1-1 Definition—**

A. Electric lighted aids to navigation apparatus consists of the component parts of electrically operated lighted buoys, minor lights including range lights, and major lights; which may comprise a lantern, lens, power supply, lamp, wiring, lamp-changer or stand-by lamp, flasher, time clock, light sensitive control, alarm circuit, and stand-by power supply. The component parts of minor electric lens lanterns are generally interchangeable between minor lights and lighted buoys. See sections 21-2-1 for description of a minor light, 21-3-1 for a lighted buoy, and 21-15-1 for a major light.

21-1-5 Standardization of Lighting Equipment—

A. In view of the great diversity of apparatus in use, the Service in the past was not restricted to particular designs or makes. As a result there are in use at the present time a large variety of makes and types of apparatus from numerous manufacturers. However, the present trend is toward standardization, using as few types as possible, based where practicable on Service plans and specifications.

B. A full description of the physical characteristics of the particular type that is wanted should be included in all work authorization requests involving the establishment or change of lighting apparatus.

21-2 MINOR LIGHTS**21-2-1 Description—**

A. An electrically-operated minor light is exhibited from a fixed structure which may be located on shore or on a marine site in harbors, rivers, inland waterways, or other location where an aid of relatively low candlepower is required. Although many range lights show relatively high candlepower, the majority are still considered minor lights. The illuminating apparatus is usually powered from low discharge type storage batteries, primary cells, or air cells, where commercial power is unobtainable, and the lanterns are generally equipped with lamp-changers and motor-driven flashers. Minor lights are placed on various types of structures, such as pile dolphins, skeleton towers, slatted piles, or occasionally in the tower of a formerly attended lighthouse. They are unwatched and are automatic in operation.

21-3 LIGHTED BUOYS**21-3-1 Description—**

A. The illuminating apparatus of electric lighted buoys is powered from low discharge nonspill-type storage batteries stowed in pockets in the main body of the buoy, and the lantern is equipped with a flasher mechanism and lampchanger unit. When electric buoys are received from the manufacturer,

they are fully wired, ready for installation of the batteries and lanterns. The component equipment is essentially the same as that for minor lights and is largely interchangeable, i. e. flasher, lamp-changer, lantern, lens, color shade, etc. Lighted buoys may be converted from acetylene to electric. A structural description of all standard and the more prevalent existing nonstandard types of lighted buoys may be found in Chapter 24, "Buoys, Mooring Appendages and Minor Structures."

21-4 STORAGE BATTERIES**21-4-1 Types in Use—**

A. *Batteries for light stations.*—Although there are a few nickel-iron-alkaline batteries still in use at light stations, the majority use a conventional type lead-acid stationary battery.

B. *Batteries for minor lights and buoys.*—Several types of batteries are in general use at present for powering minor lights and lighted buoys such as:

- (1) Conventional lead-acid storage battery.
- (2) Low discharge lead-acid storage battery.
- (3) Wet primary cells.
- (4) Air depolarized wet cells.
- (5) Nickel-iron storage battery.

C. *Battery type to use depends on service period.*—Two general service conditions are encountered—that in which attendance occurs at frequent intervals (more often than once a month), and that in which service is attempted only at long intervals (3 months or longer, for instance). Intermediate conditions may exist and the selection of the particular type of battery must be considered in the light of local conditions, which include: amount of current drain, accessibility, cost, and importance of the aid. Other factors in addition to service period are involved when selecting the proper battery, and include: existing practice in the area, seasonal temperature range, and charging facilities. Selection of the proper battery for a minor light or lighted buoy should be made only after all of the factors have been given careful consideration.

D When submitting work authorization requests involving battery-operated lights, include complete data on factors enumerated above and suggest type of battery desired.

21-4-5 Lead Acid, Conventional Type—

A. The conventional type of lead acid storage battery is used at 115-volt high candlepower attended and unattended lights, fog signals, and radiobeacons and is also used for engine starting batteries at light stations. These batteries are either floated on direct current generators or recharged periodically or continuously from commercial electric service through rectifiers. The most frequently used size is 200 ampere-hours. These batteries usually have a one to two thousand cycle life. All batteries of this type are furnished in hard rubber (monobloc) or hard rubber and wood trays, in groups ranging from one to four or more cells, or in glass jars. Conventional-type lead acid batteries are generally unsuitable for use in minor lights as they will not

supply current for a sufficient length of time. This is due to inherent internal losses which cause the batteries to lose much of their charge within a comparatively short period, even when standing idle. In addition, they are unsuitable for use in buoys due to spillage of electrolyte which would be caused by the motion of the buoy in a seaway.

B. Stationary power batteries are also used to stabilize the voltage from, and equalize the load on, direct current engine generators, and to assure emergency power at shore establishments, particularly at radiobeacon stations. They may be either of the pasted plate, or the Planté or formed plate type. The latter type is preferable due to its long life and comparative ruggedness, although the recent addition of glass-wool retaining mats between the plates and separators in several pasted plate types of batteries may extend their useful life. Glass jars are preferred for stationary service, principally to facilitate observation and good maintenance of the batteries. Starting batteries which are assembled with many thin plates do not have a particularly long life and should not be used except indirectly for lighting, radio receivers, etc. Their principal purpose is to supply a high current for short periods.

21-4-10 Lead Acid, Low Discharge, Portable Type—

A. The low discharge battery is a portable type applied principally to aids to navigation in which the discharge period may be extended from a few weeks to a year or more. It is generally furnished in 500 ampere-hour, single cell groups. *It should never be applied to power or starting duty.* It is used as the source of power for minor lights, lighted buoys, fog signals, and low powered radiobeacons. The expression "low discharge" is applied to the Willard type DH and DHB cells because there is practically no loss of battery capacity due to self-discharge over long periods of time. Thus practically all of the battery's energy is available for useful work. The capacity of both the DH 5-1 and the DHB-5-1 cell is 500 ampere-hours if discharged at a rate of 1 ampere (to a cut-off voltage of 1.95).

B. Two types.—The low discharge battery is furnished in two types—one for use on shore structures and the other being a nonspillable type for use on buoys. This latter type has greater over all height to accommodate the electrolyte when the cell is in an inclined position. The nonspillable type should always be used in protective metal containers.

C. Difference between conventional and low discharge batteries.—Low discharge cells, such as the Willard type DH-5-1 and DHB-5-1 differ from conventional cells principally in the purity of their lead grid structure and active material. In order that a conventional storage battery may deliver large numbers of cycles, the plates must be alloyed with antimony or other elements to inhibit the gradual change (forming) of the grid (supporting structure) into active material. The presence of these alloys increases local action at normal temperatures. As stated, the low discharge cell is constructed from pure lead, thus reducing local action to a low value.

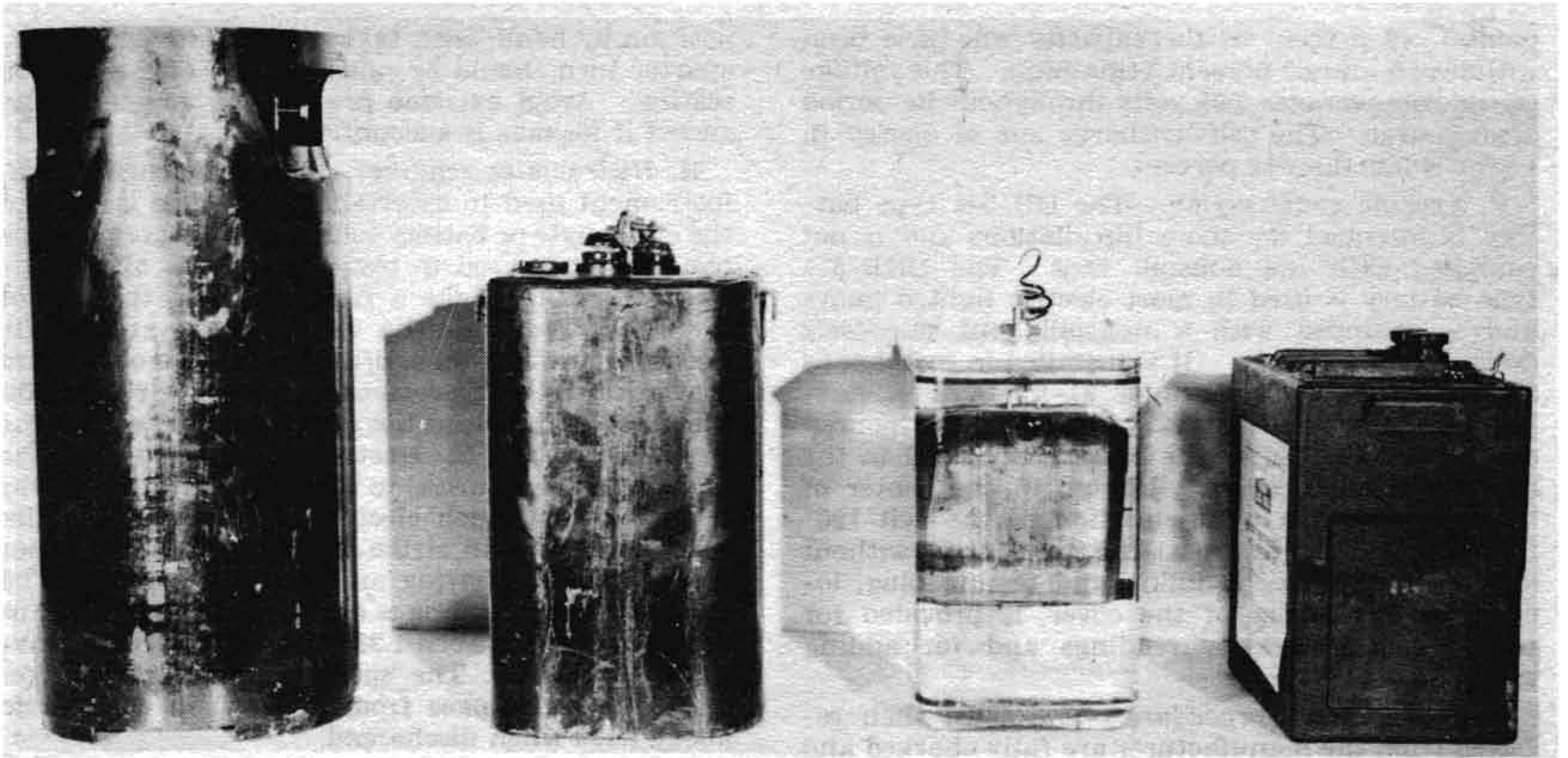
For that reason, this type of cell is suitable for service in which there may be a long interval between charging periods. In order that the rating may be attained, the rate of discharge must be low. The weight of active material in a low discharge 500 ampere-hour cell approximates that in a conventional 200 ampere-hour cell at the 8 or 10 hour rating. The foregoing explanation has been made to bring out points which are involved in proper maintenance. All storage cells have excess active material and, if discharged at low rates, will deliver considerably more than their rated capacity at the 6, 8, or 10 hour rate. The capacity is limited at low rates principally by the available acid in the electrolyte. In conventional types, when discharged over a long period, local action also exhausts an increasing proportion of the total available capacity as the discharge period is extended. When a battery is discharged over a long period the sulphation extends very deep into the active material. A battery should not be permitted to remain discharged.

D. Charging low discharge cells.—For the foregoing reasons, a fully discharged low discharge battery must be charged at its normal rate for a period of 75 hours. This process should preferably be continuous to drive out the soft sulphates which lie deep in the active material, and the charging rate must not be increased. Since the low discharge cell is constructed of pure materials, some of the grid structure is converted during the charge to active material, thus causing growth in height of the positive plates. The normal charging rate is 10 amperes and it will take about 75 hours to recharge. Lower charging rates may be used but the charge must be carried through to completion. Excessive overcharging must be avoided and only straight charge-discharge basis shall be used. *"Trickle" charging or floated service shall not be used.* The low discharge characteristic of these cells is due to the extreme purity of the electrolyte and component interior parts, and scrupulous care must be exercised to maintain this purity. More complete charging instructions and data on maintenance of storage batteries will be found in section 21-4-40.

(1) *Number of cycles.*—Low discharge batteries will give relatively few cycles, being guaranteed for 10 cycles providing the cycles do not exceed 12 months. More than 10 cycles can be obtained if the cycles are less than 12 months in duration, correspondingly, less than 10 cycles may be expected if the cycles exceed the 12-month period.

(2) *Water.*—Low discharge cells must be filled with water that is known to be free from impurities. *Pure distilled water should be used.*

E. General construction.—The battery consists of two $\frac{15}{16}$ inch positive lead plates and three negative plates and separators in sulfuric acid electrolyte, assembled in a hard rubber container with a cover supporting the vented filling plugs and terminal lugs. The specific gravity of the cell is 1.300 at 80° F. fully charged, and 1.130 discharged. When the specific gravity is some intermediate figure, it is a measure of the ampere-hours capacity remaining in the battery. For example: if the specific gravity reads 1.232 (a drop of 68 out of a total of 170



WILLARD
DHB-5-1

WILLARD
DH-5-1

EDISON
S-500

EVEREADY
AIR CELL

FIGURE 21-1.—Batteries used in minor light and buoy service.

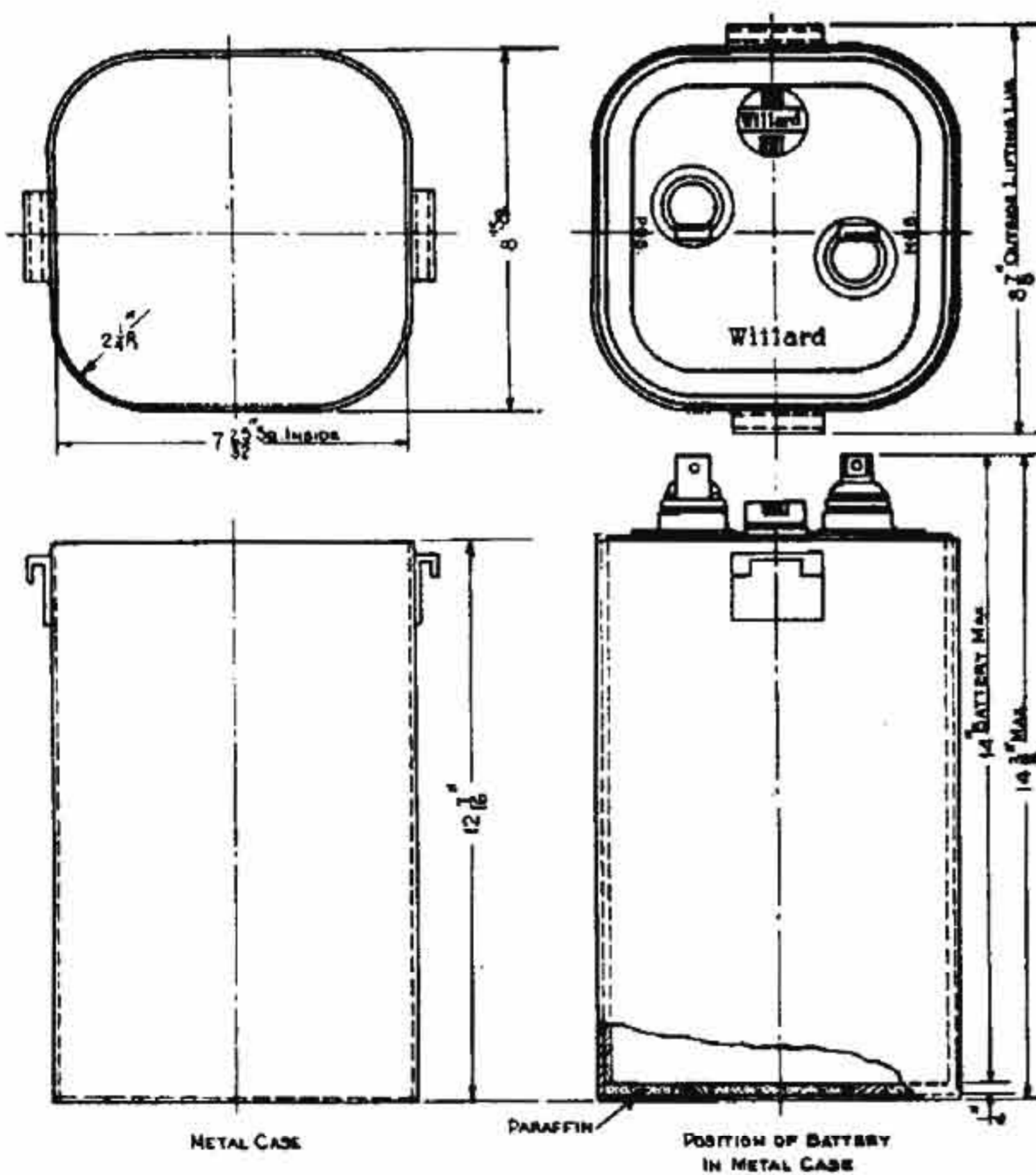


FIGURE 21-2.—DH-5-1 low discharge battery, single cell. (Weight 54 lbs.)

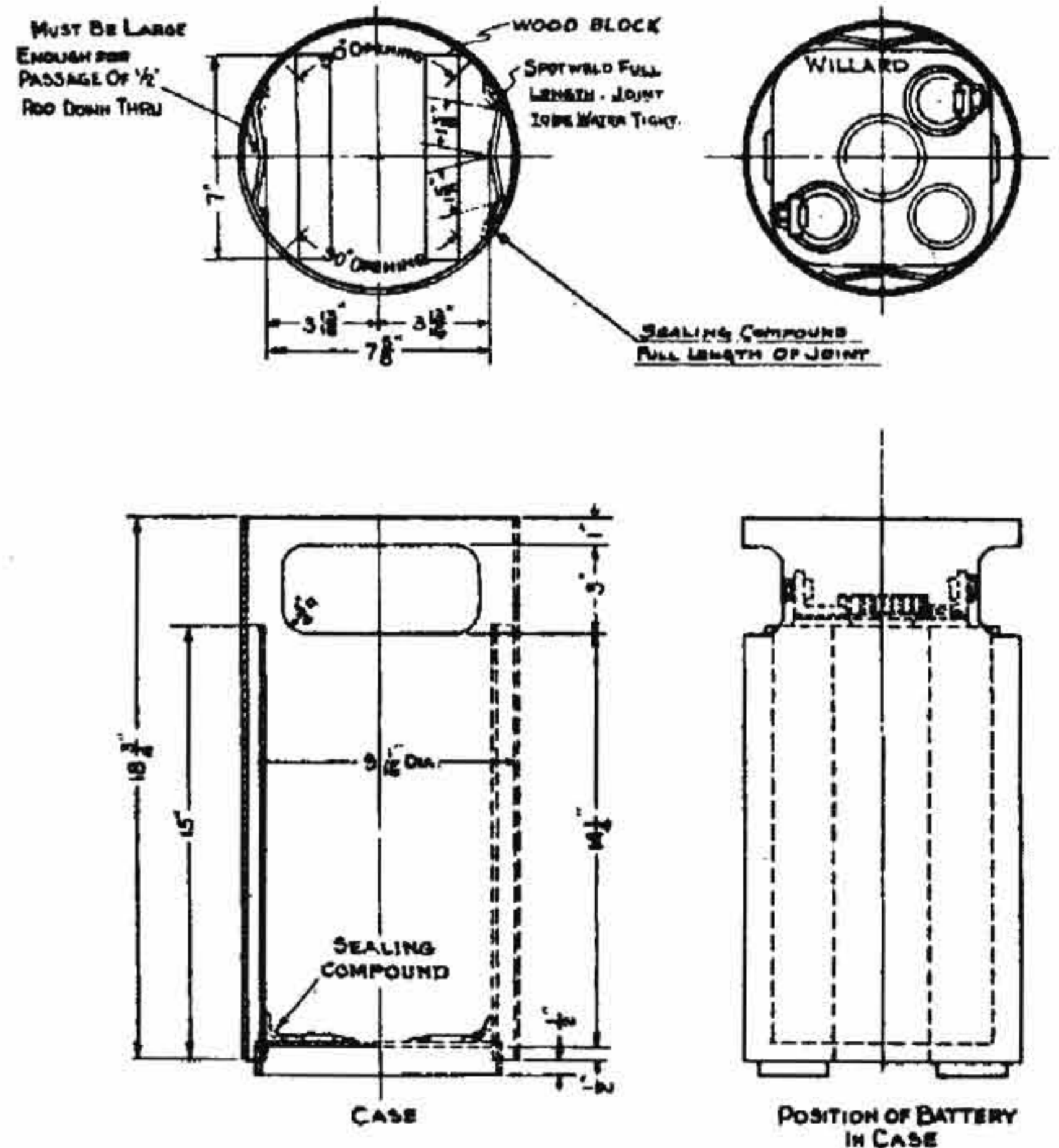


FIGURE 21-3.—DHB-5-1 low discharge battery in metal can. (Weight 83 lbs.)

points), 40 percent of the capacity will have been withdrawn and 60 percent remaining. The voltage of the cell averages 2.05 volts throughout its period of discharge. The self-discharge loss of energy in 1 year is less than 15 percent.

F. Specific construction.—The DH-5-1 type battery is intended for shore installations and is not equipped with the nonspill vent. The DHB-5-1 type battery is used in most electric lighted buoys and is equipped with a nonspill vent purposely designed for buoy use. It is installed in metal cans for protection as shown in fig. 21-1. Paraffin, having a melting point of 127° to 130° F., is poured around the cells after the battery is placed in the can. A mechanical vent located in the center of the cover permits an inclination of the cell 120° from the vertical (30° past the horizontal) without loss of electrolyte. A filling and testing plug, located in the corner of the cover, is provided for taking specific gravity readings and for adding water.

G. New battery procedure.—The cells when received from the manufacturer are fully charged and ready for installation. The following procedure is recommended before installing either a new battery or a battery which has not been in service for a period of several months.

(1) Remove filling plug and test the specific gravity. It should read 1.285 to 1.300 at 80° F. when fully charged. (If the specific gravity reads below 1.280, the cells are to be given an equalizing charge at 10 amperes until the specific gravity stops rising.)

(2) **Special filling syringe.**—Test the level of the electrolyte by means of the special filling syringe. To do this, insert the syringe until it seats in the filler opening. By squeezing and releasing the bulb, excess acid or electrolyte will be drawn off. A low level is indicated by lack of suction. If the electrolyte is low and the specific gravity reading indicates a fully charged condition (1.285-1.300 at 80° F.) the level should be adjusted to the proper height by adding pure distilled water until the specified height of 1¾ inches above the plates has been reached.

(3) After the proper electrolyte level has been obtained, the cells should be placed on charge for a few hours to allow the water to become thoroughly mixed with the electrolyte. Before charging, loosen the hard rubber packing nut on the positive terminal one-quarter turn.

(4) Replace filling plugs and clean the tops of the cells and retighten the rubber packing nut not more than one-half turn. It is important that the filling plugs be properly seated and acid-tight.

(5) **Test mechanical vent in DHB-5-1 type.**—If a DHB-5-1 type battery, see that the mechanical vent operates freely and is firmly in position, and as a final test for the proper seating of the mechanical vent and filling plug, lay the cell on its side and roll it through 360° to detect any possible leakage which might occur.

(a) To remove the vent, use the special wrench provided to loosen it, then unscrew the vent by hand. (Caution: Place index finger on the counterweight while the vent is still in a horizontal position to prevent the counterweight from revolving rapidly and expelling the acid.) To seat the vent, screw it into

position by hand, then take up with the wrench—a quarter turn should be sufficient to secure a proper seating. Avoid extreme pressure by renewing the gasket if leakage is encountered.

H. Hydrometer readings.—The hydrometer is an instrument used to ascertain the specific gravity of the electrolyte or battery solution. The syringe type hydrometer is used to test all batteries of the enclosed type. To take a reading, insert the end of the rubber tube in the cell; squeeze and slowly release the rubber bulb, drawing up electrolyte from the cell until the hydrometer floats. The reading on the graduated scale at the surface of the liquid is the specific gravity of the electrolyte. After testing, the liquid must be returned to the cell from which it was taken. If too much electrolyte is drawn into the tube, the float will strike the stopper in the upper end of the tube, giving an incorrect reading. The specific gravity reading is expressed in points. Thus the difference between 1.230 and 1.250 specific gravity is 20 points. The specific gravity of the low discharge cell ranges from 1.300 when charged to about 1.130 when discharged.

(1) **Determining removal date.**—Accurate hydrometer readings, correctly interpreted, are absolute checks on the charge still remaining in a battery. In event intermediate readings are taken, the date for removal may be predicted with reasonable accuracy and arrangements made within sufficient time to avoid undue discharge or electrical failure of the installation. For example, in an installation of low discharge cells that have been in service for 6 months, the specific gravity reading is 1.210. The date for recharging the battery cells can be determined from the following data:

Specific gravity:	
At start.....	1.300
When discharged.....	1.130
Range.....	170
When tested.....	1.210
Capacity used.....	90
Elapsed time when tested, days.....	180

(2) During 180 days the specific gravity has dropped 90 points or a rate of 2 days per point. There are 80 points remaining before reaching complete discharge. Therefore 2 times 80 equals 160 days' life still remaining in the battery.

I. Charging.—Cells used in buoy service shall be removed from the battery racks when placed on the charging line. This is necessary because of the testing operations required to determine the proper charge and condition of the cell before reinstallation.

J. Electrolyte level.—Before putting a cell into service, check the electrolyte level with the special filling syringe. If low, adjust to the proper level by adding pure distilled water only. After adding water, continue the charge until the water is thoroughly mixed with the solution as indicated by the hydrometer readings. In this way, errors in subsequent hydrometer readings taken on discharge will be avoided.

K. Maintain purity of electrolyte.—These cells show practically no self-discharge on open circuit. This is due to the extreme purity of their component parts. To maintain this purity it is necessary to avoid scrupulously any contamination from metals,

rust, or any foreign substance. For this reason, during charge one should use a specific charging plug or place the vent plug in the vent hole to avoid contamination. Furthermore, it is imperative that a special hydrometer, filling syringe, and thermometer be provided for use on low discharge cells only. Under no circumstances should these instruments be used on the regular charging line with other batteries, as there is a possibility of transferring impurities from a conventional type battery to the low discharge cells and thus causing considerable damage.

L. *Battery cells should not stand in discharged condition.*—Cells which have been completely discharged or have stood for some time in a discharged condition should be watched for undue temperature rise when recharged. Cells may be stored without being placed in racks, but the tops must be kept clear of any metallic substances which might fall across the cell terminals and cause short circuits. Short circuits not only prematurely discharge the cells but (due to the heavy currents which may be obtained from these cells) may damage the lead plates or cause a fire.

M. See section 21-4-30 for installation instructions.

21-4-15 Primary Cells—

A. *Characteristics.*—Primary cells of the copper-oxide zinc alkaline electrolyte type are used in many minor light installations. These cells are not designed for use in buoys. The batteries resist corrosion and are not affected by dampness. They provide a self-contained power supply requiring no charging. When the battery is discharged, the exhausted elements and the electrolyte are disposed of and the battery is restored to full capacity by inserting new elements and adding new electrolyte.

B. *When exhausted.*—For primary cells contained in glass jars, an accurate indication of approaching or complete exhaustion of the cell is given by visible deterioration of the indicator panels at the bottom of the zinc plates. When pinholes appear in the indicator panel, the cell is 85 percent exhausted. (See fig. 21-6.) Primary cells in metal cans are not readily inspected, however, since the service time is well established, periodic inspection of the plates is not actually necessary.

C. A complete cell consists of the following:

- (1) A unit assembly of positive and negative electrodes.
- (2) A can of caustic soda for mixing with water to form the electrolyte.
- (3) A glass or metal jar.
- (4) A porcelain cover and gasket.
- (5) A bottle of special battery oil (certain manufacturers of primary cells do not use separate battery oil but furnish it already mixed in the caustic soda).
- (6) Nuts and washers for making connections and to attach the elements to the cover.

D. There are two types in general use. Type S-500 and M-1000, the numeral indicating the ampere-hour capacity at normal voltage of 0.66 volt per cell.

E. *Overvoltage.*—A peak voltage is built up on open circuit up to 38 percent in excess of normal voltage, i. e., if the cell is permitted to stand without current drain, the battery develops a peak voltage considerably higher than the continuous discharge voltage. During this period of overvoltage, the lamp is overloaded, which may result in lamp failure. The number of cells generally used for flashing lights are as follows:

- 3.5-volt lamp, 5 cells.
- 6.2-volt lamp, 9 cells.
- 12.0-volt lamp, 18 cells.

F. To install primary cells, proceed as follows:

(1) Check all new material carefully. Do not use cracked or broken jars, covers, or elements. Keep boxes of new cells and renewals dry and unpack elements and soda only as needed.

(2) When renewing exhausted cells, remove elements from the jars and detach from the covers. Save these elements to return for credit in shipments of 100 pounds or more. Exhausted elements should be drained and allowed to dry away from inflammables. *Do not pack for shipment when wet.* This is important since the chemical activity of wet elements may, and on several occasions has, caused spontaneous combustion.

(3) Discard used solution where it will not presently or potentially damage property, injure persons or animals, or pollute streams or other water supply.

(4) Be sure jars are thoroughly clean and fill each half full with clear water. In the absence of fresh water, salt water may be used. Pour in the can of caustic soda gradually and stir the solution in a pendulous and circular motion with a clean stick long enough to reach the bottom of the jar.

(5) Add more water to within 1½ inches from the top of the cell, using a wood liquid gauge. Be sure the soda is thoroughly dissolved.

Caution.—Handle the caustic soda carefully. It will cause severe burns to the skin either in dry mixture or in wet solution.

(6) Assemble the element to the cover, passing the lead wire and suspension bolt through the holes. Fasten with the hexagonal nuts and place two wing nuts and washers on top of the hexagonal nut.

(7) Remove the paper separators from between the element plates, being careful not to spring the plates out of position.

(8) Insert the element in the solution. Make sure it hangs vertically and the plates are spaced evenly.

(9) Place the cell in permanent position and add water until three-fourths inch from top of the jar. Rotate the cover back and forth gently several times so as to mix the added water. Be sure the solution covers the plates of the element.

(10) Tilt the neck of the cover and pour all the oil from the bottle of special battery oil on top of the solution after restirring. With the oil added, the solution should be one-half inch from the top of the jar. The purpose of the oil is to prevent evaporation of the solution. (Certain manufacturers of primary cells may furnish the oil impregnated in the caustic soda. In which case, follow the manufacturers instructions for assembling the battery.)

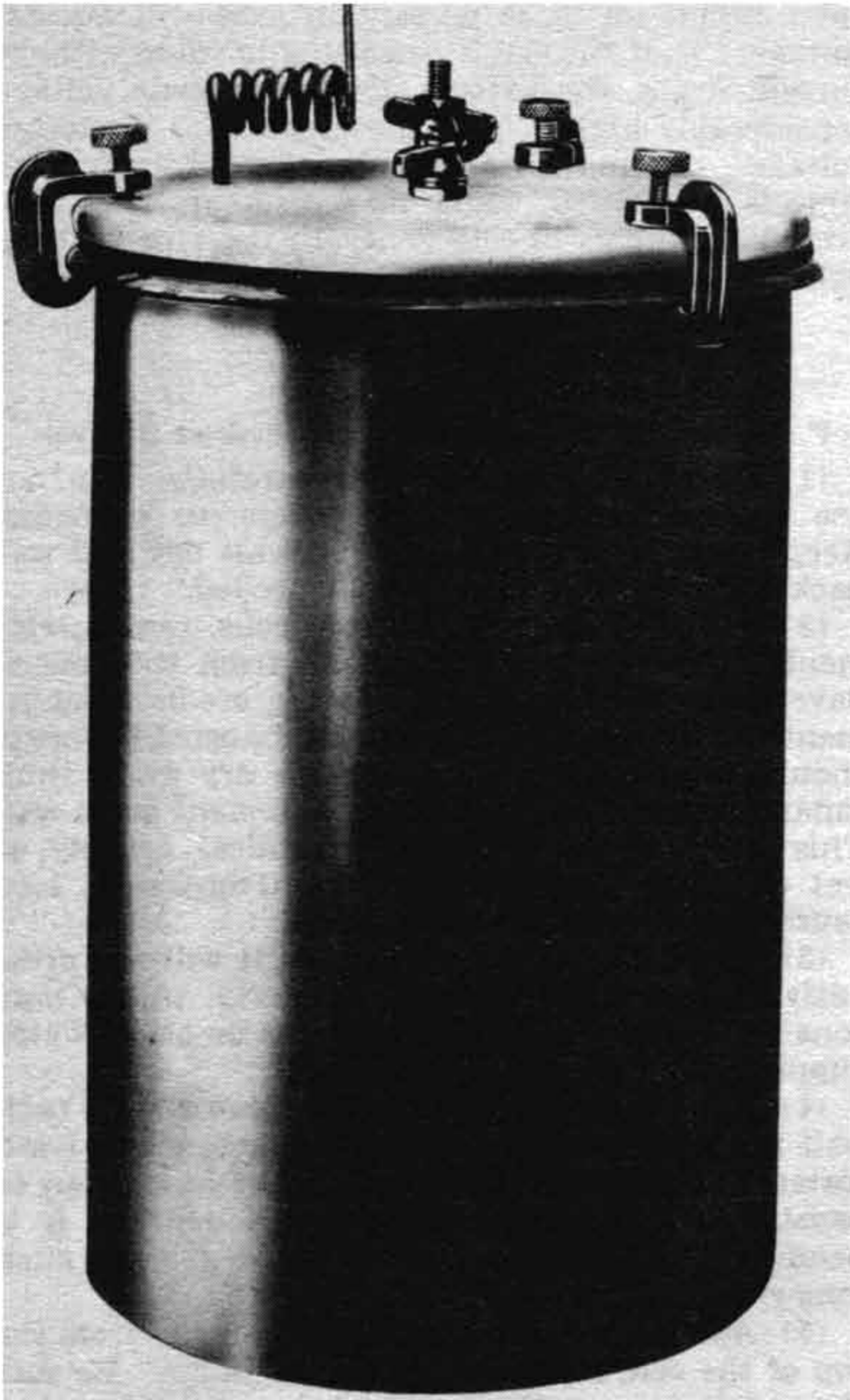


FIGURE 21-4.—Edison-type S-507 copper oxide primary battery.

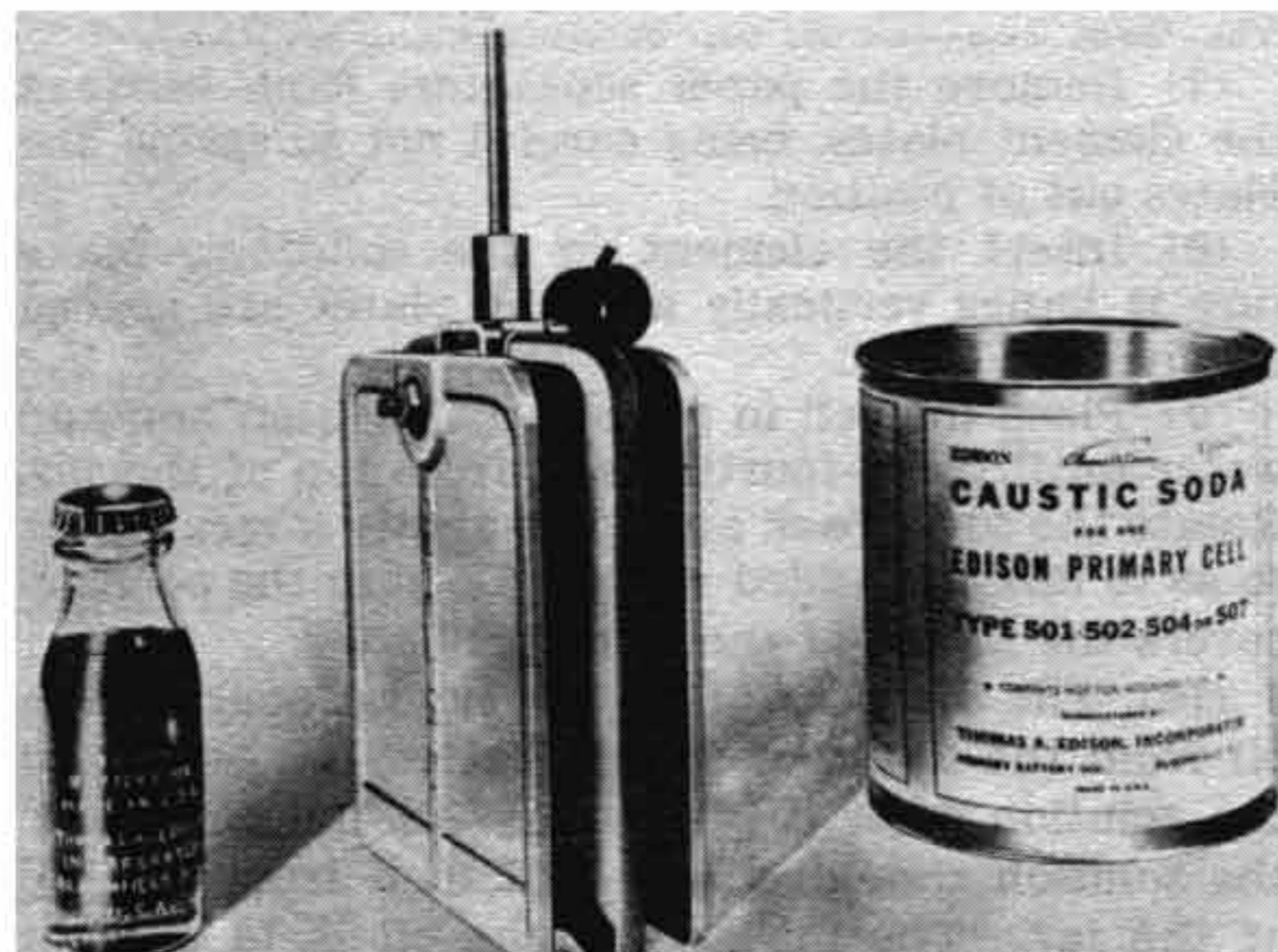


FIGURE 21-5.—Complete renewal for Edison-type S-507 copper oxide primary battery.

(11) Short each cell by touching the negative lead to the positive post for about two minutes, or until the wire becomes too hot to hold. This dissipates the normal surge of voltage (up to 38 percent) and starts chemical action.

(12) Make the connections to the circuit, making sure they are clean and tight. Use the same number and type of cells in each leg of a multiple-service battery.

(13) Coat all connections with vaseline.

G. In preparing primary cells, seek to *avoid* the following mistakes:

- (1) Failure to place caustic soda in the water.
- (2) Failure to dissolve all the caustic soda.
- (3) Dissolving two cans of soda in one jar.
- (4) Adding oil before putting the elements in place.
- (5) Failure to take proper precautions in handling caustic soda.
- (6) Failure to tighten connections.

H. The following treatment is recommended for batteries used as stand-by units in A. C.-operated installations in order to keep them in their most active condition. When first set up, or renewed, connect a series resistor across the battery for 15 minutes once each month. Batteries having a tendency to give lower than normal voltage at service rates of discharge, due to inactivity, should also be similarly treated. Each separate bank of a multiple series battery should be treated separately. The ohmic value of the resistor is governed by the number of cells in each bank as shown below:

Number of cells	Voltage	Resistor value in ohms
5	3.5	0.12
9	6	.25
18	12	.50

21-4-20 Air Cells—

A. The air cell is used in shore installations where service conditions require light weight and ease of handling. It has replaced many installations where the dry cell packs were formerly used. The air cell battery does not use the oxygen bearing chemical depolarizer (manganese dioxide) such as the dry cell battery but obtains its oxygen from the air through a special carbon "lung" or electrode. The air cell is purchased in 500-ampere-hour capacity and is suitable for all types of shore installations where the current drain is not over 0.66 amperes.

(1) The average initial voltage under discharge conditions is 1.25 volts per cell, falling to 1.0 volt per cell near the end of the service life.

(2) Reference is made above regarding use of this battery where current drain does not exceed 0.66 ampere-hour. This applies where a closed circuit is involved such as a fixed light, in which case a lamp of higher rating should not be used without adding enough banks to equal the lamp. In the case of flashing lights, under normal conditions, a lamp of up to 50 percent higher rating than the battery may be used where the lamp is not burning more than one-fifth of the characteristic cycle.

B. *Electrolyte.*—The battery is activated by the addition of any water suitable for drinking. The electrolyte is formed by the self-mixing of the water

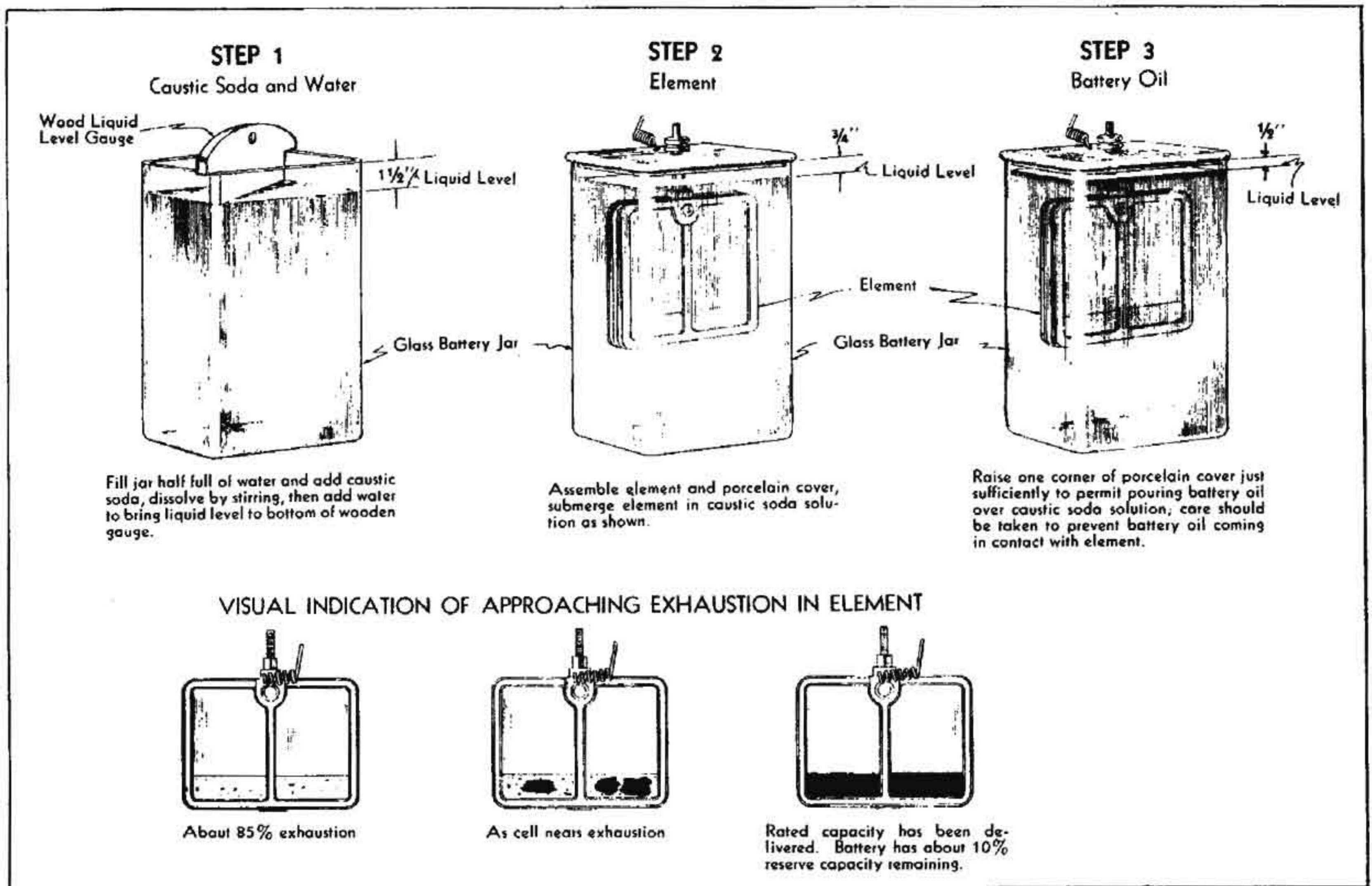


FIGURE 21-6.—Primary battery instructions.

with a cake of caustic soda within the cell and requires no stirring.

C. As in the case of all wet-type batteries, a certain amount of care should be exercised in placing air cells in operation and maintaining them. The following instructions, which appear on the label on the back of the battery, should be carefully followed.

To install air cells, proceed as follows:

(1) Remove the filler cap and punch out the diaphragm. Pieces falling inside the battery do no harm.

(2) Pour carefully two measured quarts of cool drinking water into the battery. Then add slowly the small amount of water needed to bring level halfway into the filler openings. Wipe off immediately any spilled water on top of the battery.

(3) Replace the filler cap as soon as the water level recedes sufficiently. The solution will automatically fall to correct level without further addition of water.

(4) After filling, remove the card and transparent covering from the breathing carbon. The battery cannot breathe with these in place.

(5) The battery is now ready for service. After the battery has been put in service, never again add

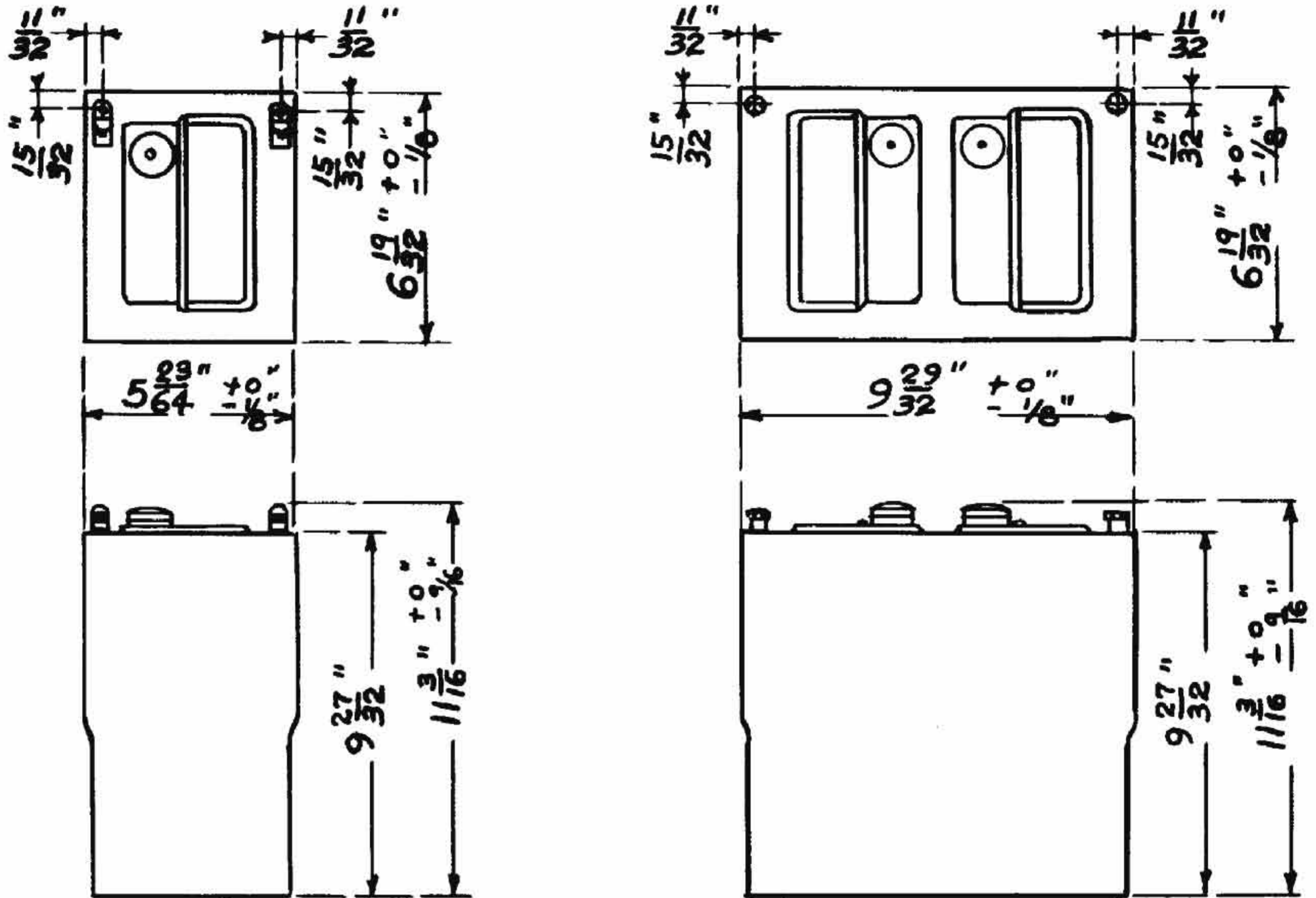
more water than is necessary to just cover the indicator wire visible through the filler opening.

(6) *Caution.*—This battery contains caustic soda (lye) in solid form before filling with water, and in solution after filling. This substance, including the solution, is a caustic poison and must not be taken internally or permitted to come in contact with the skin, eyes, clothing, or valuable articles.

(a) In filling with water, do so carefully, and immediately wipe up any water spilled on top of the battery. Do not permit water to get on the carbon breathing element.

(b) Do not fill the battery with water until it arrives at its destination. If the battery is carried any distance after filling, thoroughly wipe out the filler cap before placing the battery in service.

(7) *Inspection.*—In hot dry locations the battery should be inspected every 2 months (under normal conditions, every 4 months). The vent hole in the filler cap should be kept open and free from salts at all times. Low temperatures do no harm on open circuit, and have no serious effect at light drains and short closures. For higher continuous drains, the battery should be used at customary room temperatures. Never test the battery with an ammeter as this short circuits the battery and causes damage.



TERMINAL POSTS - No. 8-32 THREAD.

FIGURE 21-7.—Eveready air cell batteries, T-1600 and T-2600.

(8) *Types.*—The following types of air cell batteries are presently in use:

T-1600—1.25 volts, 500 ampere-hour capacity.

T-2600—2.5 volts, 500 ampere-hour capacity.

Cells—T-1600, one; T-2600, two, connected in series.

Voltage—T-1600, 1.25 volts; T-2600, 2.50 volts.

Maximum current rating—660 milliamperes at voltage rating.

Weight unactivated—T-1600, 11 pounds 6 ounces;

T-2600, 21 pounds 5 ounces.

Weight activated—T-1600, 15 pounds 13 ounces;

T-2600, 31 pounds 9 ounces.

21-4-21 Disposal of Batteries—

A. Care must be exercised in the disposal of batteries and electrolyte when no longer serviceable. This is particularly true in the case of the electrolyte of primary cells when recharging and in the disposal of exhausted air cell-type batteries. The electrolyte

of all batteries is a poisonous substance capable of inflicting burns externally, and severe injury or possibly death from internal contact.

B. Streams or other water supply can become polluted from the discard of electrolyte. A case is on record where air cells were discarded in what was apparently a safe place but which later became accessible to cattle who perished from the contact. Care in battery disposal cannot be too strongly emphasized.

21-4-25 Low Discharge Battery Racks—

A. *Use in buoys.*—DHB-5-1 low discharge batteries for use in buoys are placed in racks or frames which may be lifted in and out of the pockets in the body of the buoy in much the same manner as acetylene cylinders. When battery racks are removed for servicing, they should be cleaned and painted with acid-resisting or asphaltum paint.

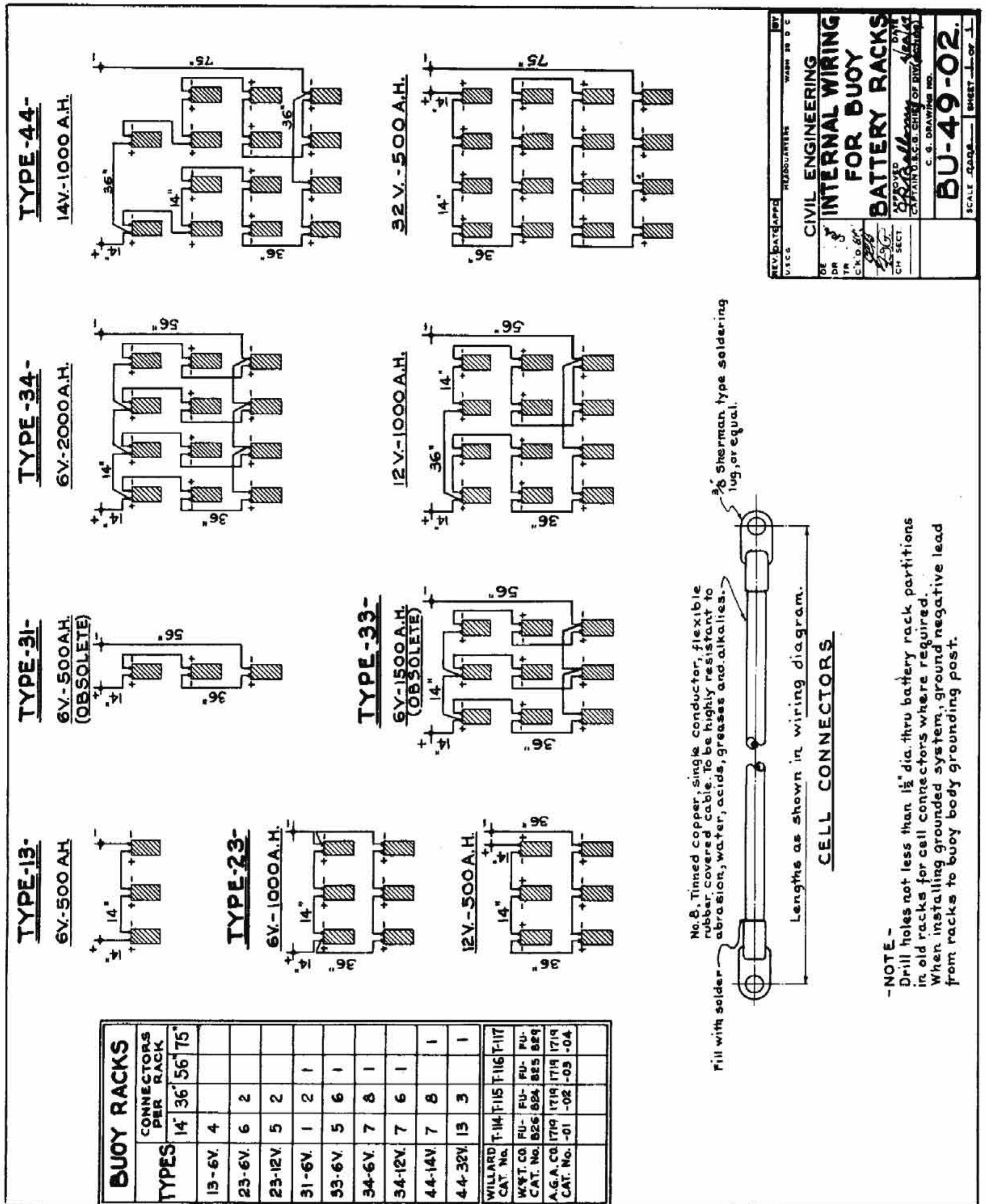


FIGURE 21-9.—Internal wiring for buoy battery racks.

changer are correct. See that the battery cells are properly wired and secured to the battery rack. Check for correct voltage. See that all cells are leakproof when the rack is rolled in a horizontal position on deck or ashore, to assure that the electrolyte will not spill inside of the buoy pocket. After placing the battery racks inside of the buoy pockets, see that the wedging screws are jammed against the side of the pocket to prevent the racks from moving out of position. The batteries must be securely wedged in the pockets, however, the clamps must *not be set up too tight*, or the cells may become cracked and thus permit leakage of the electrolyte. (In certain small buoys there is a framework open to the entire body of the buoy in lieu of a pocket in which the batteries are placed.) The batteries are interconnected and wired to a pair of insulated lugs or terminals at the top of the rack. The terminals and connections should be firmly connected and greased. Leads must be properly run inside the racks so they will not shear off or be broken when the rack is installed in a buoy pocket.

D. Buoy wiring circuit.—An electric buoy battery rack wiring diagram is shown in figure 21-10. Two-conductor rubber-covered No. 12 wear-resistant cable is used for making the electrical circuits from the inside of the buoy pocket terminals to the lantern. The ends of the wire are to be securely soldered to proper size terminals after it is run through the connectors.

(1) The terminal box on the daymark plate provides for connecting the two circuits running from the batteries in the two pockets with the wiring to the lantern. Connections of this type are usually made by securely fastening like terminals together.

(2) The electric cable is run through watertight connectors which are located at the lantern, daymark terminal box, and wherever the wiring comes through the buoy head or through the upper portion of the battery pocket just below the flange (on recently designed buoys).

(3) The electric cable is secured with $\frac{1}{4}$ -inch diameter cable hook clips spaced about 24 inches apart. The clips are located on the inside of the tower legs or inside of the buoy body in such manner as to afford the cable the best protection.

E. Ventilation—Caution.—Lead-acid batteries in buoys have a tendency to create a highly explosive hydrogen gas and care must be observed when opening battery pockets. The vent, which is similar to that of an acetylene buoy, must be kept operating freely. The rubber tube on buoy vents has a tendency to dry out and should be inspected frequently at each servicing and renewed if required.

21-4-35 Computing Service Time—

A. As previously mentioned, the number of batteries required in a given installation will vary with the requirements of the particular light. The length of time that an electric battery installation will continue to operate a lighted aid depends on the ampere-hour capacity of the battery, the light ratio,

the ampere rating of the lamp, and a surge factor which is used to take care of the variation in current consumed by an alternately hot and cold filament.

B. The service time is computed from the following formula:

$$T = \frac{C \times N}{24 \times R \times a \times F}$$

T = Service time in days

C = Capacity of one string of batteries in ampere hours

N = Number of strings in parallel

R = Luminous time ratio

a = Amperage of the lamp.

F = A surge factor obtained from figure 21-13

Example: There is a light consisting of a 200-mm. lantern containing a 2.03 amp. 12-volt lamp showing a characteristic of 0.4 second flash and 3.6 second eclipse and having 24 low-discharge cells connected in four parallel banks of six cells to a bank. What is the service time?

In the above formula,

C = 500 ampere-hours

N = 4

R = $\frac{1}{10}$ th

a = 2.03

F = 1.285

Substituting these values in the formula:

$$T = \frac{500 \times 4}{24 \times \frac{1}{10} \times 2.03 \times 1.285} = \text{approx. 332 days}$$

In the above, no allowance has been made for the consumption of the flasher, which is considered negligible.

C. Other methods of computation.—The nomogram (fig. 21-11) may be used in lieu of the formula for approximate results. Also, a very handy "Electric Beacon Calculaide" (fig. 21-12) is available from the Wallace & Tiernan Products, Inc., which enables ready calculation of all problems involving the service period of electric battery installation without the necessity of recourse to a formula.

D. Remaining service time.—The computation of the remaining service time left in a battery installation may be accomplished in the following steps:

(1) Take the specific gravity reading of the electrolyte.

(2) Find the difference in range of points between the present gravity reading and 1.300 (the normal fully charged specific gravity).

(3) Determine the number of days installation has been in service.

(4) Apply the figure found in step (2) to the total range in points between fully charged and discharged condition, (1.300 and 1.130 respectively), or 170 points) to determine the number of days used up per point of specific gravity drop.

(5) Compute the number of points of specific gravity range remaining before cell is discharged (i. e. present reading less 1.130).

(6) Multiply days per point (found in step 4) by remaining range (found in step 5). Answer is approximate remaining service period in days.

CHART FOR COMPUTING BATTERY REQUIREMENTS FOR FLASHING LIGHTS

EXAMPLE:

ASSUME 1 LAMP - 0.70 AMPERE
 CHARACTERISTIC - 15 FLASHES/MINUTE
 0.4 SECOND LENGTH OF FLASH
 (I.E. 0.4 LIGHT - 3.6 SEC. DARK)

ENTER LEFT SIDE OF SECTION 1 OF CHART (SEE DOTTED LINE) - FOLLOW HORIZONTAL LINE TO SLOPING LINE MARKED "15 FPM. AT POINT OF INTERSECTION WITH THIS LINE DROP VERTICALLY TO SECTION 2 INTERSECTING SLOPING LINE MARKED "0.70 AMPERE LAMP A HORIZONTAL LINE DRAWN TO THE LEFT FROM THIS POINT INTERSECTS THE SCALE BETWEEN SECTIONS 2 & 3. READ VALUE ON THIS SCALE FOR BATTERY REQUIREMENTS FOR ONE YEAR (740 AH) SECTION 3 GIVES THE LIFE IN DAYS FOR VARIOUS BATTERIES - FOR THE EXAMPLE SHOWN A 500 A.H. BATTERY WOULD LAST 233 DAYS.

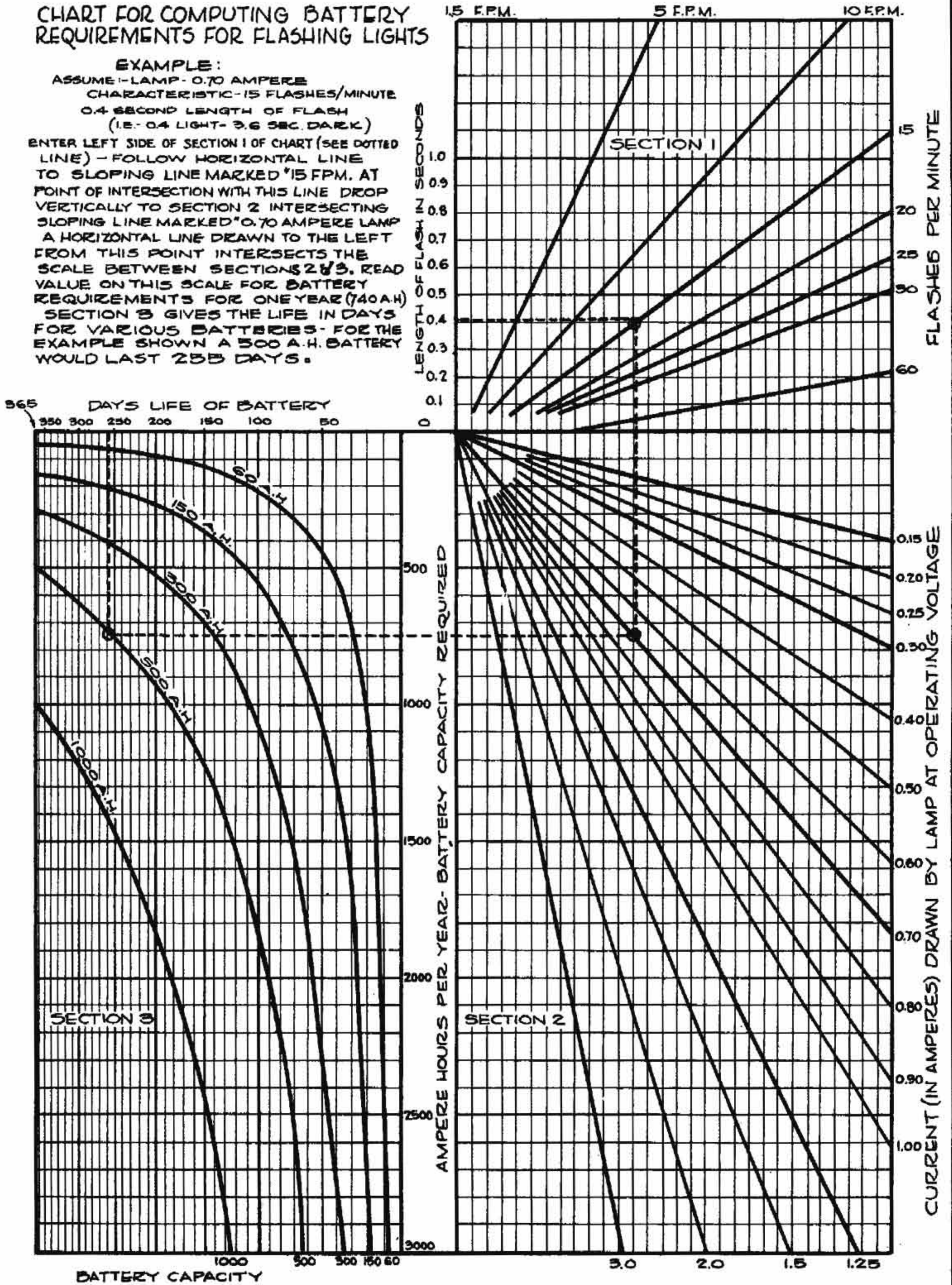


FIGURE 21-11.—Chart for computing battery requirements of flashing lights.

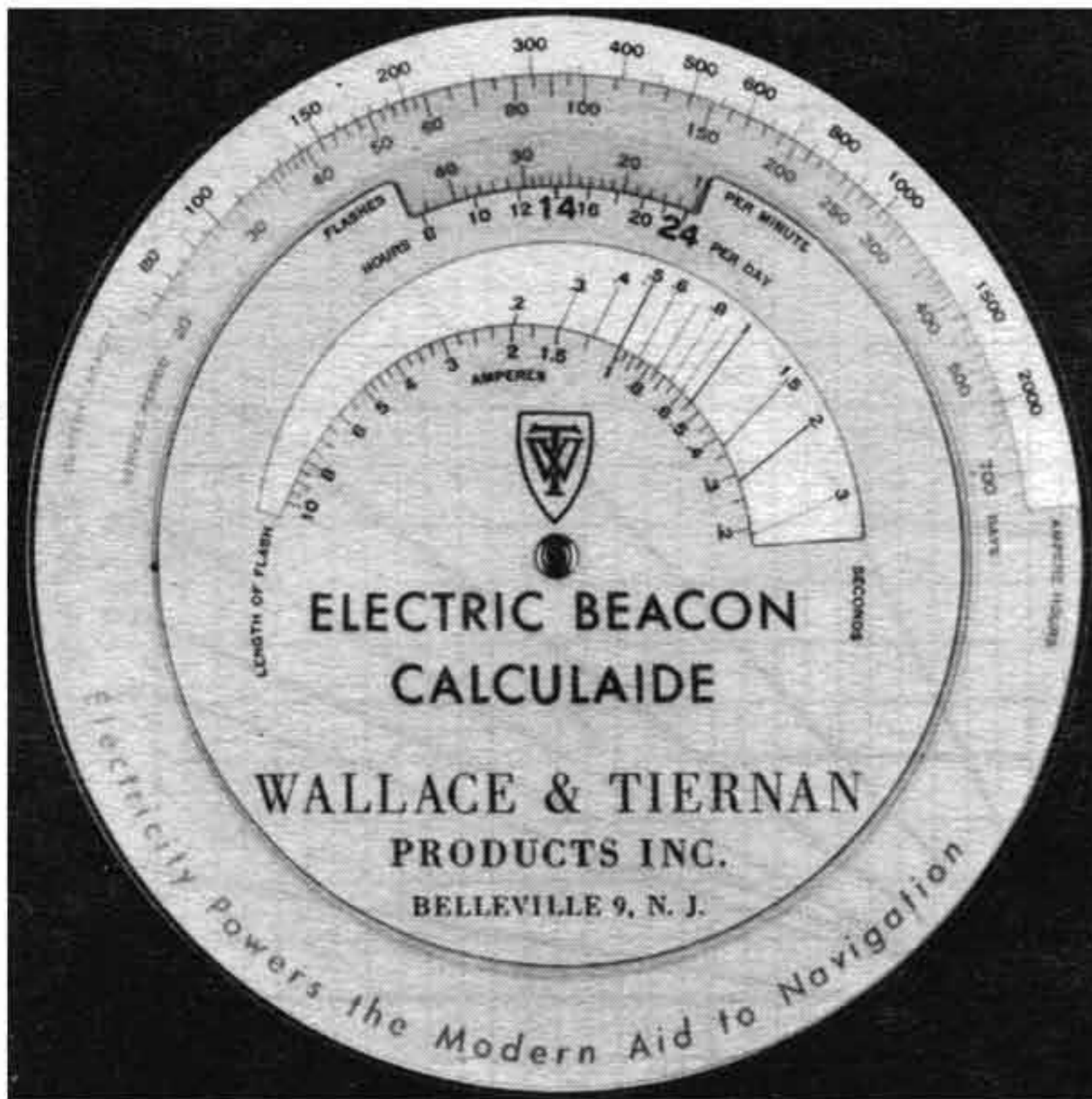


FIGURE 21-12.—“Electric Beacon Calculaide.”

21-4-40 Charging Batteries, General—

A. Methods of charging.—Since many light stations have batteries other than the types listed previously for powering lighted buoys and minor lights, general charging information is given herein.

B. Two general methods of charging batteries are at present in use. They are the *constant current method* and the *constant potential method*. Both have their advantages, and their use depends on the application. The principal factor determining the charging method should be the class of service in which the battery is used. The available charging facilities will indirectly affect the charging procedure.

C. Constant current charging and two-rate constant current charging are usually applied to 6-volt and special low-voltage batteries.

(1) *Constant current charging* of line batteries may be accomplished either by connecting the cells in two parallel groups or by charging them in one series.

(2) *Series parallel (parallel series) charging* of 110-volt 54-cell batteries is a type of constant current charging. It is wasteful of current and has other disadvantages, and is seldom used except for charging old-type Edison nickel-iron-alkaline batteries.

(3) *Constant current series charging* is commonly used at shore stations. Its principal use is for charging strings of low-discharge cells and conventional type batteries of low voltage.

(4) *Two-rate constant current charging* is a method used for low voltage conventional-type batteries whereby the battery is placed on charge at the normal rate (as prescribed by the manufacturer for the particular battery). The charge is continued at this rate until the battery begins to gas freely. At that time the current should be reduced to approximately one-half the normal rate and

continued at this rate until the specific gravity has risen approximately to the normal full charge value for the particular battery.

D. Constant and modified constant potential charging is preferable to obtain the best service from lead-acid storage batteries. This method is used primarily for large battery installations of 32 and 110 volts such as used in light and lifeboat stations. If combined with operation of the generators at all times that the electrical loads are heavy, a charging procedure known as *modified float charging* is obtained, which combines all the advantages of long life of battery, highest charge-discharge efficiency, minimum size of generator to carry average load, highest potential reserve in battery, etc. This system is the only one which will normally be approved.

(1) For satisfactory modified float charging, the voltage must be adjusted to meet the particular operating conditions. (See sec. 21-4-45.)

E. Minimize gassing.—Appreciable gassing during charge does not occur until the voltage has been raised to about 2.35 volts per cell. Gassing is an evidence of the flow of excess current, which in turn is wasted in electrolyzing the solution. The formation of gas bubbles pushes off active material from the plates. Hence, any charging system which normally accomplishes the charge at voltage below that value is preferable.

F. Maximum battery temperature.—The temperature of storage batteries shall normally not be permitted to exceed 110° F. The maximum temperature is 130° F.

This value should never be approached except in an emergency when a quick recharge may be necessary for continued operation.

G. Charging accessories.—A number of devices are in use to facilitate the charging and maintenance of storage batteries. They are, in order of importance:

- (1) Hydrometer and syringe.
- (2) Cell-testing voltmeter.
- (3) Cell thermometer.
- (4) Charge controller.
- (5) Ampere-hour meter.

H. Certain hydrometers not recommended.—A hydrometer calibrated to indicate at least every five points from 1.050 to 1.250 shall always be used in 1.220 gravity cells. A hydrometer calibrated as above and reading from 1.100 to 1.300 shall always be used in 1.280 gravity batteries. Hydrometers showing only the words “full,” “half,” “discharge,” etc., are not satisfactory. The hydrometer syringe should be kept in a glass or rubber bottle adjacent to the battery.

I. Voltmeter.—A cell-testing voltmeter similar to Weston Model 280 battery-testing voltmeter is an essential part of the equipment, to properly record the cell data on the monthly equalizing charge. Any testing instrument having equivalent voltage ranges is also satisfactory.

J. A cell thermometer is necessary. It should have a temperature range of 30° F. to 120° F.

K. Charge controller.—At stations where the engine generators are provided with push button or similar automatic remote controlled starting, a

NOTE: TO OBTAIN THE SURGE FACTOR (F) FOR USE IN THE FORMULA, ADD THE ADDITIONAL CURRENT VALUE OBTAINED FROM THIS CHART TO 1.0; THUS IN THE CASE OF A 1.35 AMP. LAMP WITH 0.3 SEC. FLASH, THE SURGE FACTOR (F) IS 1.28

SURGE FACTOR CHART

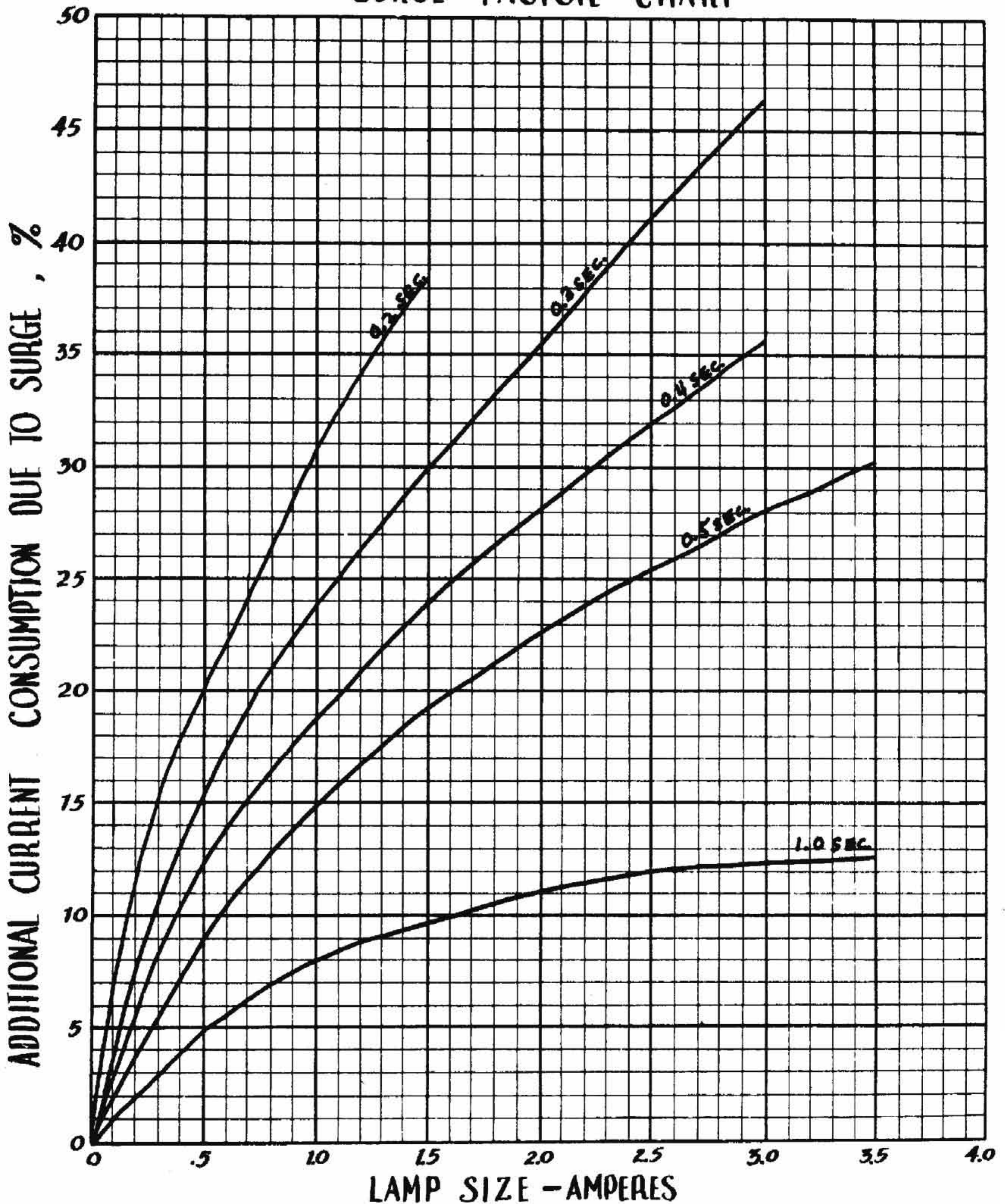


FIGURE 21-13.—Surge factor chart.

charge controller may desirably be installed. It will start the generator (if not already running) at regular periods, which may be adjusted from ½ hour to 2 hours. It continues the generator operation until the battery voltage has risen to 2.31 volts per cell when the engine is shut down. This device is advantageous since it releases personnel from engine starting and takes the proper maintenance of the batteries out of the field of guesswork. (Charge controllers are furnished only for use with 54-cell batteries.)

L. Ampere-hour meter.—Sangamo type NF ampere-hour meters have been widely used in the past and a few are still installed. They were a valuable accessory in constant current systems, but are not suited to constant or modified constant potential "float" charging.

21-4-45 Maintenance of Storage Batteries—

A. The maintenance of a storage battery is not a difficult task if certain fundamentals are appreciated and complied with. The following paragraphs contain instructions which should be strictly adhered to.

(1) The usefulness of a storage battery lies principally in its ability to deliver electric power as and when required. To accomplish this it is desirable to keep it well charged. Never permit a battery to remain in a semidischarged or completely discharged condition.

(2) A storage battery is an assembly of chemical components, not a piece of machinery, and must be treated as such. Its life and usefulness are inversely proportional to the number of cycles withdrawn from it and the severity of those cycles, and proportional to the care with which it is maintained in a fully charged state. Overcharging is as bad as undercharging. It is a mistaken notion that a storage battery should be completely cycled at regular and frequent intervals. Never discharge a floated line battery unnecessarily. Run the generators whenever the electrical loads are large enough to justify the operation of the generator. The battery will thus be ready for an emergency, will care for periods of very light load, and will assist the generators over short periods in which they might otherwise be overloaded. It provides a steadying effect on the voltage and lessens electrical and mechanical stresses on the engine generators.

(3) Since it is a chemical device and not a machine, its care differs from that of a machine. For the purpose of illustration, a storage battery may be thought of as an organic device. The chemical reactions therein are similar to those of the organic kingdom in some respects. A battery is said to be "healthy" if the plates have the right color and consistency. Permanent sulphation of the plates and corrosion of the terminals are "diseased" conditions. Lack of proper care causes buckling of the plates, cracking of separators, loss of active material, etc., resulting in shortening of "life." The presence of certain impurities in the water used to refill the battery "poisons" it, etc.

B. Keep the outside of the battery clean and dry. Always keep vent caps in place except when watering cells on all types of batteries, and except when

charging Willard low discharge cells. The latter cells should always be charged with the vent caps unscrewed and placed loosely in the openings.

(1) Ammonia or soda solution will neutralize the effects of spilled or sprayed acid if applied immediately. Be sure vent caps are tight before applying ammonia or soda solution.

C. Caution.—Keep exposed flames away from the battery. Be sure all terminals are kept clean, tight, and coated with vaseline or cup grease. A loose connection may easily cause an arc and burn off a post or cause an explosion, with possible injury to personnel.

(1) *Posts are fragile.*—Care must be exercised when tightening lugs on a battery not to impose severe stresses on the post by twisting or pulling. A post may be partially fractured below the acid level without the fact being immediately noticeable.

D. Addition of acid.—Never add acid solutions to the battery except when authorized by proper authority. Never apply patent rejuvenators. There is no substitute for an electrical charge, and while sulphated batteries may be partially restored by slow and long-continued charging, old batteries cannot be renewed by any trick means.

E. Watering.—Keep the separators covered with solution. Do this by adding water to the cells at regular intervals. When adding water do not put in too much. If a cell is accidentally filled too full, immediately withdraw solution to the proper level and flush the solution withdrawn (which may contain a diluted solution of acid) back into the battery distilled-water container. Use only approved water for battery solution. Use only distilled water in low-discharge cells.

F. Generator operation with series or float connected batteries.—The operation of the generator should be scheduled so that it is running during all periods when sufficient electrical load exists to justify its operation. If such operation does not bring the battery to at least a 90 percent charged condition some time during each day between monthly equalizing charges, the daily operation of the generator must be extended until the daily specific gravity in rubber jar batteries rises to within 20 points, or in glass jar batteries, within 8 points, of the maximum specific gravity attained by each corresponding cell during the last monthly equalizing charge.

G. Daily operation.—The voltage required to maintain a 1.210 to 1.220 specific gravity battery floated on the line under the foregoing conditions depends on the length of time the generator is operated. Good battery maintenance will result by setting the generators at the voltage shown in the following table:

Average hours, daily continuous generator operation	Voltage required per cell	Generator voltages	
		16 cells	54 cells
24	2.15	34	116
18	2.20	35	119
12	2.25	36	122
8 or less	2.31	37	125

H. *Charging current with modified constant potential system.*—When a generator is connected to bus bars, across which a power storage battery is solidly connected (that is, by low resistance wires), and the voltage is set as outlined, the initial current flow into the battery will be high. It may reach 100 amperes for a short period if the regulation and capacity of the generator are such as to permit this amount of current to flow. The charging rate will, however, rapidly decrease as the charge progresses until finally, as the battery approaches full charge, the current will decrease to, and remain at, a few amperes (possibly 5 or less, depending on the length of charge, temperature, and age of battery). These conditions are proper and will result in good operation with a minimum of gassing.

I. *Temperature affects charging voltage.*—Voltages discussed herein are based on a standard battery temperature of 77° F. In practice, the average battery temperature seldom will be 77° F. The normal compensation in voltage of the generator due to temperature change tends to automatically provide the necessary adjustment if the generator and battery are in the same or similar compartments. Certain classes of generators are provided with thermostatically operated voltage adjustments.

J. *Monthly equalizing.*—Once each month at a convenient time, with the exception noted below, the floated station power batteries must be given an equalizing charge to safeguard against periods of undercharge and to make certain that all cells (particularly those in a warmer portion of the battery) are brought to a fully charged state. The equalizing charge is given by maintaining the generator voltage at 2.31 volts per cell continuously for 24 hours, e. g. 37 volts for 16-cell batteries and 125 volts for 54-cell batteries.

Exception.—Where generators operate on a daily schedule of less than 18 hours, the equalizing charge is automatically accomplished after any prolonged period of running (over 24 hours). The equalizing charge readings (columns 2 and 3 of form 2552) may be taken at the end of such a run, and no special equalizing charge need be given for that month.

K. *Care of stored batteries.*—When batteries containing electrolyte are unused or held in stock they gradually become discharged due to local action within the cells. They must be given a periodic freshening charge. The procedure is generally similar to that for the equalizing charge; set the voltage so that the full charge rate flows at first, unless by so doing it is necessary to raise the voltage above 2.31 volts per cell. Thereafter, maintain 2.31 volts per cell during the freshening charge. The frequency of this freshening charge depends on the temperature and age of the battery. In general, it should be repeated every time the specific gravity of the cell drops 20 points in rubber jar batteries, or 8 points in glass jar batteries, below the last recorded monthly equalizing charge record. New cells should be given a freshening charge immediately upon receipt unless they are to be placed in service without delay.

21-4-50 Storage Battery Report—

A. *Form CG-2552* is the only form required for keeping battery records. Instructions for its preparation and submission by the unit are printed on its reverse side.

(1) Only one daily reading on each storage battery is required. It is entered in column 1. Take this reading of the pilot cell at the same hour each day. Do not correct the gravity reading for temperature. The temperature required is that of the electrolyte in the pilot cell. Change the pilot cell every month, rotating throughout the entire battery. Some electrolyte loss occurs when taking the specific gravity reading. By rotating throughout the battery this loss is equalized.

(2) Column 2 is used only during the monthly equalizing charge. Enter actual, not estimated, data in each subcolumn. Be sure and enter the data every 6 hours while the equalizing charge is in progress.

(3) In column 3, follow explicitly the instructions to record the voltage of each cell (to the nearest hundredth) just before terminating the charge, and the gravity after the charge is completed. Fluctuations in charging rate cause proportional changes in cell voltage. Hence, it is important to keep the charging current as steady as possible while obtaining the individual cell voltages, if those voltages are to tell the true story of the cell's condition.

(4) *Purpose of battery report.*—The storage battery monthly report form serves a twofold purpose:

(a) It is the engineer's record of the battery.

(b) It furnishes the district engineering officer a valuable check on the condition of each power battery.

(5) *Interpretation of data.*—Since the data in column 1 is recorded at the same period each day it tells the engineer whether the battery is being properly maintained between equalizing charges. At the end of the equalizing charge, reference to columns 2 and 3 enables him not only to assure himself, by comparing the last month's maximum gravity with the present maximum gravity of the pilot cell, that the equalizing charge has been adequate, but also, by comparing the cell voltage and gravity of individual cells with the readings for the previous month, whether trouble is developing in any cell. A fairly certain indication of impending trouble is a drop in both cell voltage and gravity. A drop in one but not in the other may be due to error in taking readings, recent addition of water, or fluctuation in charging current, and has little significance if it does not recur in successive monthly reports. As a battery ages, there will be a gradual decrease in average and a tendency for the cell readings to spread.

(6) *The end of useful life* may be indicated by any one or all of the following facts:

(a) With solution level correct for all cells and after completion of equalizing charge, if the difference (spread) in gravity of the highest and lowest cells exceeds 30 points for portable batteries or 20 points for glass jar types, or if abnormal temperatures or excessive use of water are noted in one or more cells, or if a gradual but increasing decline is

noted in the gravity of one or more cells which an increase in daily charging or the monthly equalizing charge do not overcome, then the battery may be approaching the end of its useful life and should be given a capacity test, as described in paragraph 21-4-55 (D). If the symptoms are confined to one or two cells, the difficulty may be confined to those cells. Usually, spread in gravity will be general throughout the battery, accompanied by a gradual decline in the average gravity of all cells as the battery ages.

(7) *Indications of over-charging.*—If the water added to a 110-volt 200-ampere-hour battery exceeds about 2 gallons per month, it is an indication of overcharging. If the temperature rise in column 2 exceeds about 10° F., it is an indication that the charging rate was too high. If some unusual condition, such as excessive gassing in one or more cells, explosion in or above a cell, cracking or bulging of covers, difficulty in getting gravity to rise, etc., is noted, it should be recorded under "remarks."

21-4-55 Battery Repairs and Replacement—

A. Repairs shall not normally be attempted by station personnel; however, certain minor repairs may be performed by qualified depot personnel.

B. *When to replace.*—If a battery fails to deliver sufficient capacity to adequately perform the work intended of it with a moderate reserve, it should be replaced. The usual indications of end of useful life are increasing differences in individual cell voltages and gravities, which finally exceed the limits specified in paragraph 21-4-50 (A) (6).

C. *Sediment space.*—In stationary batteries, exhaustion may also be indicated by the sediment in the bottom rising until it touches the plates. The sediment space is designed to just hold the lost active material throughout the useful life. In portable types, the amount of residue may in some cases be determined by probe sticks.

D. *Capacity test.*—Before replacement of power batteries is requested, their capacity should be determined by a capacity test. This is accomplished as follows:

- (1) First give the battery an equalizing charge.
- (2) Then place it on discharge at a rate as near to its normal 8- or 10-hour rate as is practicable. (This may be accomplished during the daytime by turning on loads and keeping the rate as constant as possible by watching the ammeter and controlling the amount of load.)
- (3) Record the voltage at the beginning and every hour thereafter, or at more frequent intervals as the voltage begins to decrease.

E. A battery has 100 percent capacity if it carries its 8-hour rating in amperes (the rated capacity divided by 8) for 8 hours before the voltage drops to 1.75 volts per cell. If approximately the full capacity of a battery is required for the duty in which it is used, then it should be replaced if it delivers less than 80 percent of rated capacity. For instance, if the voltage of a 200-ampere-hour battery, which should deliver 20 amperes for 10 hours, falls to 1.75 volts per cell in less than 8 hours, it has delivered less than 80 percent capacity.

F. When it has been determined that replacement is necessary, *all cells* in the battery should be replaced. Insertion of new cells or cells of different capacity in a battery is very inadvisable except as a temporary expedient. The charging current consists normally of two components, one to restore normal discharge, the other to compensate for local action in the cells. Since the latter depends on the age and temperature of the cells, it thus follows that new battery cells requiring less current for local action become charged sooner than older cells. The practical result is that not only are new battery cells unnecessarily overcharged but older cells may be starved. The battery will rapidly become unbalanced, resulting in still more injury due to the need for additional charging of some of the cells.

G. *Manufacturer's inspection.*—The manufacturers who are awarded the term contracts provide, as a portion of their service with the batteries, inspections at regular intervals of at least every year. These inspections are made by qualified service engineers at the request of authorized Coast Guard officers. The advice given to the operating personnel during, and the report furnished the commanding officer after, such inspections, are most helpful to assure good service from the batteries.

H. *Procurement.*—Batteries should be purchased from the nearest office of the manufacturer having the current term contract.

I. *Disposition of exhausted batteries.*—Exhausted batteries must be surveyed as provided by Pay and Supply Instructions. Some term contracts provide a trade-in allowance on old batteries. This should be taken into account by members of a board of survey.

J. *Preparation for shipment.*—When preparing cells for shipment to the manufacturer, dump all acid from the cells, flush and dump a second time. When crating cells for shipment, be sure that the terminals are protected so that metal objects cannot accidentally span them. Even apparently exhausted cells may accumulate sufficient charge to cause a spark and fire.

21-5 CANDLEPOWER

21-5-1 Candlepower for Small Drum Lenses—

A. Following is a table of candlepower ratings for small drum lenses.

Lamp			Lens size					
Volts	Am-peres	Fila-ment	90 mm.	150 mm.	200 mm.	300 mm.	200 mm. di- rectional	
							Maxi- mum	Mini- mum
3.5	1.0	C8	40					
6.2	.25	C8	12	12	15		170	11
6.2	.46	C8	20	25	30		375	25
6.2	.70	C8	30	40	50		640	45
6.2	.92	C8		75	90		940	70
6.2	1.4	C8		110	140		1,450	115
6.2	1.84	C8		160	190		2,000	160
6.2	2.8	C8		210	270			

Volts	Am-peres	Fila-ment	V & H	200 mm.	300 mm.			
12	.77	C8	-----	85	140	-----	1,065	60
12	1.15	C8	-----	130	220	350	1,515	105
12	1.35	C8	-----	180	300	450	2,200	140
12	2.03	C8	-----	260	440	650	-----	-----
12	3.05	C8	-----	410	700	1,100	-----	-----

Volts	Watts	Fila-ment	150 mm.	200 mm.	300 mm.	375 mm.	500 mm.
32	36	C5	-----	280	400	-----	-----
32	60	C5	-----	1,300	2,000	3,000	4,000
32	100	C5	-----	2,500	3,700	5,000	7,500
32	250	C5A	-----	-----	7,500	10,000	15,000
32	500	C5	-----	-----	-----	25,000	35,000
115	56	C5	330	400	600	-----	-----
115	94	C5	-----	750	1,100	1,700	2,300
115	100	C5	-----	1,300	2,000	3,000	4,000
115	150	C5	-----	2,000	3,000	5,000	6,500
115	250	C5	-----	-----	5,500	7,500	10,000
115	250	4C8	-----	-----	2,500	4,500	6,000
115	500	C5	-----	-----	-----	15,000	20,000
115	500	4C8	-----	-----	-----	7,500	10,000
115	1,000	4C8	-----	-----	-----	15,000	20,000
115	1,000	CC8	-----	-----	-----	10,000	13,000
115	1,000	2C5	-----	-----	-----	20,000	25,000

NOTE 1.—Reduce the candlepowers by 12 percent when stormpanes are used.

NOTE 2.—200-mm. directional drum lenses give maximum candlepower on the main beam and minimum candlepower around the remainder of 360°.

B. Color transmission factors.—Apply the following average transmission factors to the candlepowers listed under paragraph (A) above to obtain the corresponding candlepowers for red and green color beams.

Red—0.22
Green—0.20

Example.—A 6.2 volt, .70-amp. lamp in a 150-mm. lens giving 40 candlepower in white beam will give 9 candlepower red or 8 candlepower green.

21-6 MINOR ELECTRIC LENS LANTERNS

21-6-1 General Description—

A. Lanterns used for minor electric lights and lighted buoys inclose low voltage electric lamps and their operating mechanism. They are of rugged cast bronze, iron, or aluminum watertight construction and are composed of two sections: a lower or

base section which houses the light operating mechanism and an upper section containing a lens which forms an integral part of the lantern. The upper section of the most commonly used lanterns is hinged to the base to provide easy access to the lampchanger and flasher mechanism.

B. Size.—Lanterns are used in size from 90 mm. to 375 mm. and may show a light 360° around the horizon, or a narrow beam as on a range. Lanterns are provided with colored shades or screens, or colored lenses, when a light of red or green color is desired. Range lanterns may be of the bull's-eye type showing a beam of light in one direction only, or may have a directional drum lens which shows a strong concentration of light along a narrow beam with a light of lesser brilliance showing around the remainder of the 360°.

C. Drum and disc lenses.—Lenses used in minor electric lanterns are generally pressed glass except for the 300- and 375-mm. lanterns which are cut and ground glass. Two basic designs are in use: the cylindrical or drum type, and the disc type. The size of the lens is designated by its inside diameter in millimeters. Lenses are generally furnished clear in color; however, red and green lenses are currently being manufactured in the 90- and 200-mm. sizes.

(1) Pressed glass drum lenses are molded in one piece, cylindrical in shape, having horizontal prisms molded on the outer surface. These lenses concentrate the light into a fan beam. Pressed glass directional drum lenses have vertical prisms molded on the inner surface as well as horizontal prisms on the outer surface. This type of lens emits a 360° beam of light with a concentrated beam in one direction.

(2) Cut-or ground-glass lenses are made up of separate prisms in the form of complete rings which are mounted in a framework in such a manner as to form a cylindrical or drum section. These rings are ground and polished and then mounted in the desired shape. A cut-glass lens is more efficient than a pressed-glass lens, especially in the larger sizes. In lenses up to 200 mm. the difference does not warrant the increased cost of the cut-glass lens.

(3) Disc type lenses are pressed glass lenses used in range lanterns and may vary from 9 3/8 inches to 8 1/2 inches in diameter. The prisms are moulded in two forms; concentric rings around a center bull's-eye which emits a concentrated pencil beam, and straight horizontal or vertical prisms which produce a spread beam. Disc lenses may be flat or convex and their size is designated by their outside diameter. Spread lenses are called "roundels" or "doublets".

D. Mirrors are used in certain range lanterns. In this event, a plain front glass is substituted for the dioptric lens. When it is desired to produce a spread beam, however, a spread lens is either substituted for, or used in conjunction with, the plain front glass.

E. A "shade" is a device installed in a lantern to change the natural color of the light source to red or green. They are colored glass cylinders or discs located inside the lens. The term "screen" as used by Wallace and Tiernan Products, Inc., is synony-

mous with "shade" or "color filter." Shades are furnished in different sizes to fit various size and type lanterns and may or may not be interchangeable. See specific lantern type descriptions below.

F. Acceptable designs.—No distinction is now being made in the design of lanterns for application either to structures or to buoys. All acceptable present designs except range lights are suitable for mounting on buoys. All designs adhere to standard mounting dimensions and must be waterproof, except the post lanterns in use on the Mississippi River system and in protected inland waterways. The size and comparative weights of electric and acetylene lanterns are:

Approximate weights of lanterns		
Lantern size (millimeters)	Electric lantern (bronze) (pounds)	Acetylene lantern (bronze) (pounds)
90	30	-----
150	45	30
200	45 (20 alumin.)	170
300	270	300
375	530 (280 alumin.)	530 (280 alumin.)

21-6-5 360-degree Types—

A. The types of 360° lanterns in current use are described in the following paragraphs.

NOTE.—The abbreviations A. G. A. and W. & T. used in this chapter mean American Gas Accumulator Co. and Wallace & Tiernan Products, Inc. respectively.

B. 300-mm. A. G. A. type (fig. 21-17).—This is a stormpane lantern and is a modification of its acetylene counterpart. A cut-glass lens is used and is interchangeable with the acetylene lantern, although the *colored shade is not*. A type C shade without rings sets on a shade holder and is held in place by fingers fastened to the top hinge ring. The W. & T. type FU-1297 lampchanger is used. A few lanterns are equipped with a nonstandard "Daisy-chain" type lampchanger. (This is the type lampchanger shown in fig. 21-17.)

C. 300- and 375-mm. A. G. A. types.—The 300-mm. A. G. A. lantern (fig. 21-17) is a stormpane lantern similar to its acetylene counterpart. The hinged top is a conical casting providing a mount for the sun relay, which may also house the flasher and protective relay, when used. The color shade used is not interchangeable, being of a larger diameter than the acetylene shade. This shade, without rings, sets on a shade holder and is held in place by fingers fastened to the top hinge ring. The standard type FU-1297 lampchanger can be used, provided suitable mounting is furnished.

The 375-mm. lantern (fig. 21-18) is a modification of its acetylene counterpart, equipped with a W. & T. type FA-147 lampchanger. The modification consists of replacing the acetylene lantern ventilating top head assembly with a conical casting and replacing the acetylene test valve manifold with a terminal box. The lantern may be of bronze or aluminum construction. A sun relay may be mounted as shown in figure 21-17. This illustration shows the type FU-847 lampchanger ("daisy-chain") of which only a few are in use. A type

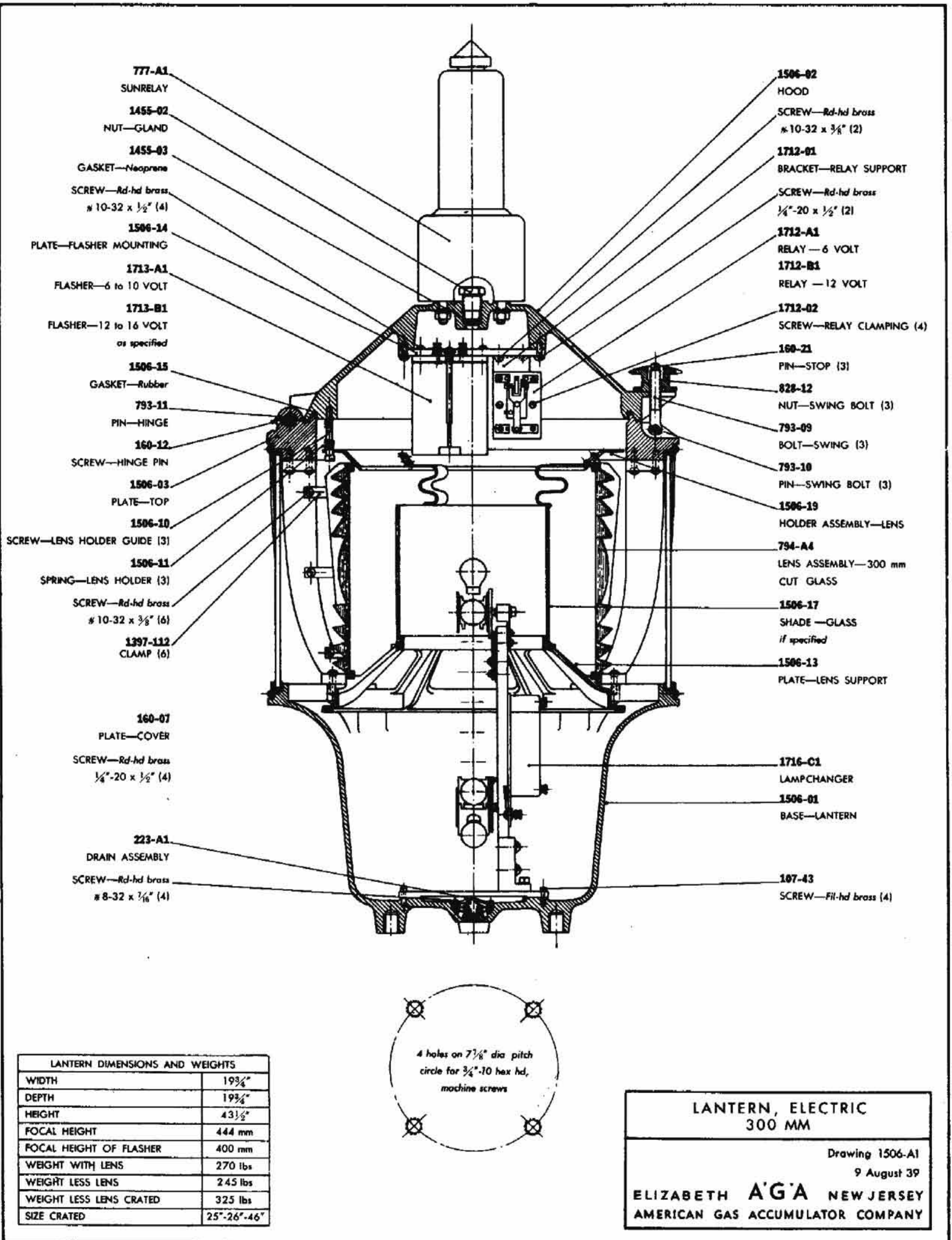
FA-147 lampchanger is generally installed. The 375-mm. lantern is sometimes manufactured as a duplex lantern with the base of the upper lantern being cast integral with the hinged top of the lower lantern. A pressed-glass lens or a standard A. G. A. cut-glass lens may be used. These lanterns are presently operated on 32 or 110 volts a. c. or d. c. A standard color shade for the 375-mm. acetylene lantern may be used in the electric lantern if used without lampchanger, otherwise small individual shades fitting over each lamp must be used when a type FA-147 lampchanger is installed (see fig. 21-50). A fixed lamp stand may be installed, equipped with a socket for lamps of commercial line voltage. In the event a single lamp stand is used, a standard acetylene 375-mm. shade is suitable for high voltage lamps of up to 5 inches in diameter (PS or P-40). For larger lamps, special provisions must be made.

D. 300-mm. Service-type.—This is a two-section lantern having three 120-degree pressed-glass lens sectors fitted in the upper framework. The upper section is hinged to the base for access to the flasher and lampchanger. A 200-mm. type "C" color shade is used, having a spun brass protecting ring installed on the bottom edge. The shade sets in a machined ring and is held in place by thumbscrews. A standard 6-10- or 12-16-volt W. & T. flasher and a four-lamp type FU-1297 lampchanger is mounted on a lampchanger support using mounting studs.

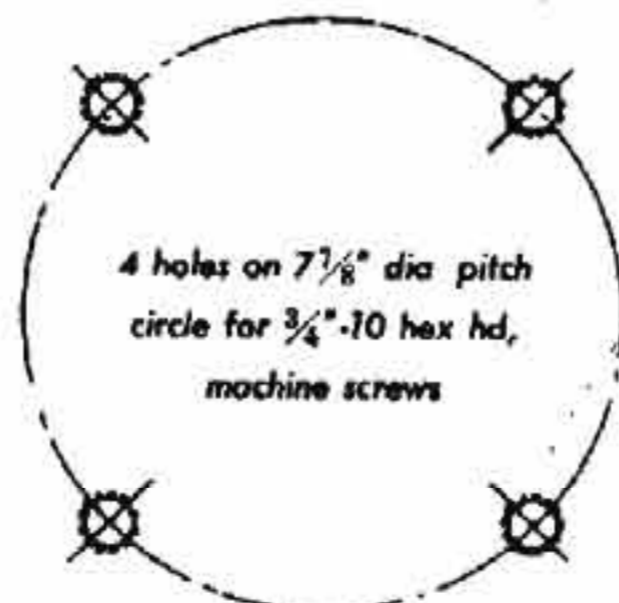
E. 300-mm. type 1954.—This is an aluminum lantern fitted with a one piece 300 mm. closed top pressed glass lens. The lantern is serviced through a door in the side of the base on which a standard 6-10 or 12-16-volt W. & T. flasher mounts. The lantern is ordinarily equipped with a 17-unit 6-16-volt W. & T. type 3800 lamp charger which permits lamps to be overvoltaged. Lenses are being produced in clear, red and green.

F. 200-mm. Service-type (fig. 21-19).—This is a two-section lantern, the base containing three mounting bars for the flasher and lampchanger mechanisms, and the top containing a 200-mm. 360-degree pressed-glass drum lens and a conical top casting. The lens is identical with the 200-mm. acetylene Service-type, except that it is not fitted with rings. A standard type C color shade with rings is used. This shade is installed by compressing the spring fingers which, when released, clamp the shade in place.

G. 150-mm. Service-type (fig. 21-19).—This lantern is similar to the 200-mm. Service-type, but correspondingly smaller. The same flasher and lampchanger support as provided for the 300-mm. Service-type is used instead of the flasher mounting adapter bars. The lantern contains a standard 150-mm. pressed-glass 360-degree lens which is not interchangeable with the W. & T. 150-mm. lens. Type B color shades are used in this lantern and a S-8 lamp must be inserted when color shades are installed because of insufficient clearance for the S-11's. The type B shade is, like the type C, provided with rings and spring fingers and is installed inside the lantern lens. Although almost identical in size with the W. & T. shade, they cannot be interchanged, since the closed-top W. & T. lens is not deep enough to take the type B shade with rings.



LANTERN DIMENSIONS AND WEIGHTS	
WIDTH	19 3/4"
DEPTH	19 3/4"
HEIGHT	43 1/2"
FOCAL HEIGHT	444 mm
FOCAL HEIGHT OF FLASHER	400 mm
WEIGHT WITH LENS	270 lbs
WEIGHT LESS LENS	245 lbs
WEIGHT LESS LENS CRATED	325 lbs
SIZE CRATED	25"-26"-46"



LANTERN, ELECTRIC
300 MM

Drawing 1506-A1
9 August 39

ELIZABETH A'G'A NEW JERSEY
AMERICAN GAS ACCUMULATOR COMPANY

FIGURE 21-17.—300-mm. A. G. A. lantern.

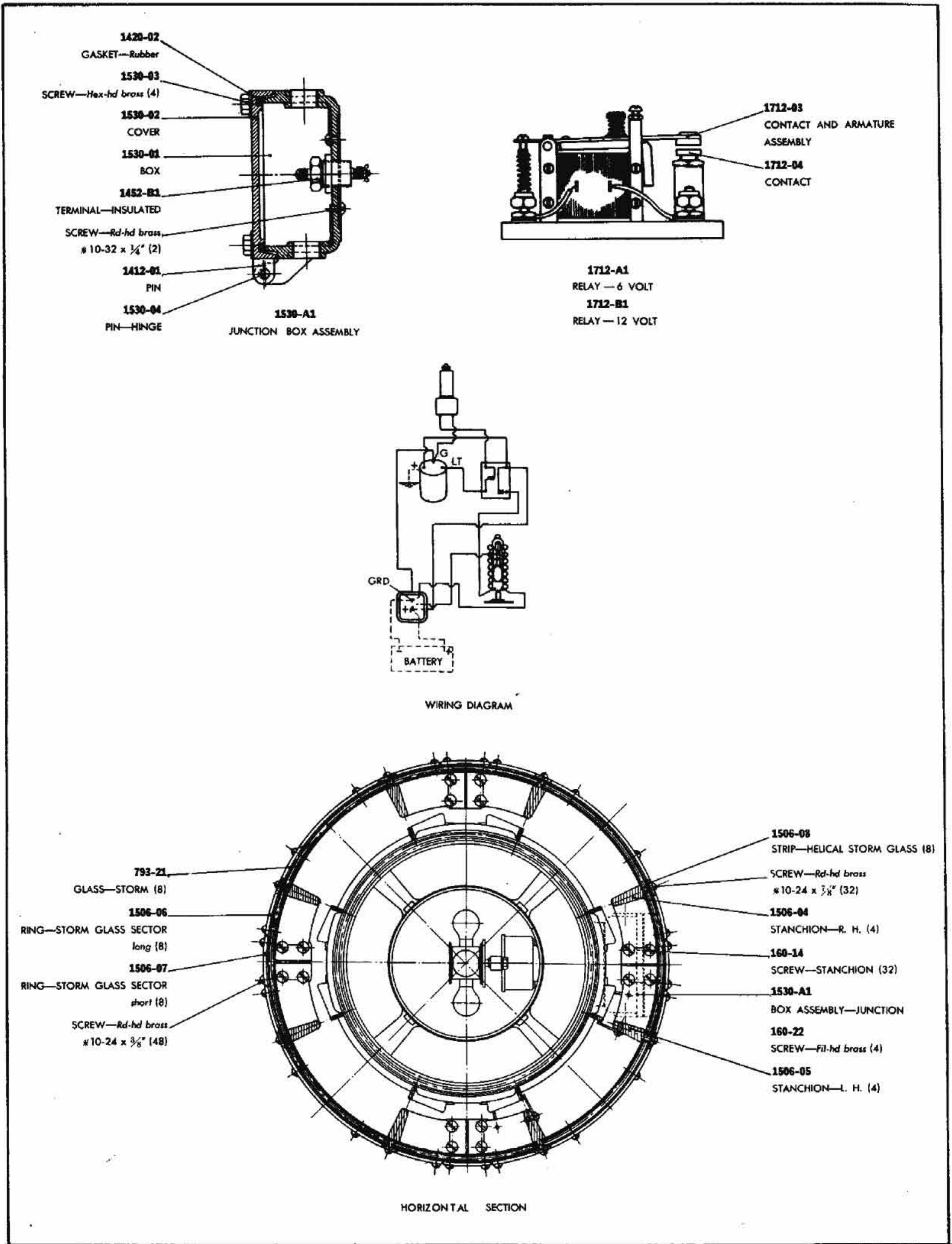


FIGURE 21-17A.—300-mm. A. G. A. lantern parts assemblies.

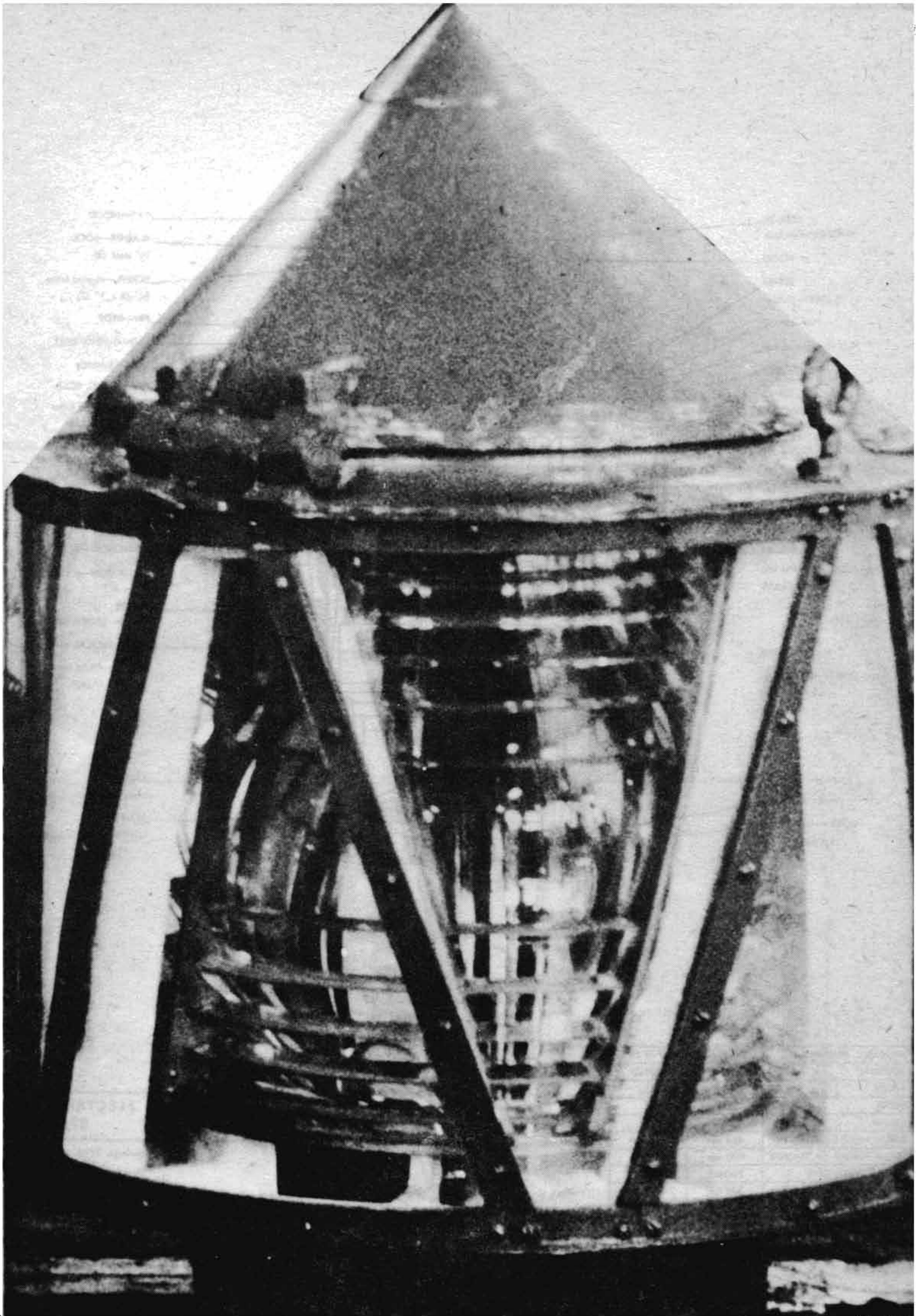


FIGURE 21-18.—375-mm. A. G. A. lantern.

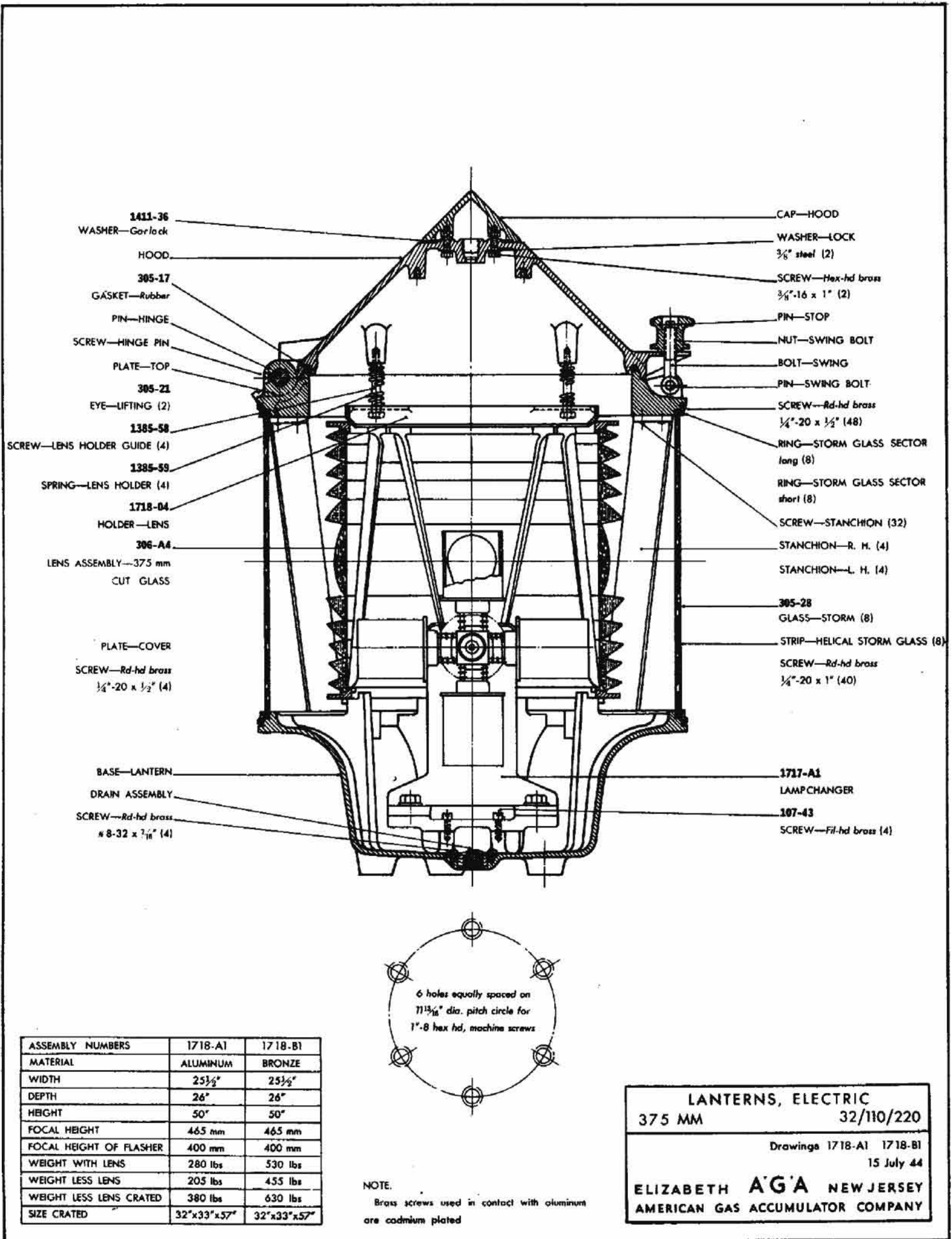


FIGURE 21-18A.—375-mm. A. G. A. lantern.

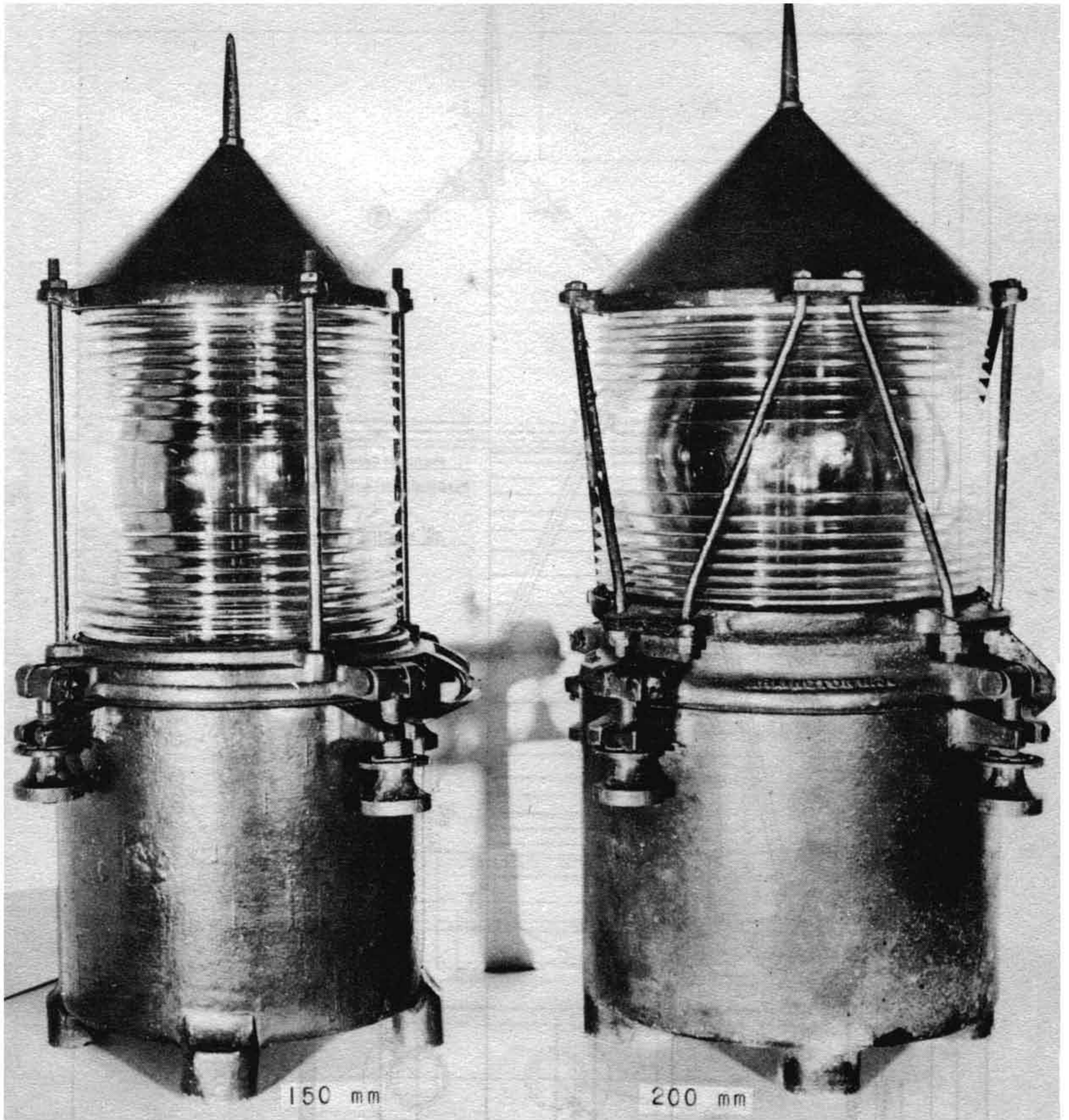


FIGURE 21-19.—150- and 200-mm. Service-type lanterns.

G. 200-mm. Coast Guard standard-type (fig. 21-20).—This lantern is the latest design of Headquarters, available in aluminum or bronze construction and uses a standard 200-mm. pressed-glass lens in clear, red, or green color. A type FU-1297 W. & T. lampchanger with a 6—10- or 12—16-volt standard flasher is installed. The top and lens section are secured by round astragal bars, and the entire section hinges at the bottom lens ring.

This lantern (sometimes called the "new" style Service-type) differs from the Service-type 200-mm. lantern (see par. E above) in the following important respects:

(1) The lantern base (pot) in the new style lantern is smaller in diameter and is provided with mounting bolt lugs instead of tapped holes. Therefore, bolts with nuts and washers are required instead of threaded studs.

(2) The new design does away with the mounting and adaptor bars (see fig. 21-20). The flasher and lampchanger are mounted on a flat offset bar which is secured to a machined surface inside the upper section of the base. Spacers are provided for accurate focal height adjustment.

(3) Lens gaskets are flat instead of the "channeled" type formerly used.

(4) The hinge ring gasket is now a channeled ring instead of the strip form previously used.

(5) Except for the lens used, none of the parts of either lantern are interchangeable. The wiring of the new lantern is identical with the old-style Service lantern. Both lanterns use either a 6—10-volt W. & T. type FU-839, or a 12—16-volt FU-840, flasher and a type FU-1297 lampchanger.

H. 200-mm. W. & T. type FA-51 (figs. 21-21 and 21-22).—This lantern, like the 200-mm. Service-type, is made in two sections, the lower housing the flasher and the upper being the lens section. A 200-mm. 360° pressed-glass drum lens is set in rubber gaskets, clamped by helical tie bars. A waterproof cover is located between the upper and lower sections, under which the flasher is attached and on top of which is mounted the lampchanger. This cover is to provide watertight protection for the flasher in the event the lens is broken. The entire lantern may be submerged without damage or interruption of service. The same lower section of this lantern is used on the 150-mm. W. & T. type FA-50 lantern. The drum lens is interchangeable with the 200-mm. Service- or Coast Guard standard-types. This lantern takes either a 6—10 or 12—16 volt flasher and a type FU-1297 lampchanger. In the absence of a red-colored lens or if a green color is desired, a color shade (screen) must be used. The color shade is considerably larger than the type C shade and the lens must be removed from the lantern in order to install it.

This shade is equipped with rubber protecting rings and sets inside of the lens on a machined rim of the hinge ring. A type "C" shade could be used in this lantern; however, the W. & T. shade is not adapted for use in the Service- or Coast Guard standard-type lantern.

I. 200-mm. W. & T. dual-purpose type FA-98 (fig. 21-23).—This lantern is identical to the type FA-51 200-mm. W. & T. lantern except for the lens section.

It is designed for the dual purpose of providing a lighted aid for the aviator as well as the mariner. The lens has a dome shape which casts a useful beam from 3 degrees below the horizontal to the zenith. The lens is secured to the hinge ring section by a clamp ring and lens flange. The colored shades or screens are also dome shaped. The lens must be removed in order to replace the shade. A rubber protective ring is provided for the edge of the shade and a clamp screw is fitted through the top center to hold the shade firmly in place. A dual contact W. & T. flasher mechanism (FU-876 or FU-878) is used with a standard lampchanger when 120 flashes per minute are desired, otherwise a standard flasher is used.

J. 200-mm. W. & T. duplex type FA-137 (fig. 21-24).—This is a duplex 200-mm. lantern similar to the W. & T. FA-51. The base of the upper lens section is hinged to the top casting of the lower lens section. Two lampchangers are furnished with a protective relay to prevent excessive lamp current through the flasher contacts if lamps of more than 2 amperes are used. One 6—10- or 12—16-volt standard flasher is used. The lampchangers operate only when the flasher contacts are closed, therefore when the two lampchangers are connected in parallel, it is impossible to use the direct positive connection. If it were used, the failure of a lamp in one lampchanger would cause the lamp in the other to burn fixed, and a failure of the lampchanger containing the defective lamp to rotate. Without the direct positive connections, the lampchangers will rotate intermittently, i. e. each time the flasher light contacts close. Standard 200-mm. color screens or colored lenses are used in all 200-mm. lanterns.

K. 200-mm. W. & T. duplex dual-purpose type FA-138 (fig. 21-25).—This lantern is a duplex dual-purpose (vertical and horizontal) type, the top lens assembly being identical with the type FA-98. Two FU-1297 lampchangers and one flasher are installed.

L. 150-mm. W. & T. type FA-77 (fig. 21-26).—This lantern may also be furnished with an open top lens (fig. 21-27). A ring casting with a bird spike replaces the closed top. The color shade is similar but smaller in size to that used in the 200-mm. lanterns and is not adaptable for use in Service-type lanterns. The lens used in the type FA-77 lantern is not interchangeable with the Service-type 150-mm. lantern. The lens must be removed to insert the color shade, and as in the case of the Service-type 150-mm. lantern, a size S-8 lamp must be used. A similar type FA-50 lantern (figs. 21-26A and 21-27A) was formerly manufactured and a number are still in use.

M. 90-mm. W. & T. type FA-46 (fig. 21-27).—This lantern is used without lampchanger, the bulb being mounted in an adjustable receptacle for focussing. A standard flasher is mounted in the base. Red-colored lenses and green color shades with clear lenses are available for these lanterns.

N. 90-mm. Service-type lantern (fig. 21-28A).—This lantern was developed for use on inland waterways and consists of a 90-mm. closed-top lens secured by a flanged lens ring to a wooden canvas-covered battery housing. Focusing is accomplished by ad-

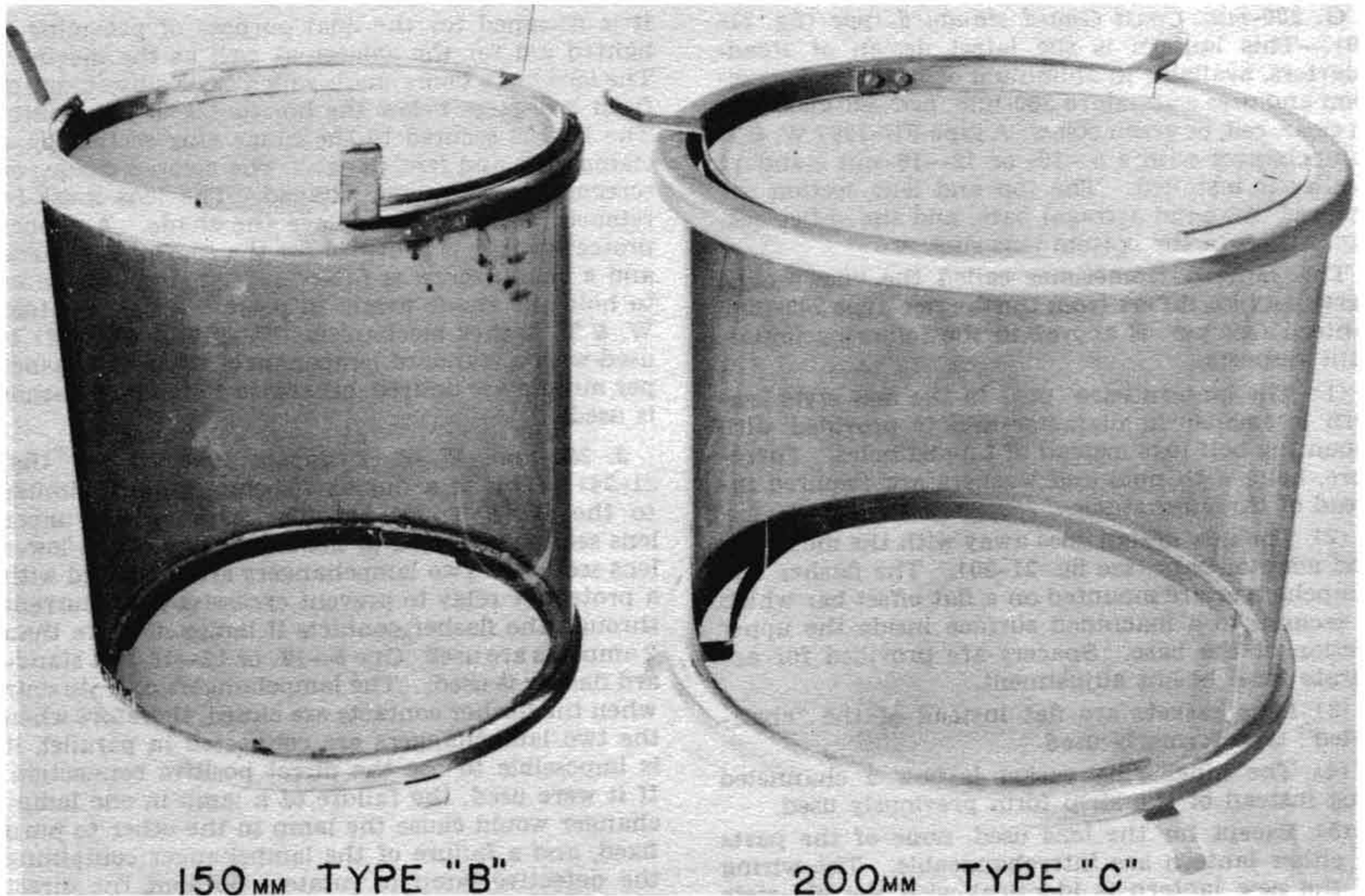


FIGURE 21-20A.—Types B and C 200-mm. lantern color shades (screens).

justing the round head 10-24 brass screw upon which the flange of the lampholder rests (fig. 21-28B). The color shade is a standard A. G. A. 150-mm. acetylene thermosyphon shade, part No. 626-10. The flasher mechanism is located in the battery housing. Other type housing structures are also used with this lens arrangement.

O. Watertight integrity of lanterns.—If it is necessary to replace either a lens in a 150- or 200-mm. lantern or remove same for color shade installation, be sure to maintain the watertightness of the lantern upon replacement of the lens. Check the new lens for chipped edges on the top and bottom surfaces. Centralize the lens in the gasket spaces and see that the "0" focusing marks are clear of the holding down bars or rods. Tighten the holding-down screws or nuts gradually and evenly, and test the lantern for watertightness as follows:

(1) Screw a one-half-inch short nipple into the one-half-inch pipe plug hole in the lantern base of the Service-type, or terminal base of the W. & T. lantern.

NOTE.—In the W. & T. lantern it will be necessary to remove the ground stud connection in the terminal box in order to admit air to the lantern base. Also remove the one-half-inch pipe plug in the flasher and lamp-changer mounting plate and remove the watertight fitting (stuffing box) in the terminal box, replacing same with a three-fourths-inch pipe plug.

(2) Screw a one-half-inch T on the short nipple; follow with another short nipple.

(3) Screw a one-half-inch globe valve on the short nipple; follow with another short nipple.

(4) Screw a one-half-inch union on the short nipple; follow with an air hose.

(5) Place a low-pressure gage on the T (0-15 pounds per square inch is preferable).

(6) Admit air slowly, *not to exceed a pressure of 5 pounds per square inch*, and submerge in a tank of water.

(7) Bubbles will indicate such leaks as may be present. The lantern may be made tight by *carefully* tightening the clamping screws or nuts adjacent to the area involved. Avoid too great a strain on the clamping devices. Compression of gaskets beyond resiliency in order to stop leaks indicates that something is wrong. Remove the lens, examine and replace the gasket if necessary.

P. Lamps used in the aforementioned lantern are of special design having a single vertical filament and are of the pefocus base type. See section 21-5-1 for further description.

(1) With the exception of the FA-98 and FA-138 lanterns, lamp currents may run from 0.25 to 4.2 amperes. Where the lamp exceeds 3 amperes, a protective relay is required, since the flasher contacts are not rated for higher values.

(2) In the type FA-98 and FA-138 lanterns where the rate of flash is 120 flashes per minute, the current value of the lamp should not exceed 1.15 amperes, otherwise the filament will not have sufficient time to cool between flashes.

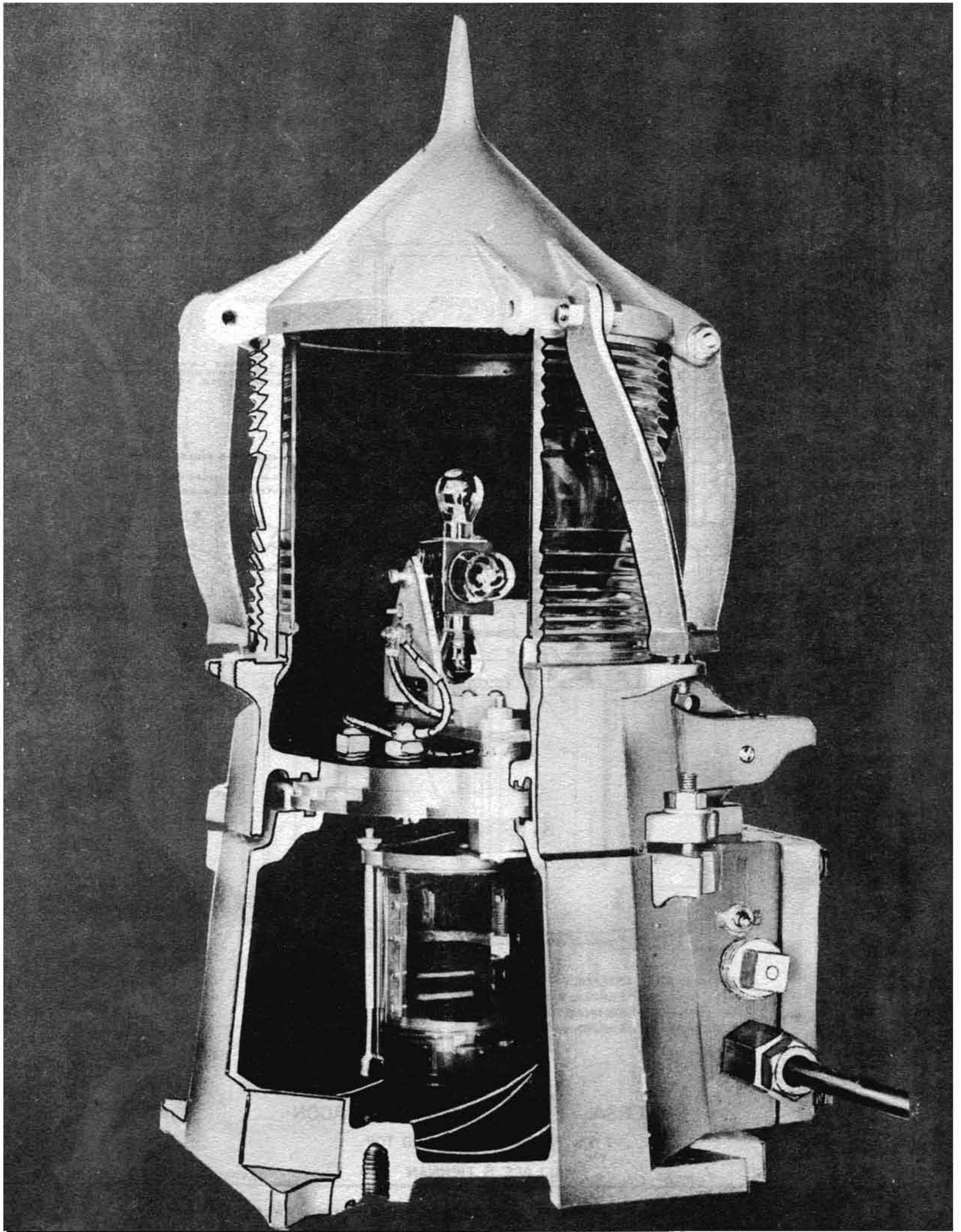


FIGURE 21-21.—200-mm. W. & T. lantern, type FA-51.

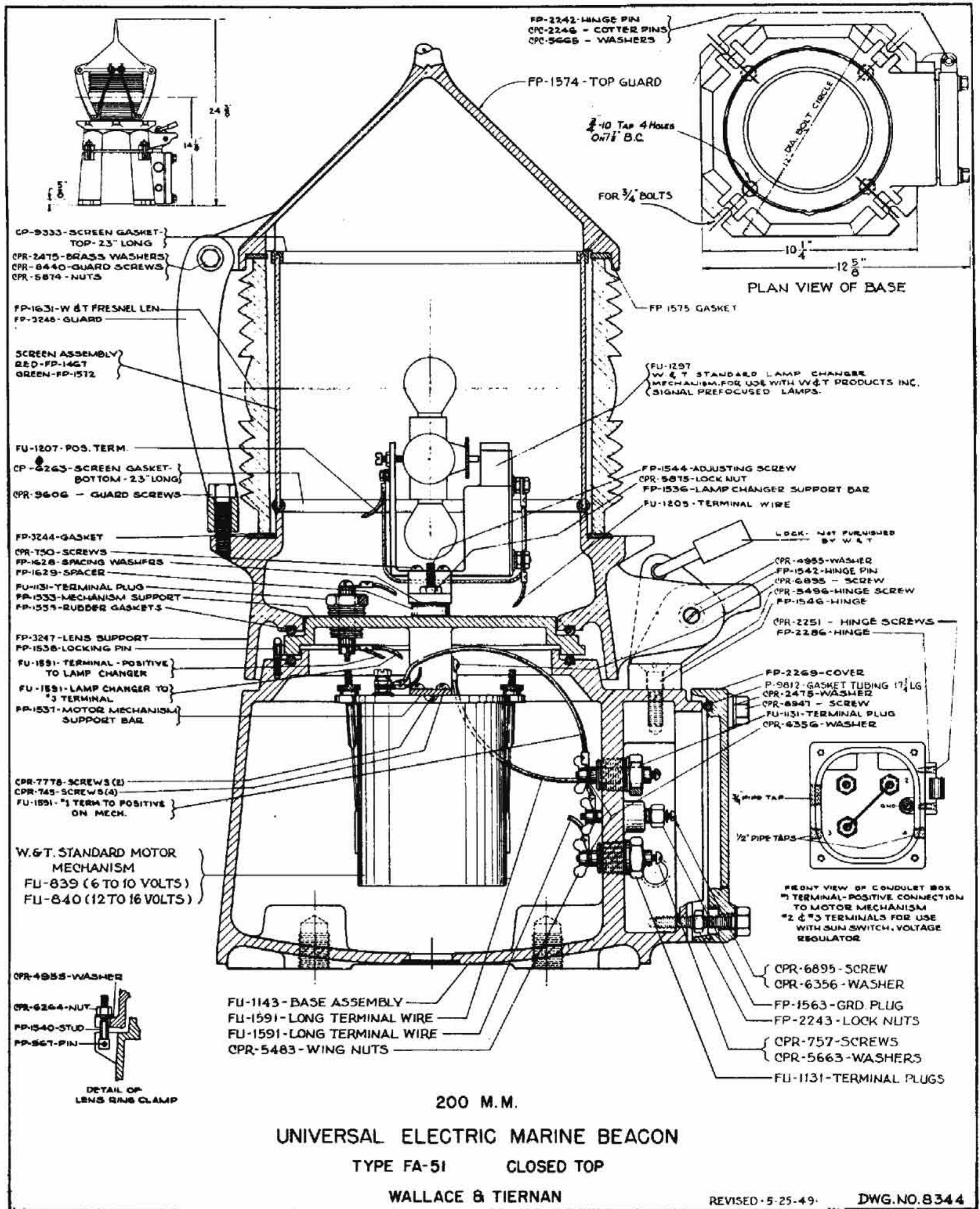


FIGURE 21-22.—200-mm. W. & T. lantern, type FA-51.

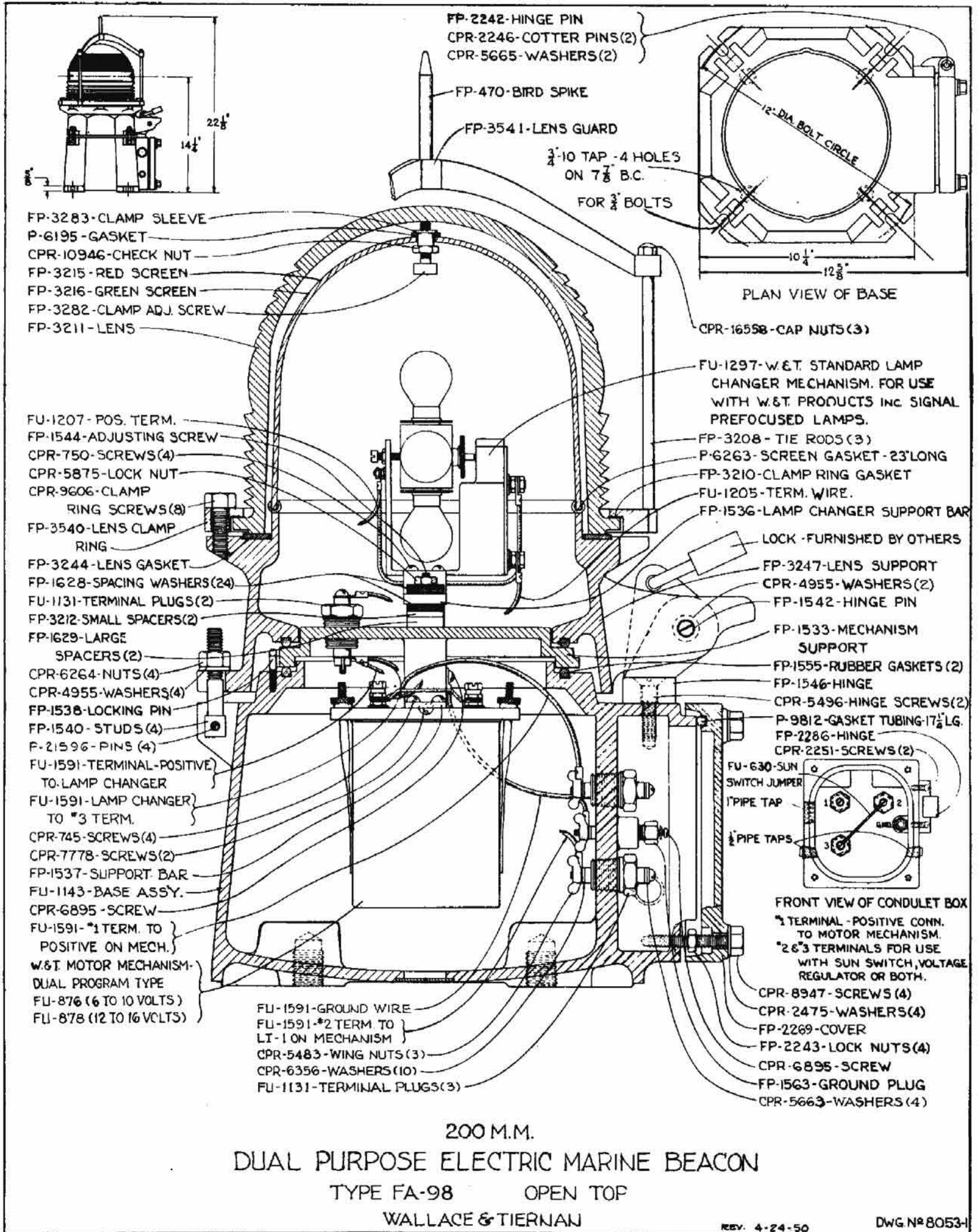


FIGURE 21-23.—200-mm. dual-purpose W. & T. lantern, type FA-98.

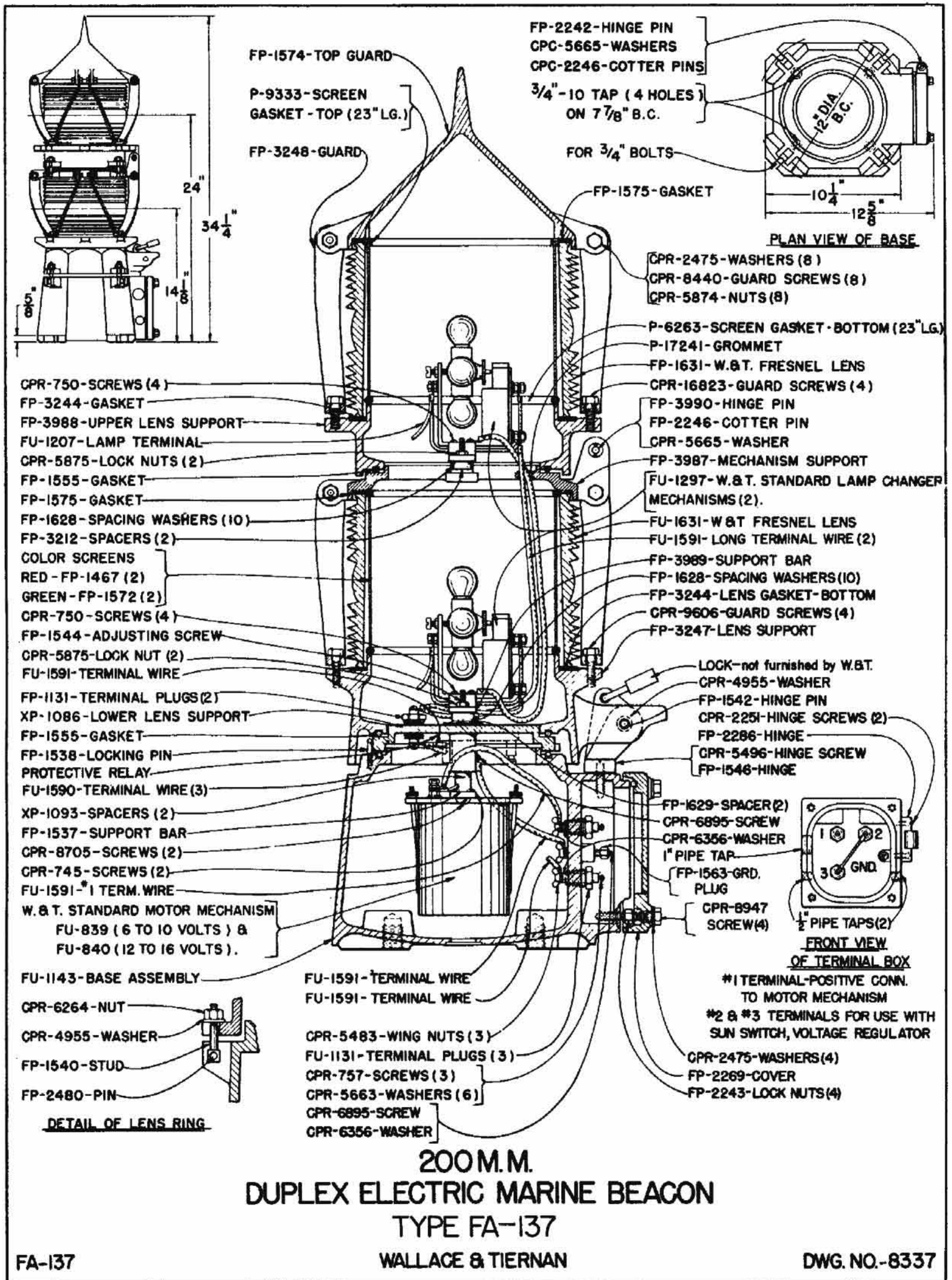


FIGURE 21-24.—200-mm. duplex W. & T. lantern, type FA-137.

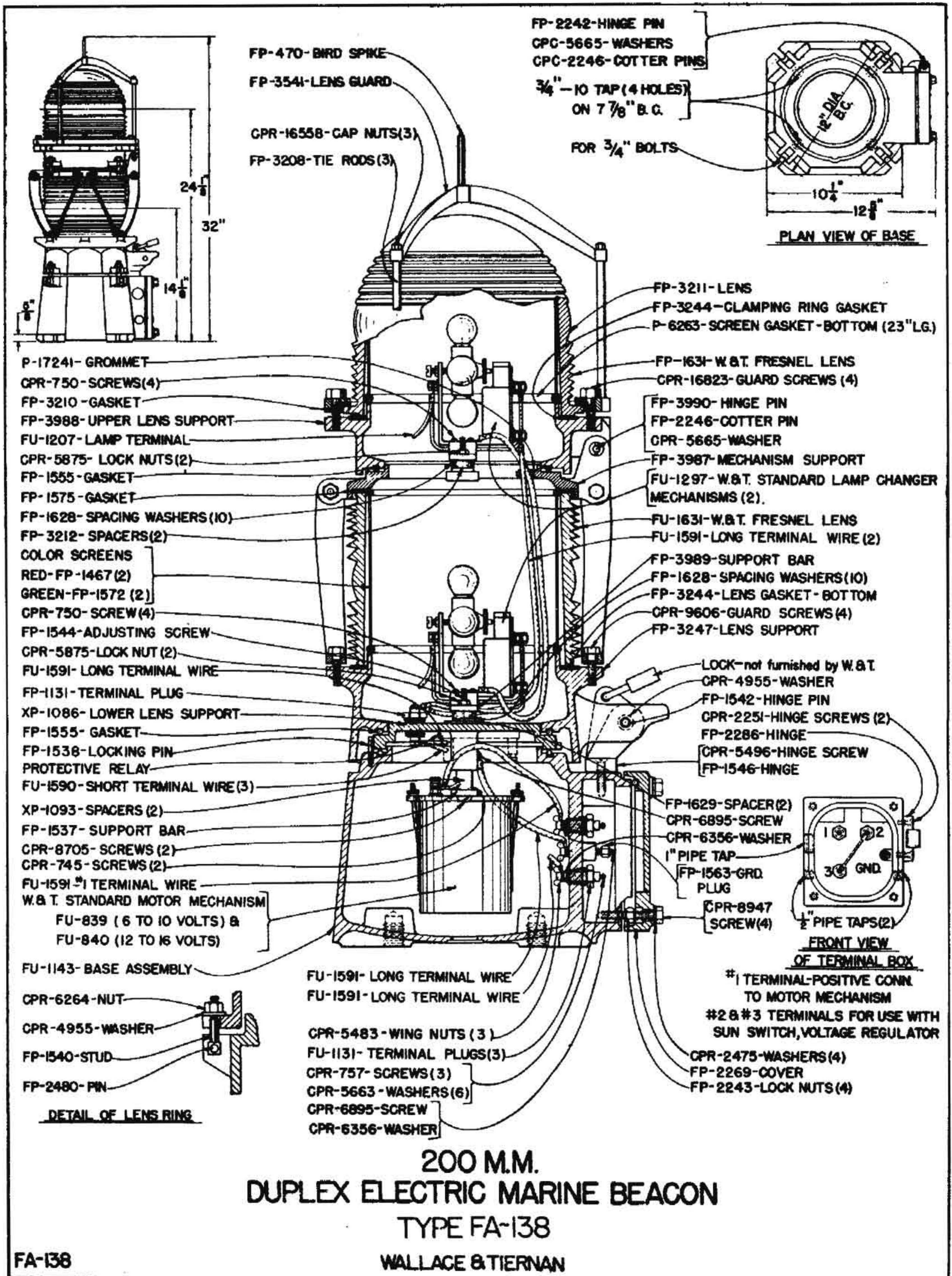


FIGURE 21-25.—200-mm. duplex W. & T. lantern, type FA-138 (dual-purpose).

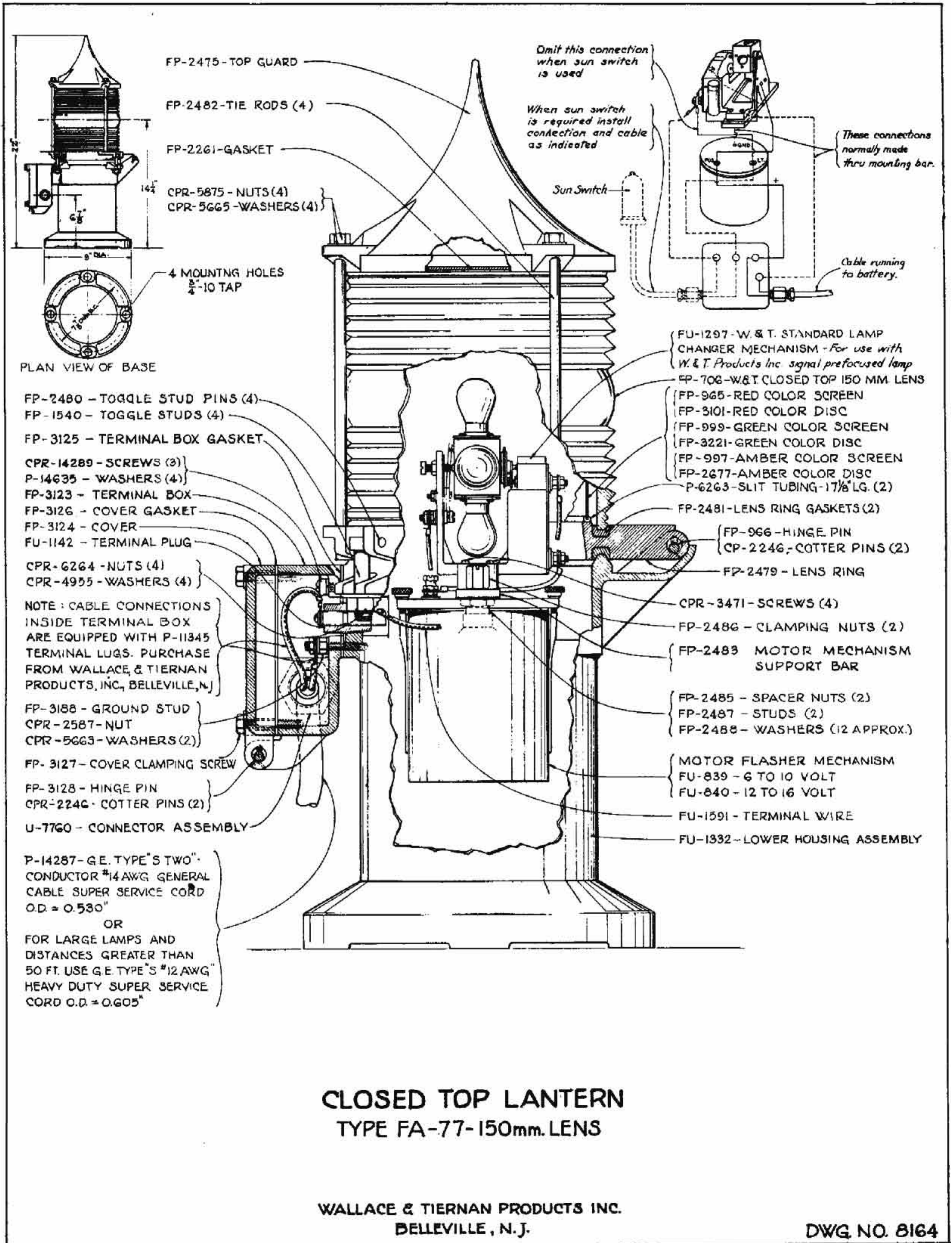


FIGURE 21-26.—150-mm. W. & T. lantern, type FA-77.

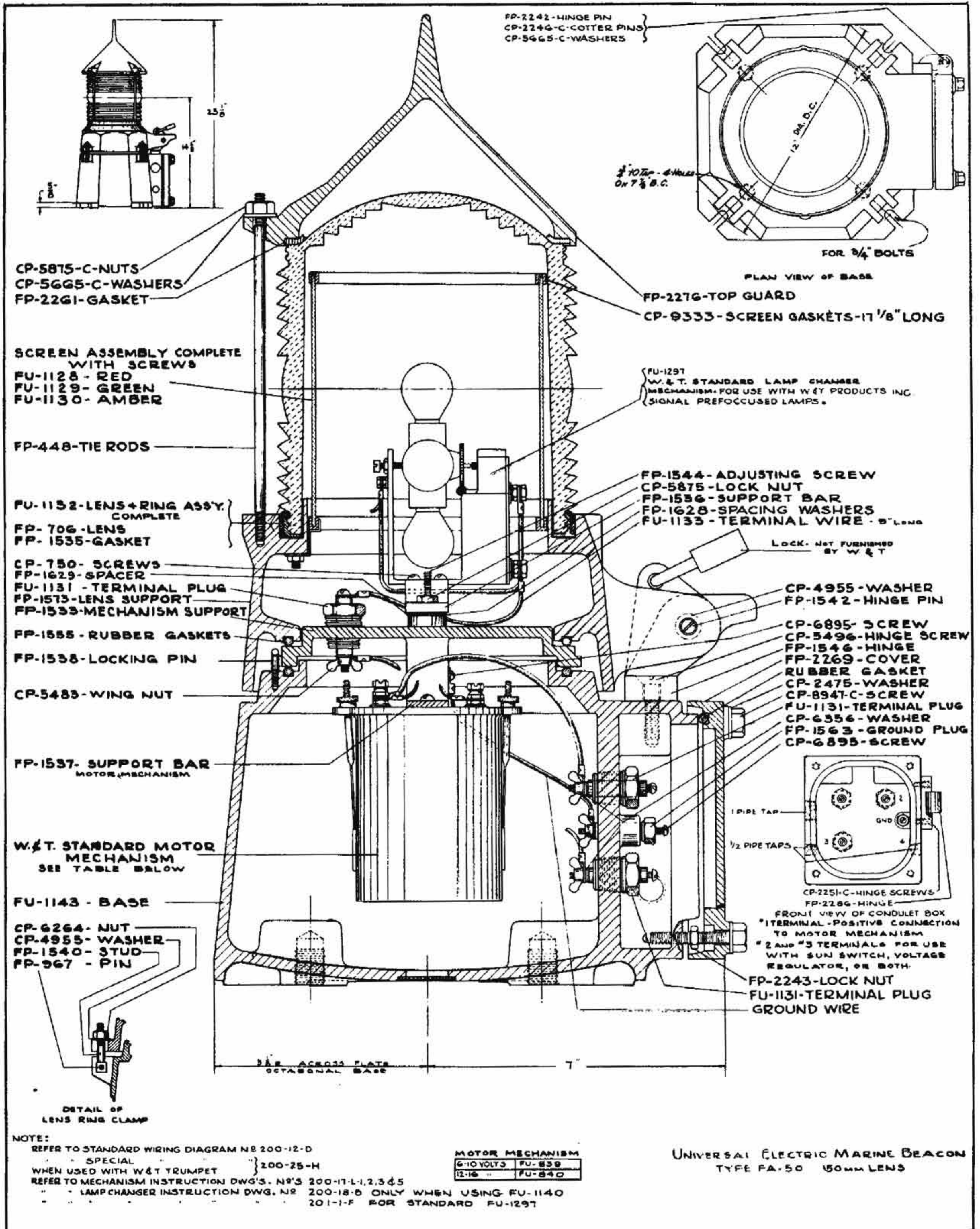


FIGURE 21-26A.—150-mm. W. & T. lantern, type FA-50. (No longer manufactured but many are still in use.)

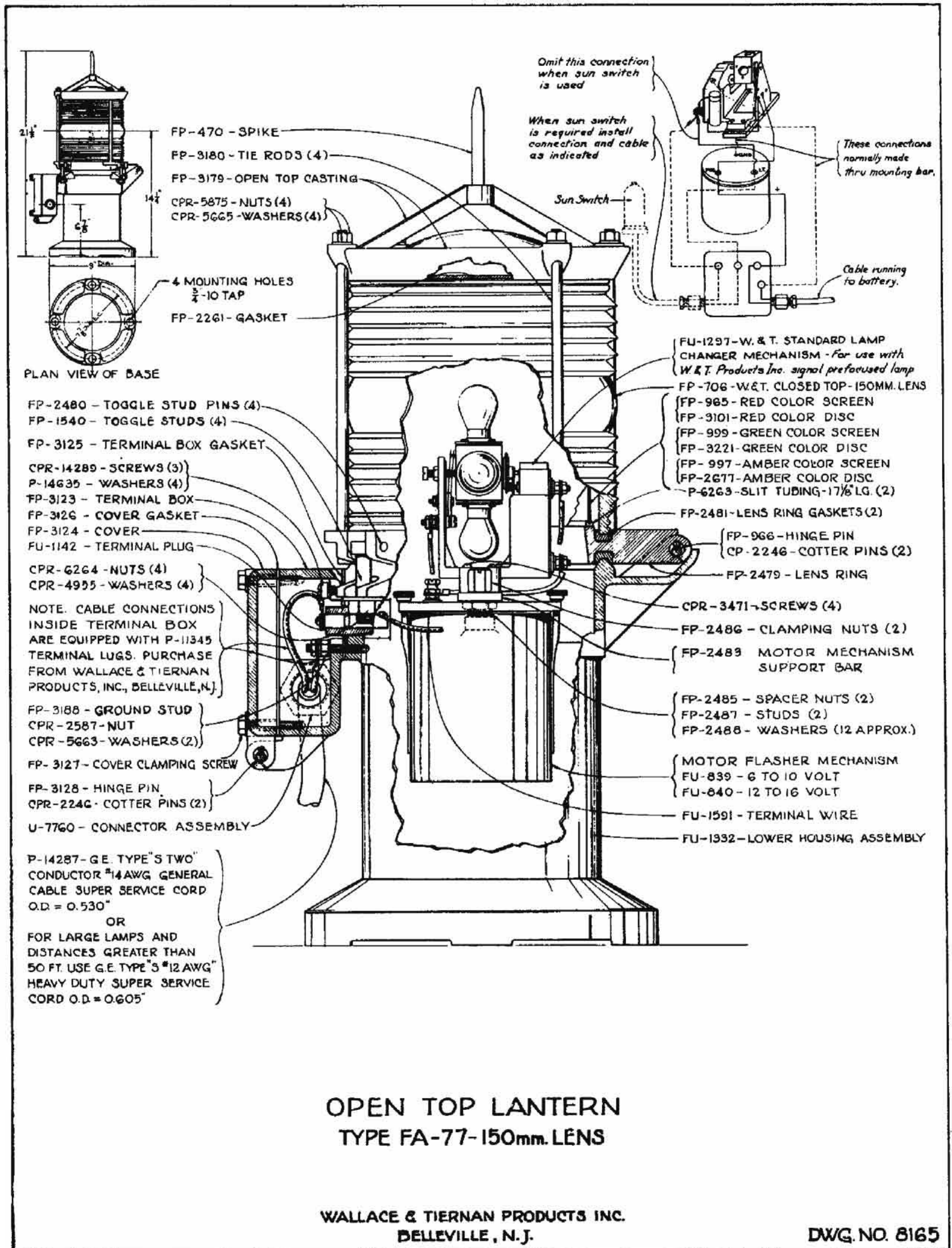


FIGURE 21-27.—150-mm. W. & T. lantern, type FA-77 (open top).

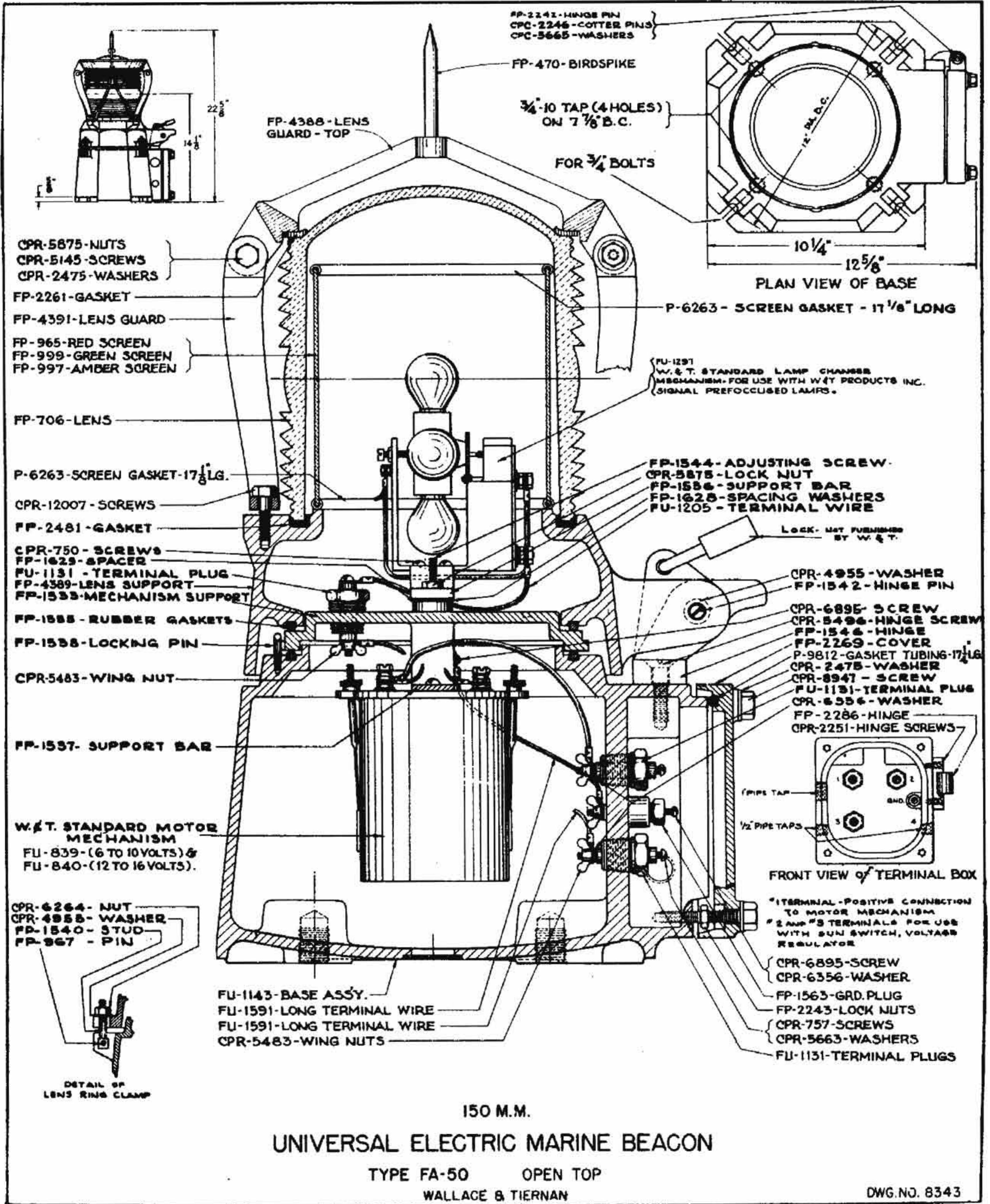
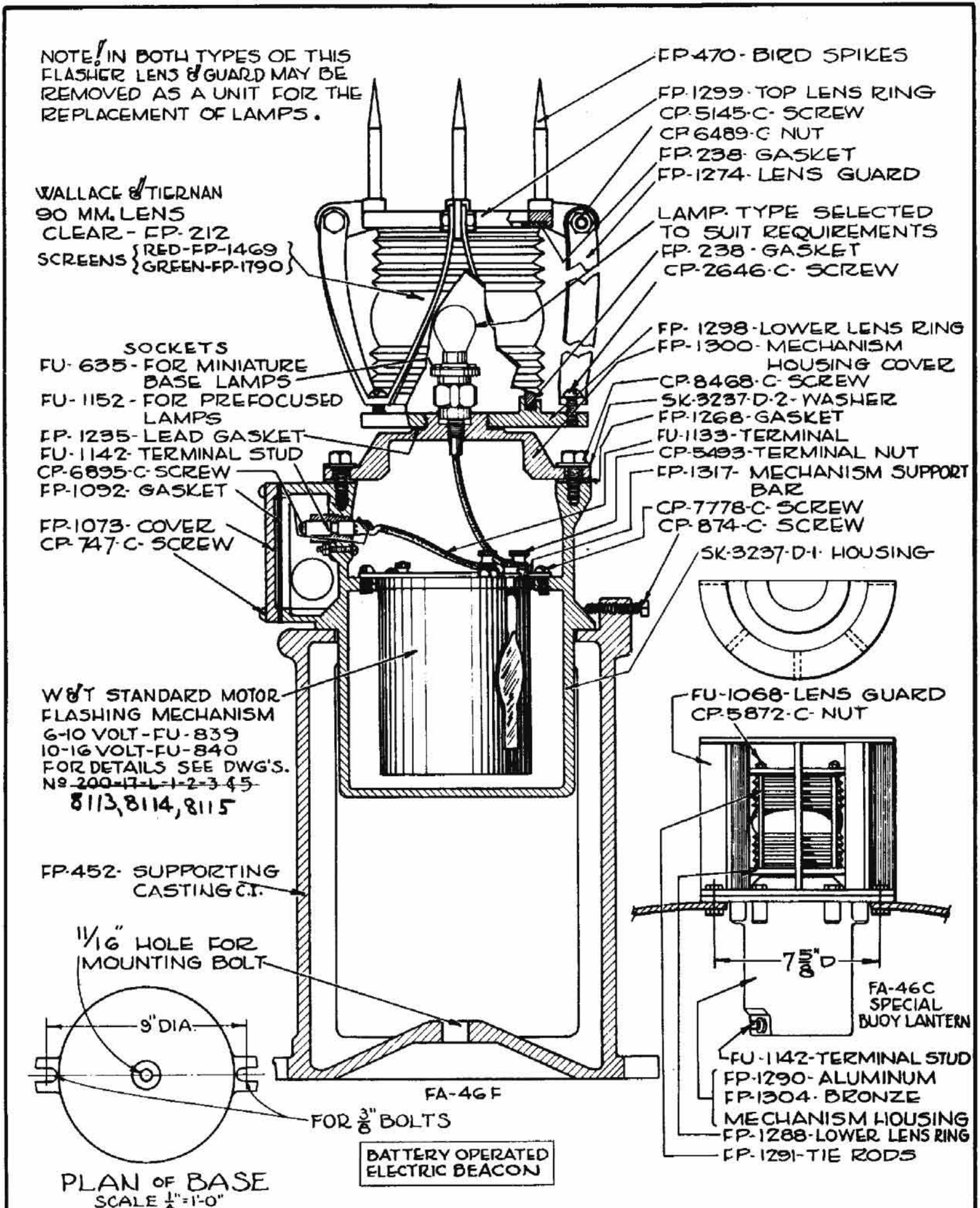


FIGURE 21-27A.—150-mm. W. & T. lantern, type FA-50 (open top). (No longer manufactured but many are still in use.)



WALLACE & TIERNAN 90 M.M. FLASHING POST LIGHT
TYPES FA-46-F AND FA-46-C

WALLACE & TIERNAN PRODUCTS INC.

BELLEVILLE, NEW JERSEY

FIGURE 21-28.—90-mm. W. & T. flashing post light, types FA-46-F and FA-46-C.



FIGURE 21-28A.—90-mm. Service-type lantern.

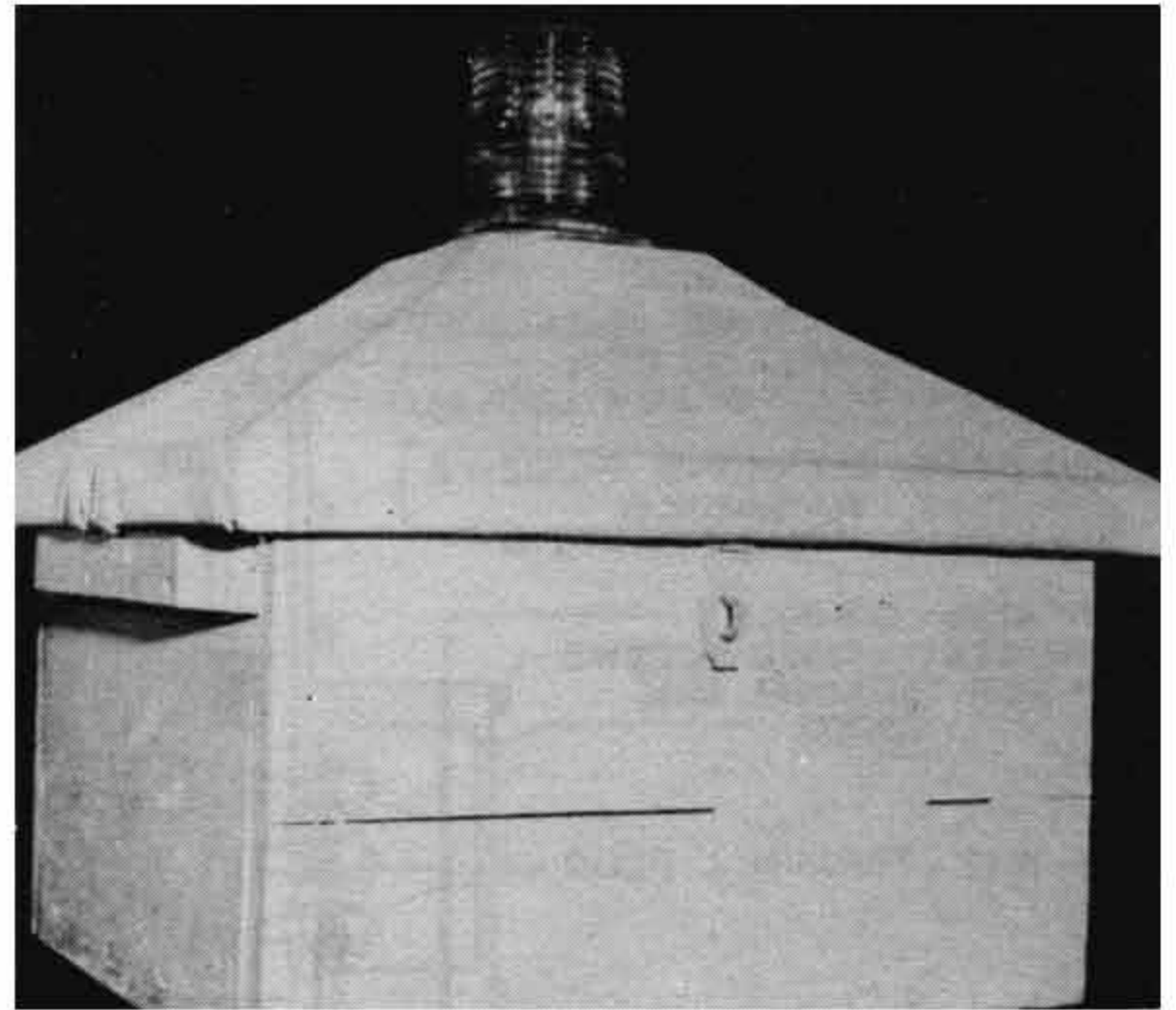


FIGURE 21-28B.—Lamp stand for 90-mm. Service-type lantern.

21-6-10 Range Types—

A. W. & T. range lantern, type FA-47 (fig. 21-29).—This range lantern consists of a rectangular cast bronze housing with a curved top and metal visor over the front face, which holds the front cover glass. The cover glass may be a flat-light lens or a spread-light lens with horizontal beam spread of 8° or 30°. Levelling screws are provided in mounting the lantern to permit tilting from 3½° from the vertical and 10° in azimuth for proper adjustment on the range line. A terminal box is cast integral with the lantern housing on one side, fitted with plugs for battery and sun-relay connections. The flashing mechanism is mounted inside the lantern housing opposite the terminal box. A special lamp changer is mounted in the rear of the lantern with the lamp projecting through a slot in a rhodium-plated parabolic mirror. It uses special lamps with precision screw sockets and C-2 filaments. All lamps have been rebased, i. e., adapters have been soldered to the original base so that the filaments of all lamps have exactly the same focal height with respect to the base.

B. G. R. S. range lantern, type SA (fig. 21-30).—This is a widely used range lantern, originally designed as a track signal for use on railroads by General Railway Signal Co. The case is of cast iron with a metal visor shielding the light; the lens system is a doublet compound lens with a deep ellipsoidal mirror with a hole for inserting the lamp

into the socket behind the mirror. The beam can be spread horizontally by use of a spread-light roundel having 8°, 15°, 20°, 30°, or 70° beam spread. A color disk is placed at the focal point in front of the lamp when needed.

A combination red, white, and green disk shade has been provided to give a clear beam on the center line of a channel with an out-of-range border of red on the right and green on the left, entering the channel. This is known as a *polychrome directional light* and only one light is required for an installation. These lanterns should be installed in duplicate in important channels, using a change-over relay for automatically placing the stand-by unit in operation in the event of a burn-out. This is done because there is no space available for installing a lamp changer. Occasionally in the past, where the use of two lanterns was not considered justified, undervoltage was resorted to in order to minimize the frequency of lamp failure. The above range lanterns operate on a wide combination of lamps and voltages.

C. G. R. S. Range Lantern, type W (fig. 21-32).—This is a lantern originally designed for use as a highway crossing light on railroads. Like the SA type, it is usually installed in duplicate.

D. Installation details for G. R. S. lanterns will be found under section 21-11-20.

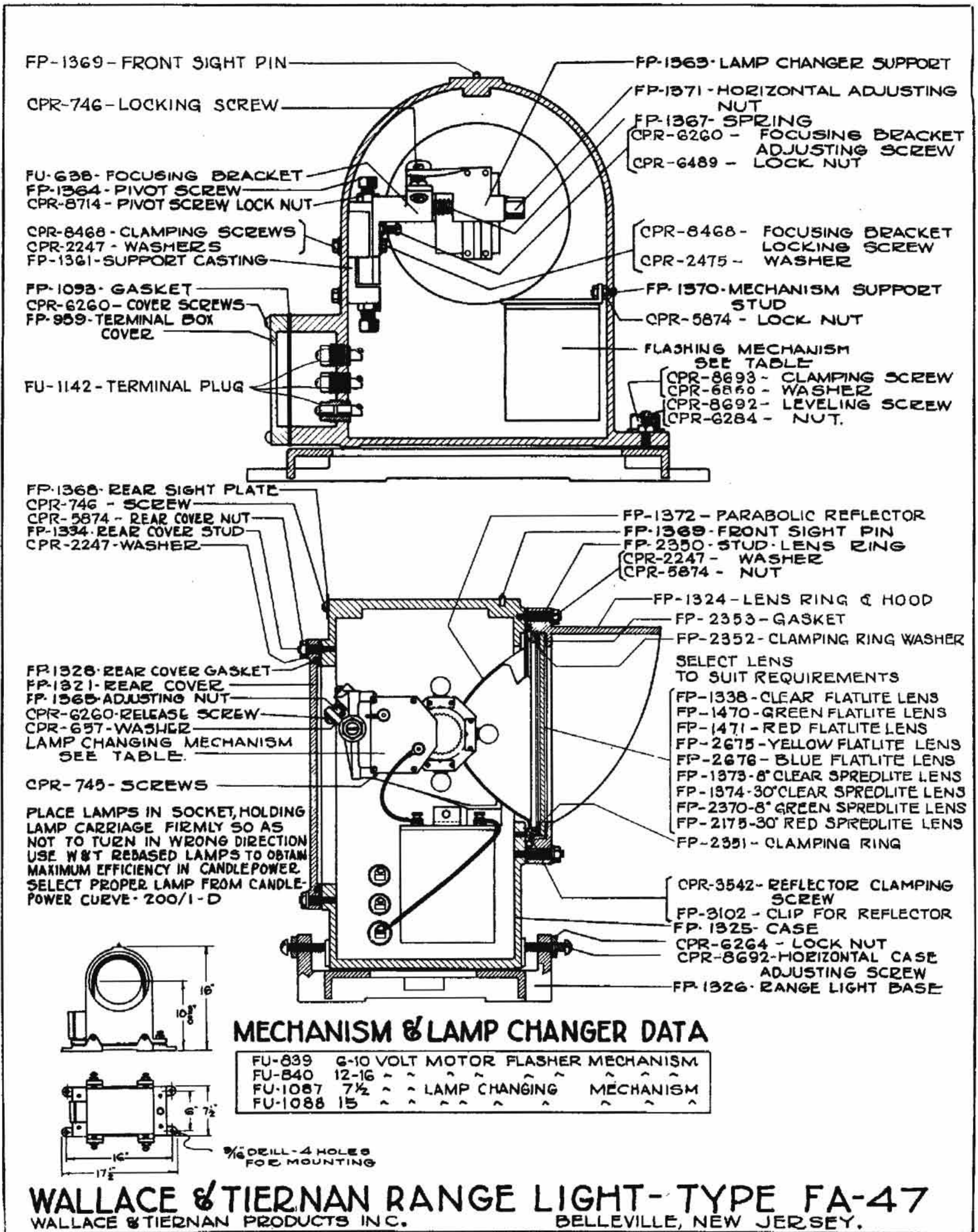


FIGURE 21-29.—W. & T. range lantern, type FA-47.

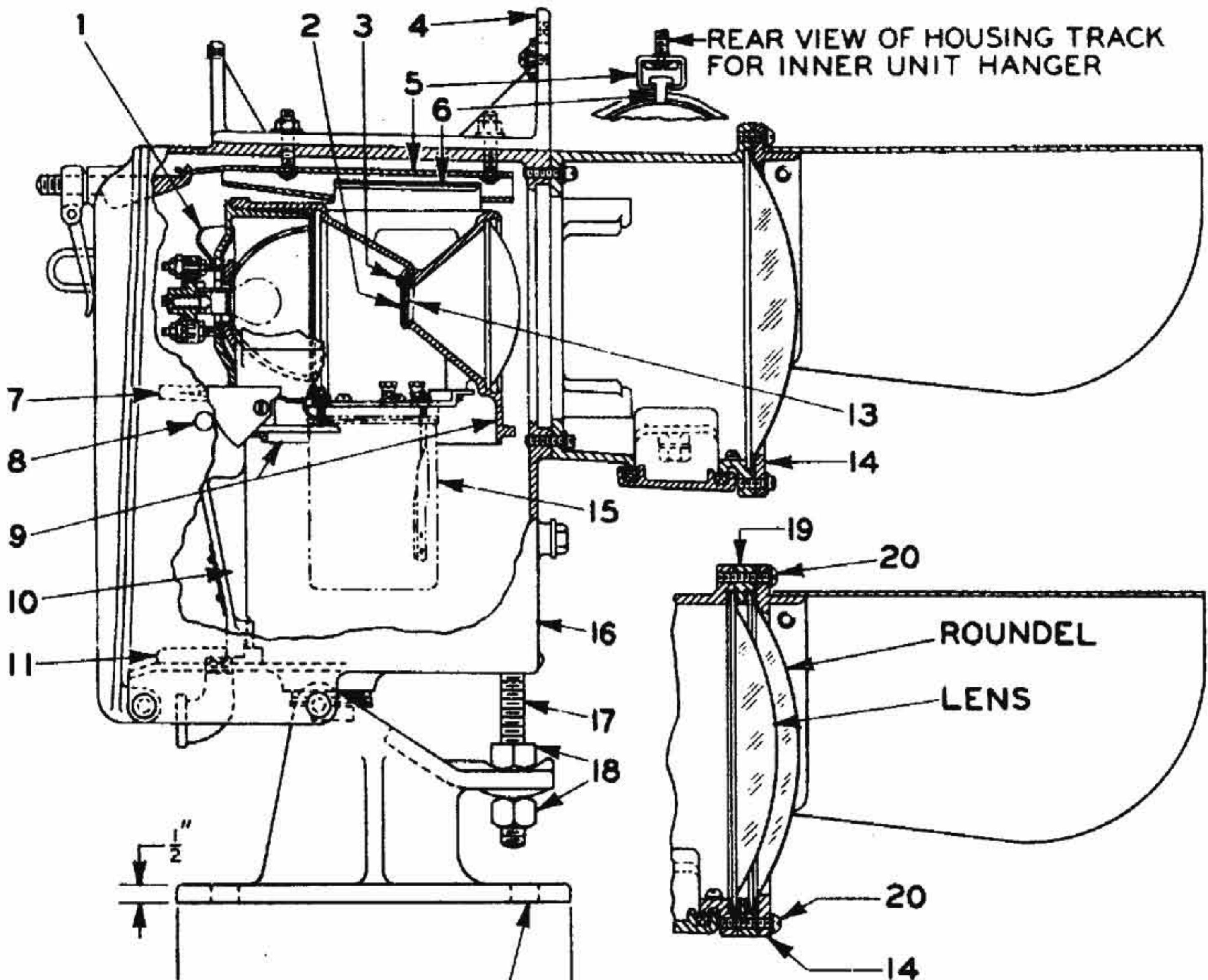


FIGURE 1. TYPE SA RANGE LANTERN, BOTTOM VIEW OF MOUNTING BASE AND SIDE VIEW OF LANTERN COMPLETE WITHOUT OUTER ROUNDEL

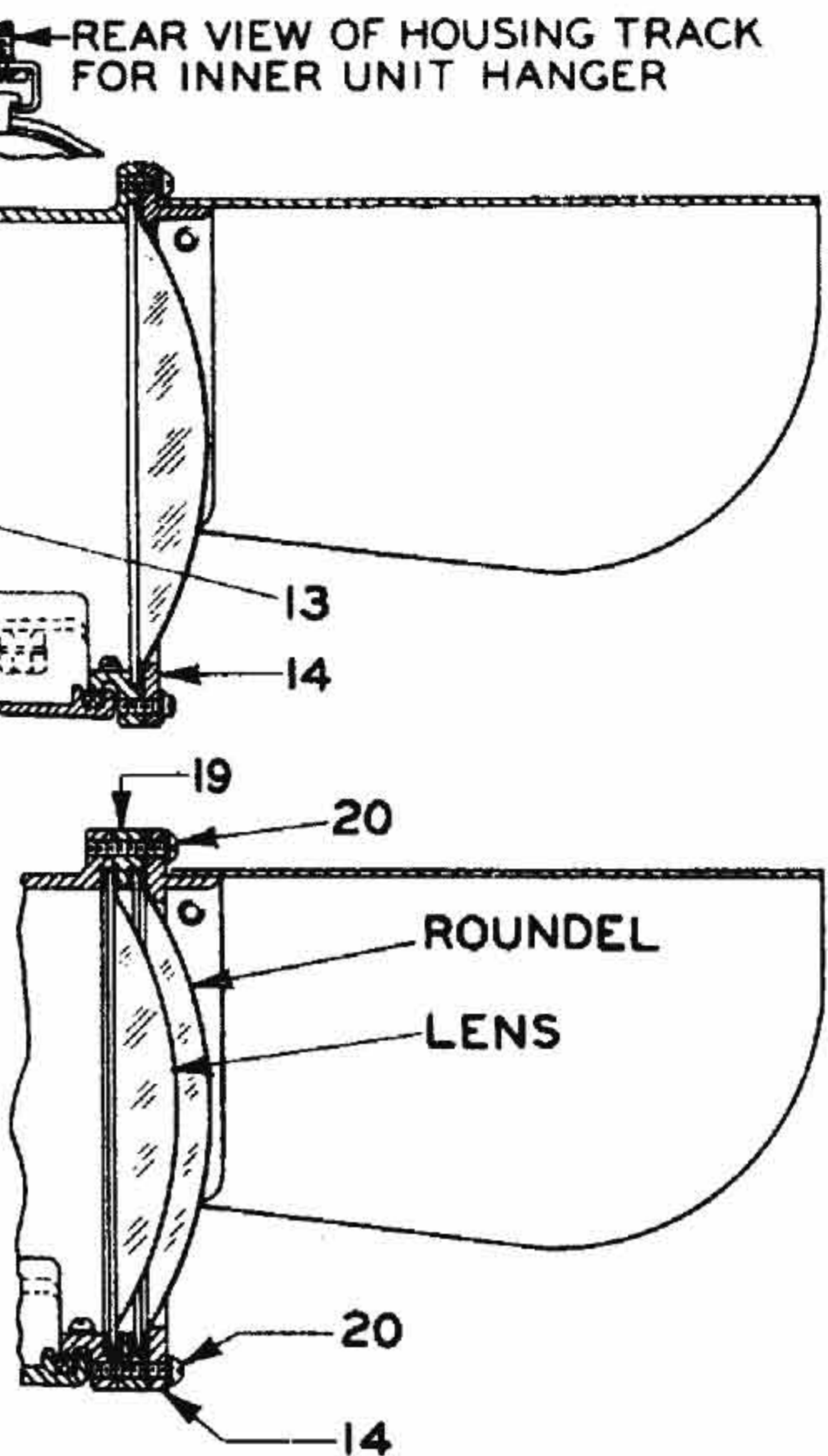


FIGURE 2. BOTTOM VIEW OF INNER UNIT SHOWING WIRING AND METHOD OF ATTACHING FLASHER

FIGURE 3. SIDE VIEW WITH OUTER CONVEX ROUNDSEL

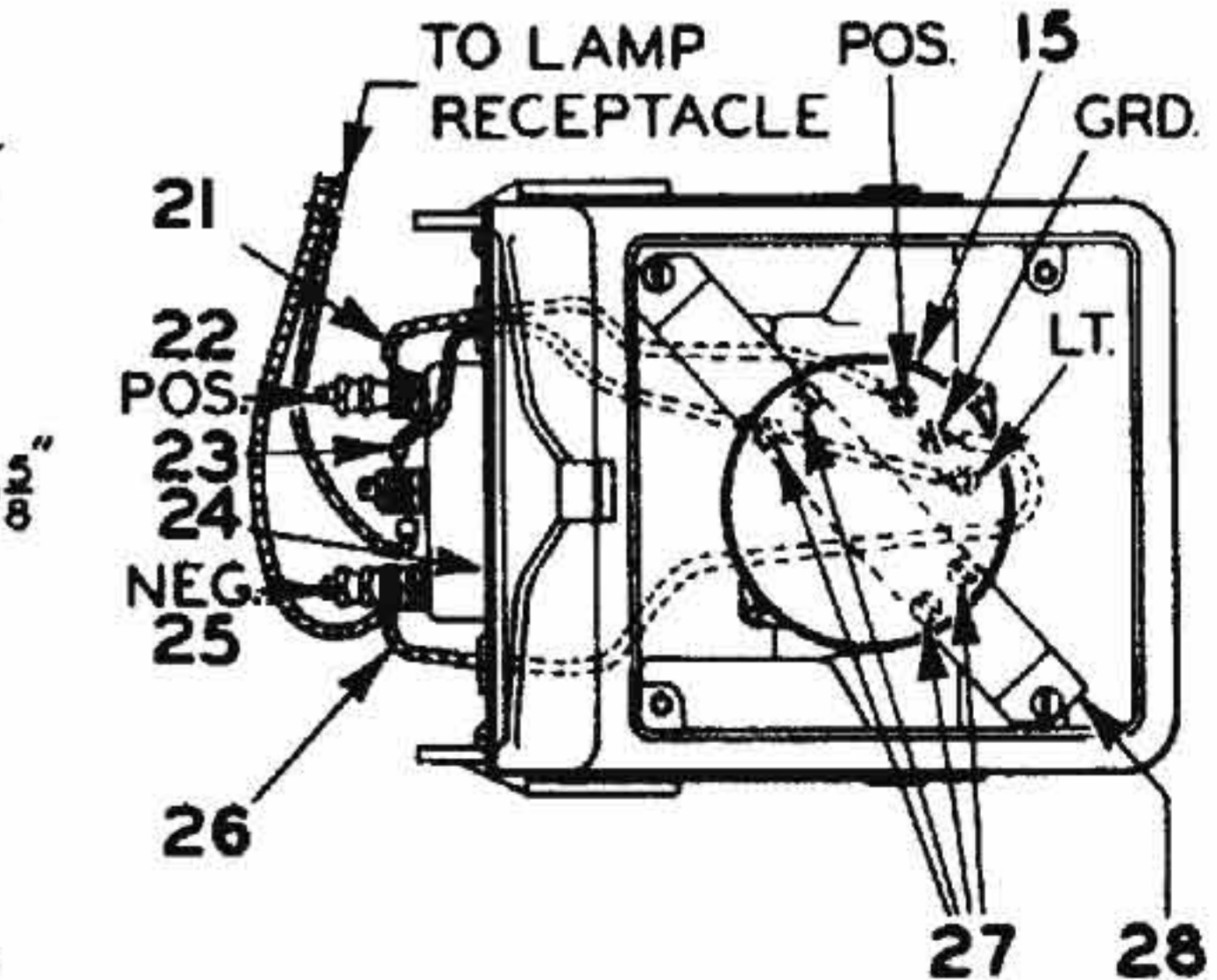
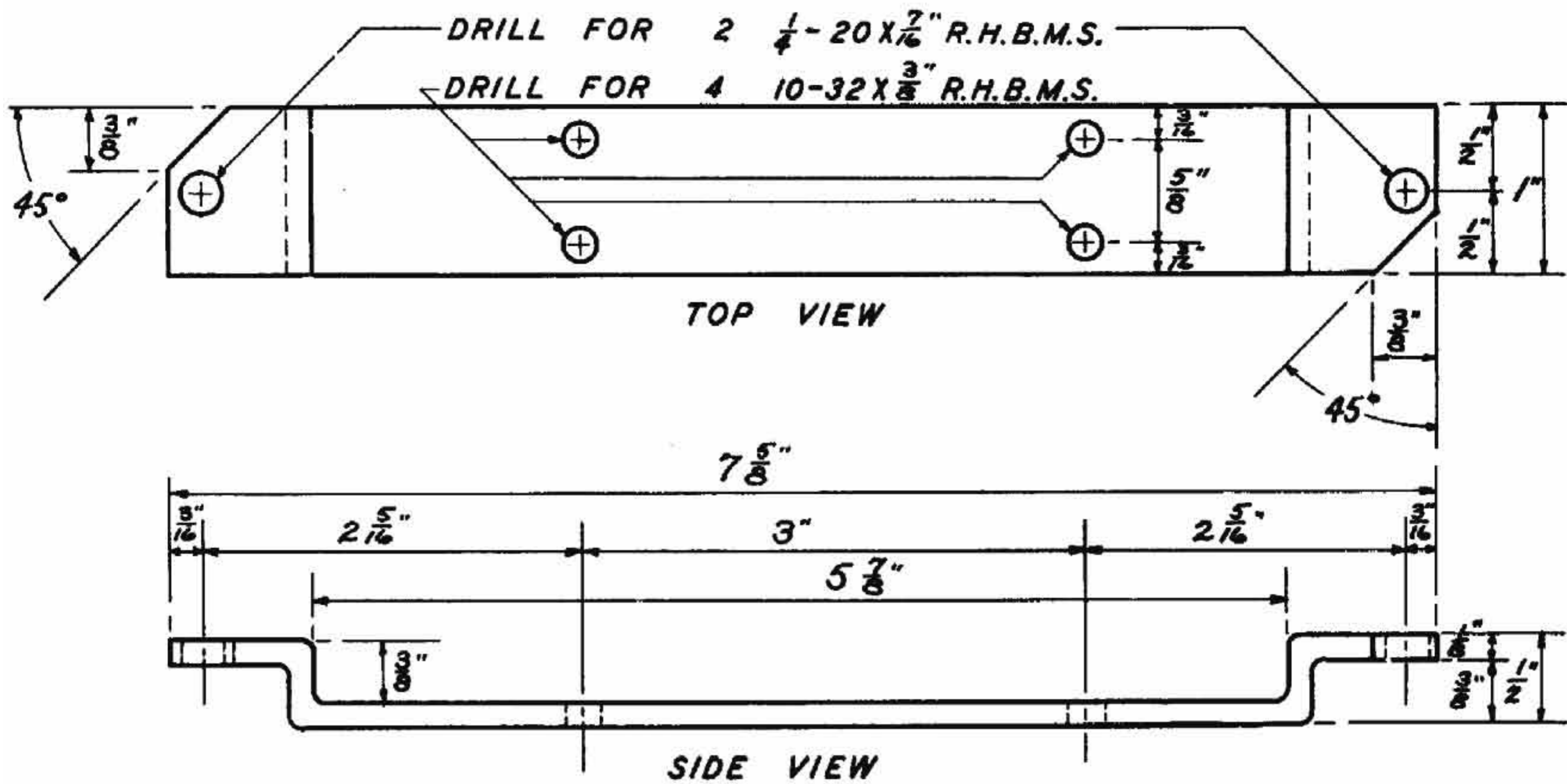


FIGURE 21-30.—G. R. S. type SA range lantern.



MATERIAL - $\frac{1}{8}$ " ALUMINUM OR BRASS.
 SCALE - - FULL SIZE.

FIGURE 21-31.—W. & T. mounting bar for G. R. S. type SA lantern.

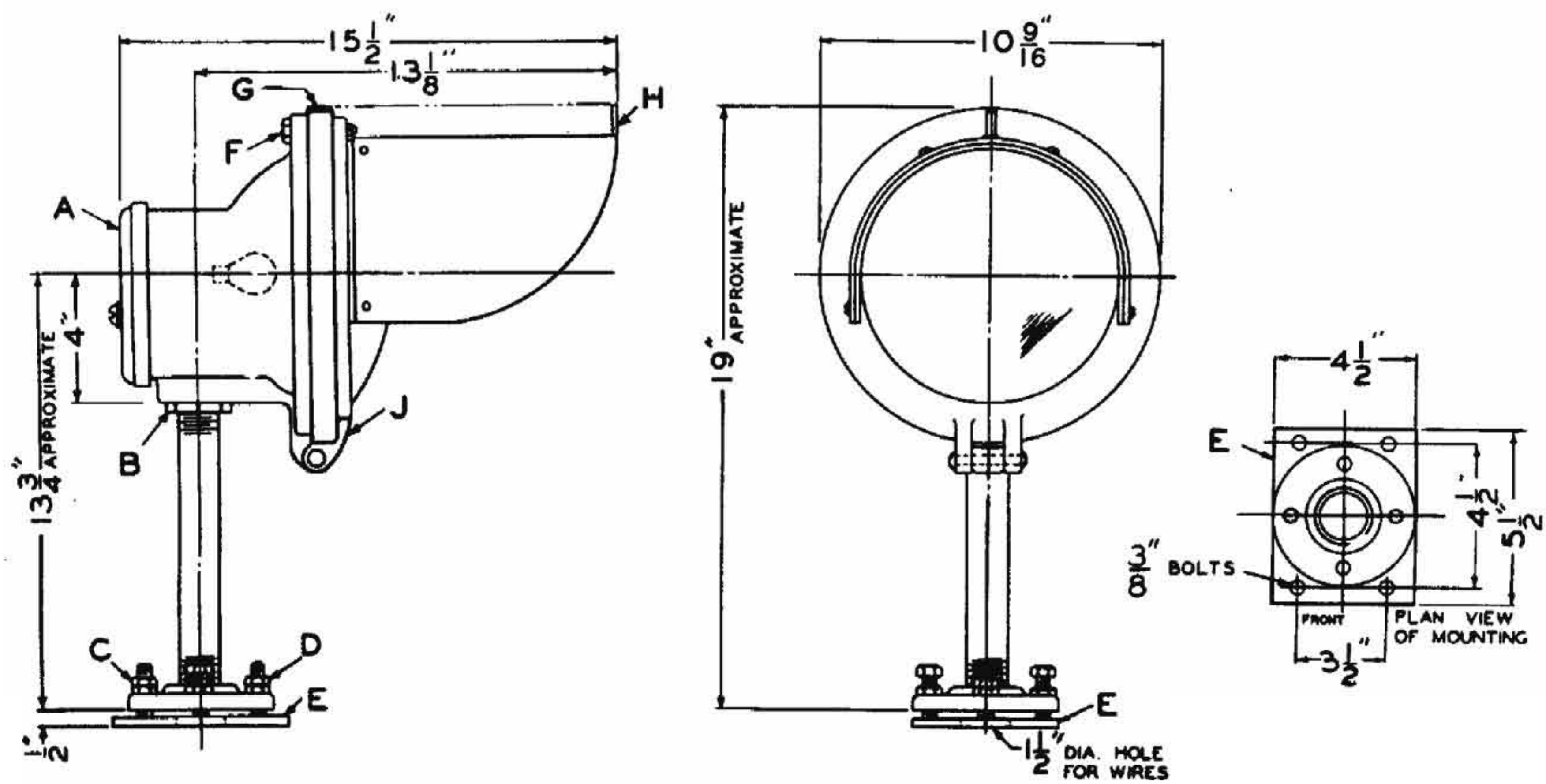


FIGURE 21-32.—G. R. S. type W range lantern.

21-6-15 Commercial Power-operated Types—

A. Commercial power-operated lights are steadily on the increase. Such lights are usually provided with a standby source of current of limited capacity, together with suitable change-over devices to insure continuous light operation in case of power failure. Provisions are also made for continuance of operation in case of filament failure, either by use of duplex lanterns or lampchangers.

B. *200-mm. lantern.*—The 200-mm. single and duplex lantern shown in figures 21-33 and 21-34 was designed in the Second Coast Guard District. This lantern uses the same lens as used in standard 200-mm. acetylene and electric lanterns, thus providing interchangeability and facilitating repair. The duplex lantern uses the same top and bottom castings as the single lantern, providing economy in manufacture. The lamp spider in the duplex lantern can be easily and completely withdrawn for re-lamping the bottom socket. The designed use of a standard 60-watt 115-volt lamp provides easy replacement of a proper lamp, since such lamps are commonly available. Both lanterns are manufactured with socket stools of proper height to focus a 60-watt lamp. Proper focusing of 25- and 100-watt lamps is accomplished by using the proper stool, shown in figure 21-35. The control features such as service entrance switch, fuse block, flasher (if any), emergency lamp relay (if any), spare fuses, spare lamps, etc., are housed in a switch and flasher box (see fig. 21-74), or the equivalent thereof. All wiring for these lanterns should be carefully accomplished to conform to ~~such local electrical codes as may apply~~, taking special care to thoroughly ground the neutral (grounded) side of the line. The grounded side of the line should be determined by actual trial with a test 115-volt lamp in the socket, connecting one lead to ground and the remaining lead to one, then the other, of the two sides of the line. When the lamp lights, the lead wire is the hot wire. The other is the grounded wire and should be thoroughly fastened to the ground rod already driven.

C. *200-mm. duplex lantern with flasher.*—Using 115-volt a. c. commercial current, this unit is automatically turned on at sunset and off at sunrise by the installed time switch or sun relay. In a duplex lantern a lampchanger is unnecessary, since the top lamp is used as the main light and the lower as the standby light through the installation of an emergency lamp relay. So long as the main light operates, the coil is energized, keeping the relay contacts open. With the failure of the main light, the circuit is broken to the relay coil, allowing the contacts to close. This completes the circuit to light the lower or standby lamp. The characteristic for either main or standby lamp is coded from the same flasher mechanism, which in this case is 115-volt a. c.-operated also. Both the clock and relay circuits, and the lamp circuit, are broken by the 115-volt 30-ampere fused safety switch. All the control units, except a sun relay (when used), are mounted in a weathertight structure so that the time switch (if used) is level for operation of the mercury contacts.

21-7 FLASHERS**21-7-1 General—**

A. Although several designs have been used since the inception of the flashing minor electric light, at the present time only one design of direct current flasher manufactured by Wallace & Tiernan Products Inc., is in use.

B. *Voltage ranges.*—The present basic flasher is supplied in three voltage ranges, 3-4, 6-10, and 12-16 volts. It may be obtained with one or two lamp contacts and with a variety of special gear and contact assemblies, depending on the application.

C. *Current rating.*—The single contact flasher without relays should be used only with lamps up to 2.0 amperes, and operated at not more than 75 flashes per minute. The double contact flasher is suitable for lamps up to 2.0 amperes and 120 flashes per minute. When interrupting lamp circuits of more than two amperes, either an auxiliary power relay or a heavy duty type flasher shall be used. Fig. 21-36 illustrates a single contact flasher. The basic mechanism is the same in all designs of flashing devices incorporating W. & T. flasher mechanisms and only lubricant (FU 1869) specified by the manufacturer should be used.

The National Electric Code

21-7-5 Construction—

A. The flasher mechanism is a constant speed motor-driven device, driving a cam which makes and breaks the circuit to provide any desired characteristic. It is driven by a small direct-current motor equipped with a governor which compensates for voltage variation. The component parts of the motor are mounted on a frame assembly consisting of a cylindrical bottom plate casting with two integral spacer lugs supporting the top plate. Permanent magnets mounted on a shaft serve as the rotor and revolve in the field of two coils, the electrical energy for which is supplied by storage batteries. A pair of electrical contacts are in series connection with each of the motor coils. These contacts are spring-hinged so that when they are swung out for inspection they automatically spring back into position when released. Each contact is opened and closed once per revolution by means of an eccentric bushing on the motor shaft. The length of time each contact remains closed is determined by the amount of eccentricity of the bushing. The amount of eccentricity of the bushing is controlled by the flyball governor. Thus the motor rotates at governed speed, as the length of time of electrical closure of the circuits to the motor coils is just sufficient to keep the motor up to speed.

B. *Power consumption.*—The flasher mechanism alone consumes about 175 watt-hours of energy per year of constant operation. This current consumption is so small that it may be disregarded when computing battery service periods.

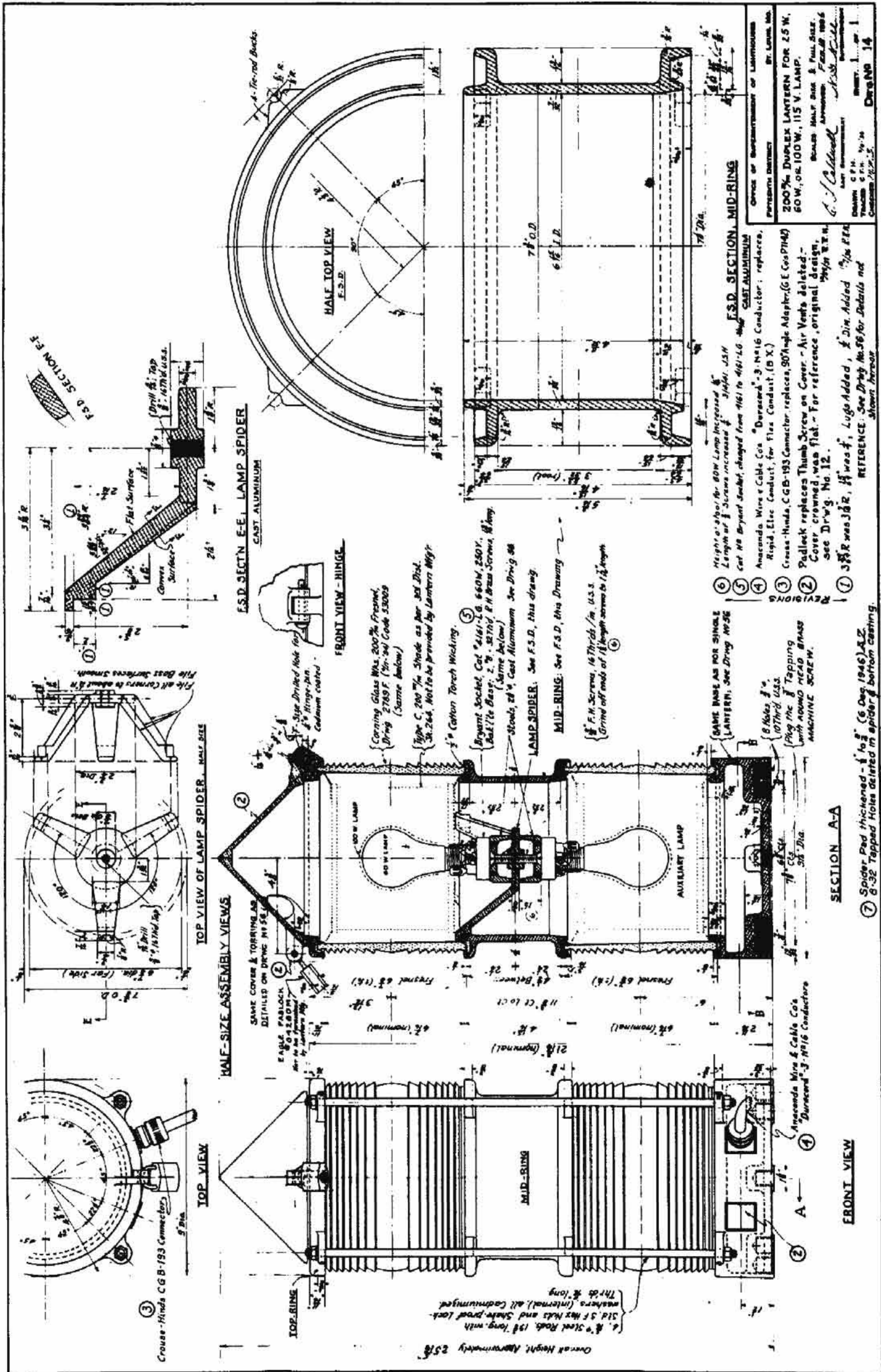


FIGURE 21-34.—200-mm. duplex lantern for 25-, 60-, or 100-watt, 115-volt lamps.

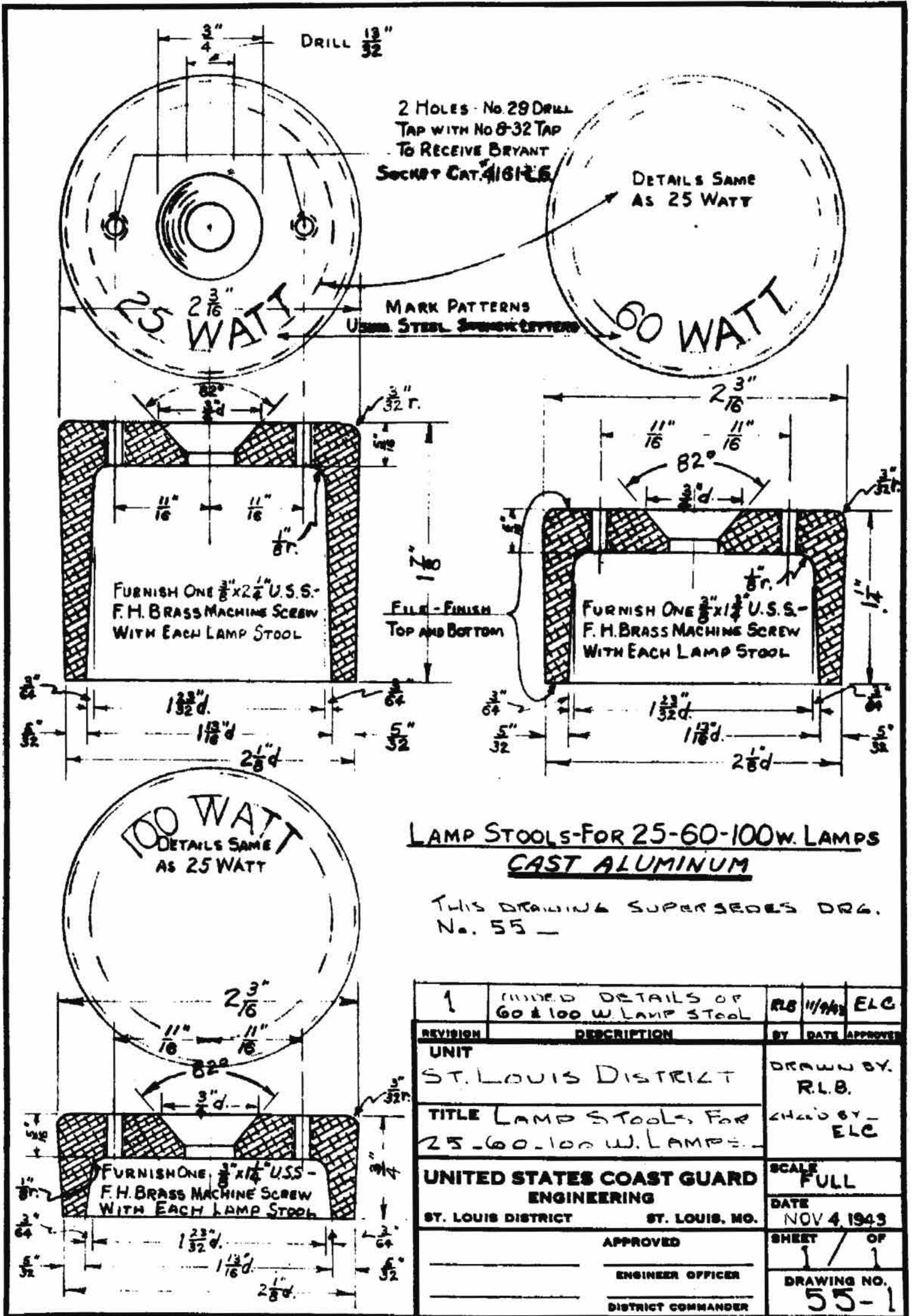


FIGURE 21-35.—Lamp stools for 25-, 60-, or 100-watt lamps.

C. Power circuit.—The flasher mechanism used must have an operating voltage corresponding to the voltage supplied by the battery. The power circuit is in duplicate, each circuit having a set of contacts, coil and condenser unit. In case of failure of one circuit the other circuit provides continuous operation of the motor. The motor shaft, which operates in a vertical position, is mounted on ball bearings for smooth operation and to assure long life.

D. Program disk.—The flasher program device, driven by the motor through a series of reducing gears, is a disk on which projections are cut to correspond to the flashing light code desired. The length of the projections determines the length of the lighted period. While the motor is normally governed to run the motor disk at a rate of 5 r. p. m., the tension on the governor spring may be altered within the range of 4 to 6 r. p. m. to allow program variation. The program disk is easily removed with a screwdriver. It is held in place by a friction clutch device to prevent jamming of the flasher contacts in case the motor rotation direction is accidentally reversed. The contacts are mounted on an adjustable plate and are suitable for breaking a circuit to a 2-ampere, 12-volt lamp.

(1) To change the program disk, remove the upper bearing plate. The entire cam assembly can then be lifted out. In so doing, hold the contact spring clear of the cam assembly. Next, unscrew the knurled cam lock nut and remove the cam spring. Remove the program disk.

(2) Be sure that the hole in the replacement cam fits freely on the knurled cam lock nut. Should the cam bind on this lock nut, the friction feature of the assembly will be destroyed. In replacing the cam, hold the program gear with the threaded end of the shaft upward and install the program disk with the beveled side of the cam lobes in a counterclockwise direction. *This is important* because if the position of the cam were reversed (wrong side up), the straight side of the cam would come to rest against the end of the contact arm and stall the mechanism, since the rotation is counterclockwise. Next, replace the cam friction spring and knurled nut. Screw the knurled nut on firmly. The degree of tightness has no bearing on the program disk itself, since the disk is held by the tension on the friction spring. If this spring, upon being removed, does not assume a full "cupped" position, it should be replaced. (*Do not use pliers on this assembly.*)

E. The whole unit is self-contained in a watertight case and is mounted in the lantern housing with the longitudinal axis vertical.

21-7-10 Adjustments—

A. The adjustments of a flasher, except for revolutions per minute adjustment, are factory set and *should not be attempted in the field* except by experienced personnel with proper equipment. The mechanism is usually furnished adjusted to turn the program disk at 5 r. p. m. A governor adjusting screw is attached to the governor assembly for limiting the throw of the governor and controlling the position of the armature eccentric which opens or

closes the motor contacts controlling the field current. To change the speed, turn the adjusting screw clockwise to increase speed of rotation, counterclockwise to decrease it. Variation of speed from 4 to 6 r. p. m. may be obtained.

21-7-15 Types—

A. *Single cam* flasher mechanisms are furnished for 3-4-volt (type FU-838), 6-10-volt (type FU-839), and 12-16-volt (type FU-840) operation. *Double cam* flashers (type FU-876) for 6-10-volt operation and (type FU-878) for 12-16-volt operation, are furnished for dual purpose lanterns when the flash is more than 75 flashes per minute.

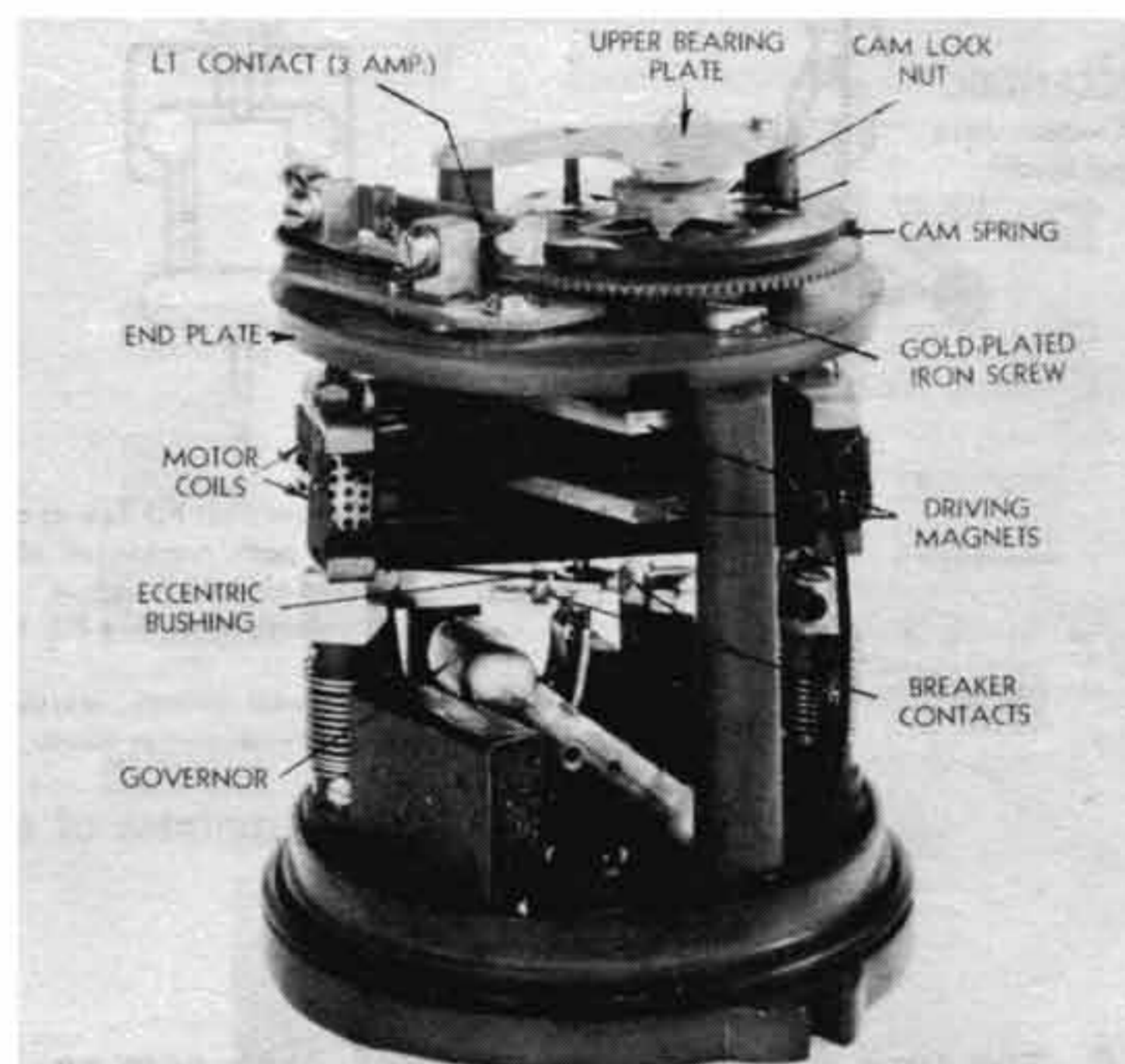
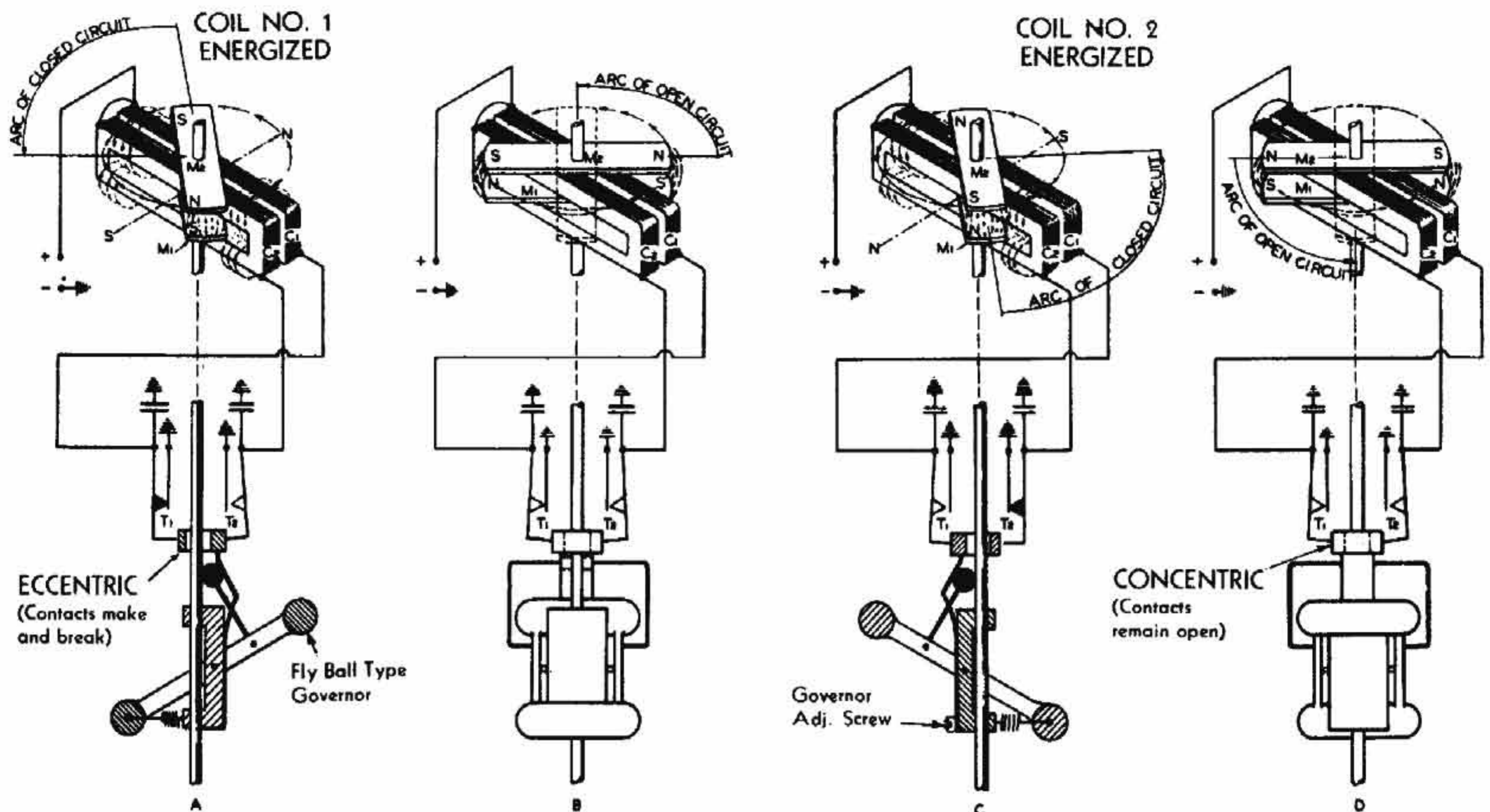


FIGURE 21-36.—W. & T. flashing mechanism.

21-7-20 Heavy Duty Flashers—

A. *Heavy duty flashers* (Types FA-89 and 90) are designed for controlling high amperage currents in 32- and 115-volt a. c. or d. c. circuits in large lamps and fog signals. Two complete standard flasher d. c. motor mechanisms are coupled to drive a gear train through a free-wheeling device which will release either driving mechanism should it fail. Each motor has sufficient power to operate the flasher. The power source used to drive the flasher motor is not necessarily the same as the circuit that is being controlled; for example; a 12-volt battery may be needed to supply current for the driving motors of a flasher which controls a 115-volt a. c. lamp circuit.

B. The type FA-89 heavy duty flasher drives a single cam which operates two mercury tube contacts normally wired in parallel to control a single circuit, although two circuits may be operated with the same characteristic.



NOTES:

1. Current does not flow at all times.
2. All parts constructed of nonferrous metal, except two gold-plated iron screws.
3. Voltage range 3-4 FU. 838, 6-10 FU. 839, 12-16 FU. 840.
4. Incorrect polarity, reverses direction of lines of force in coils and reverses motor.

FIGURE 21-37.—Principles of operation of flasher mechanism.

C. *The type FA 90* operates 3 cams, each cam actuating two mercury contacts wired in parallel, thus operating three circuits with the same characteristic. The flashers should be carefully leveled and the flexible leads running to each mercury contact tube should be looped clear so as not to interfere with the tilting of the tubes when operating.

D. *Mercury tube contacts.*—Each mercury tube-type contact used in heavy duty flashers has a maximum rating of 10 amperes at 250 volts a. c., or 5 amperes at 250 volts d. c. The mercury switch should be adjusted when the program cam is in off position. The trip lever should clear the undercut portion of the program cam approximately 0.002 inch and the counterweight should be such that the mercury does not make contact across the two contact wells. After adjusting the mercury switch, the shaft should be slowly rotated by hand through its normal arc of travel to determine if the mercury properly opens and closes the circuit. The program cam shaft and the mercury switch should be lubricated with a light oil every 12 months.

E. To place the mechanism in operation, connect

the d. c. power source of the correct voltage across the motor lead contacts, being sure to connect the positive wire to the terminal marked "plus" and the negative lead to the terminal marked "minus." Connect the circuit which is to be controlled across the terminals marked "SW-1" and "SW-2".

21-7-25 Cams and Characteristics—

A. Except for heavy duty flashers and special speed mechanisms, the speed of the flasher cams or program disks is adjustable from 4 to 6 r. p. m., thus giving a revolution in from 10 to 15 seconds. The number of characteristic cycles for one revolution will be in accordance with the number of lobes on the cam.

(1) *Cams are marked not as to characteristic, but in the form of a code indicating revolutions per minute, flashes per minute and duration of flash respectively, thus: 5-15-0.4—5 equals the cam speed, 15 equals the number of flashes per minute and 0.4 equals the length of flash in seconds. For 15 flashes per minute, the length of the period would*

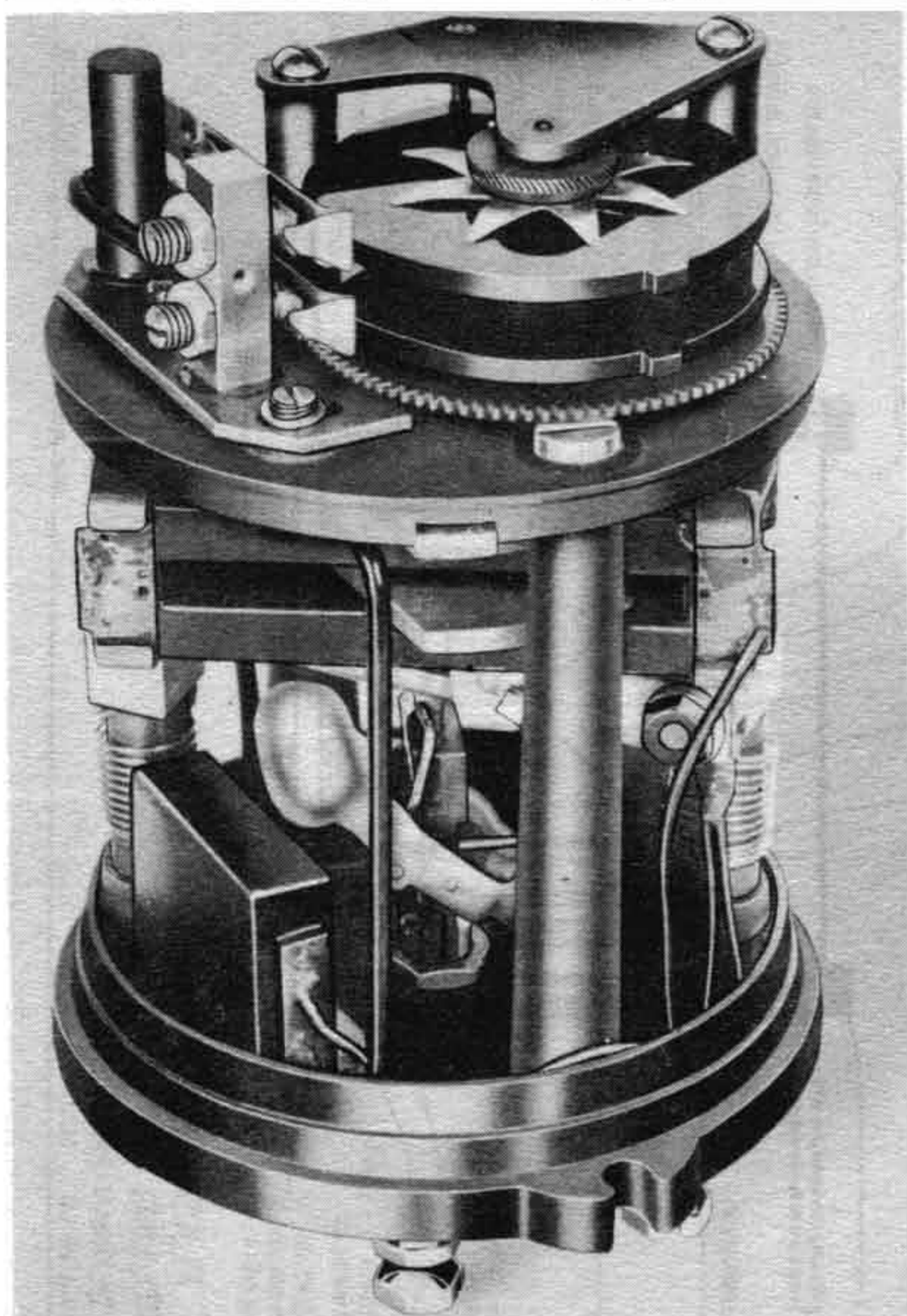


FIGURE 21-38.—W. & T. dual program disk flasher mechanism.

equal 60 divided by 15, or 4 seconds. The duration of the eclipse is not indicated but can be found by subtracting the known duration of the flash from the total period. The number of lobes on a cam equals the number of flashes per minute divided by the revolutions per minute of the cam.

(2) Cams for heavy duty flashers may be obtained for any desired characteristic. The shortest length of contact recommended for the FA-89 heavy duty flasher is 0.5 second. In the FA-90, the length of contact should be not less than 1.0 second.

B. Short-long or other compound characteristics are indicated by SUB numbers on the cam. The short-long cam will be marked SUB-29, the interrupted quick flash SUB-20, and the multiple (double SUB-11).

C. Following is a table of some of the characteristics in common use:

Characteristics			Flashes or groups	Cam revolutions per minute	Cam marking
Light	Dark	Total			
0.2	1.8	2 sec.	30 flashes	5	5-30-0.2.
0.4	3.6	4 sec.	15 flashes	5	5-15-0.4.
0.5	2.0	2.5 sec.	24 flashes	6	6-24-0.5.
0.5	4.5	5 sec.	12 flashes	6	6-12-0.5.
1.0	1.0	2 sec.	30 flashes	5	5-30-1.0.
1.0	4.0	5 sec.	12 flashes	6	6-12-1.0.
1.0	9.0	10 sec.	6 flashes	6	6-6-1.0.
Qk. Fl. (0.2-0.6)			75 flashes	5	5-75-0.2.
Int. Qk. Fl.			8 groups	4	SUB 30.
Gr. Fl. (multiple)			15 groups	5	SUB 11.
Short-long			6-8 groups	4	SUB 29.

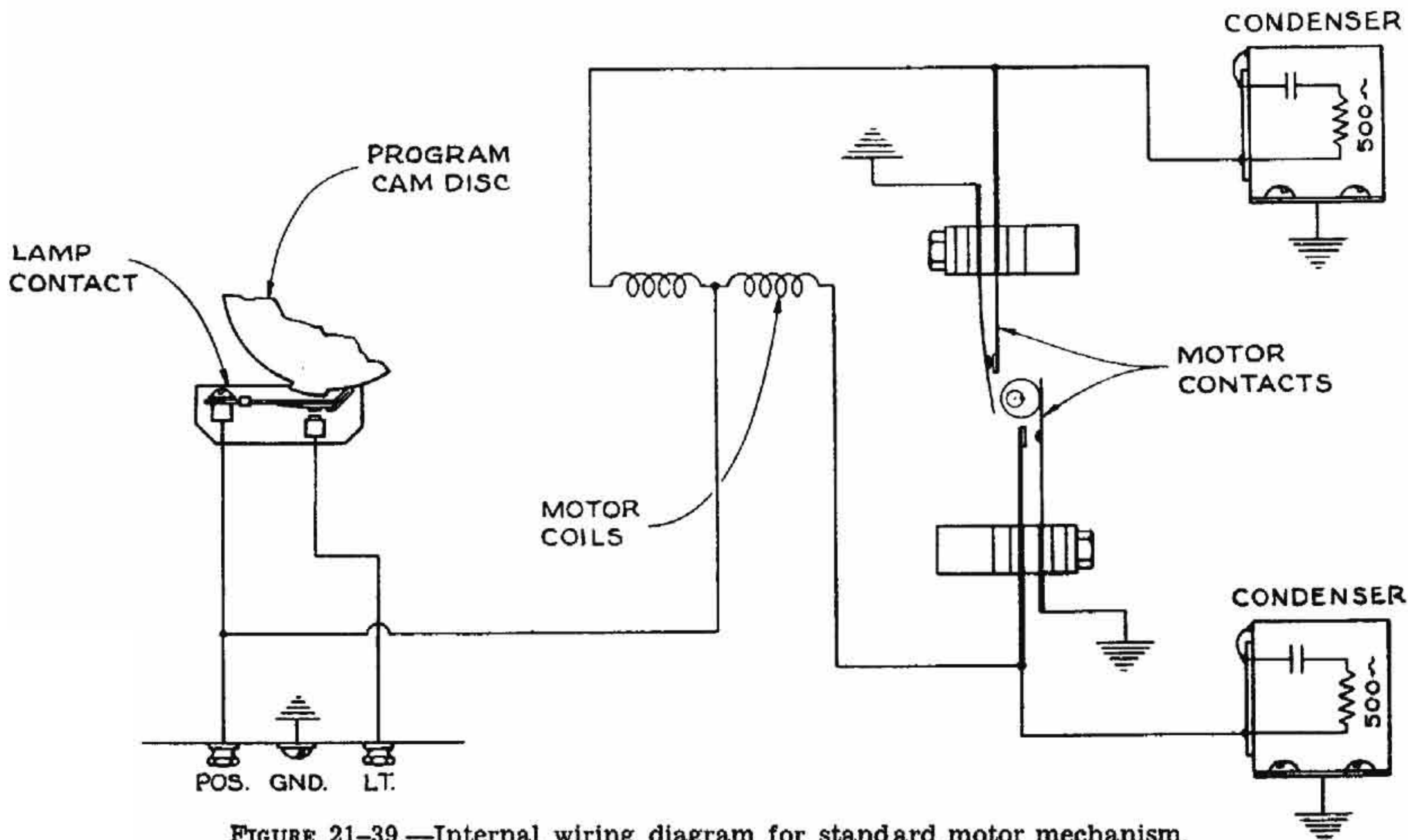


FIGURE 21-39.—Internal wiring diagram for standard motor mechanism.

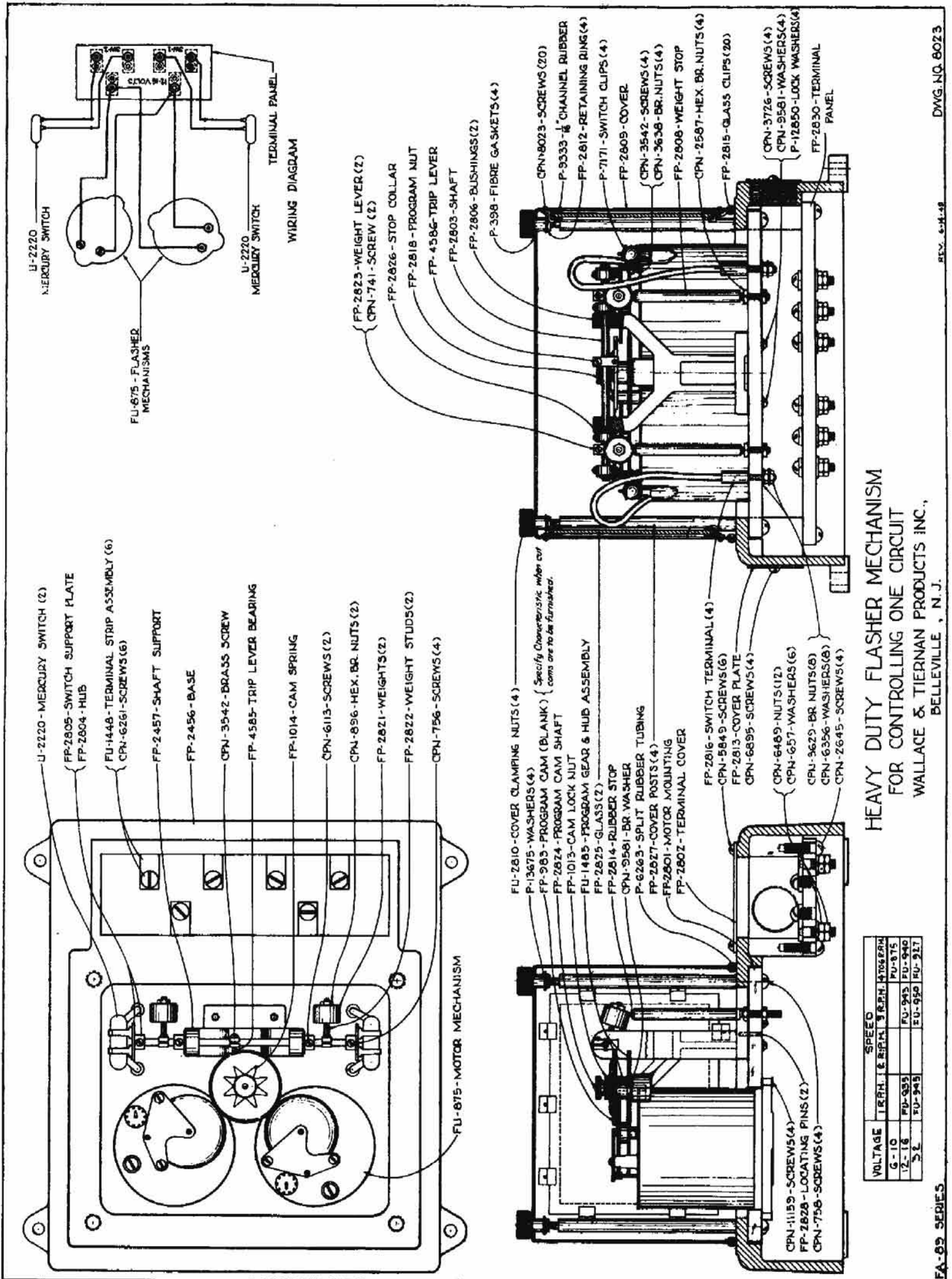


FIGURE 21-40.—Heavy duty flasher mechanism for controlling one circuit.

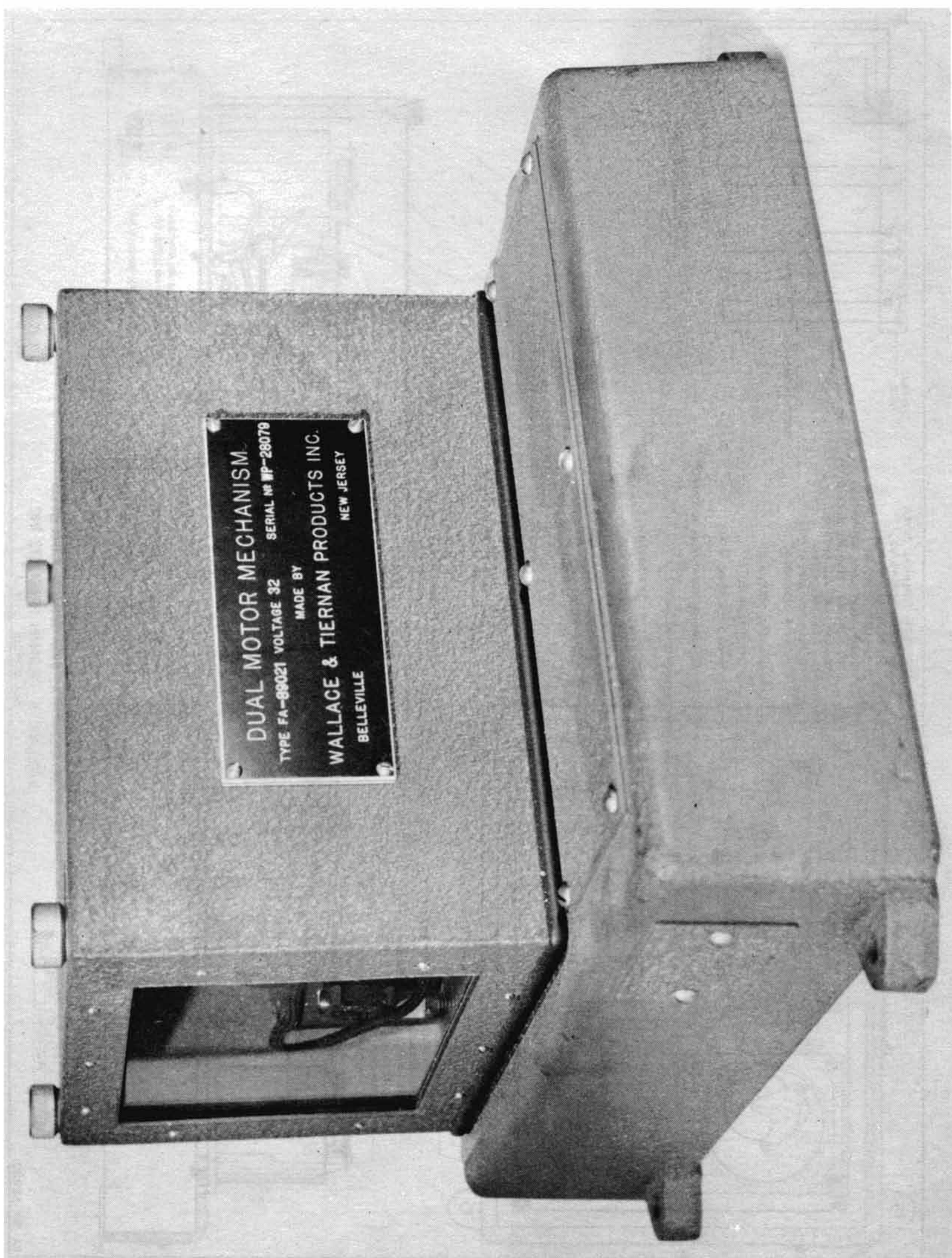
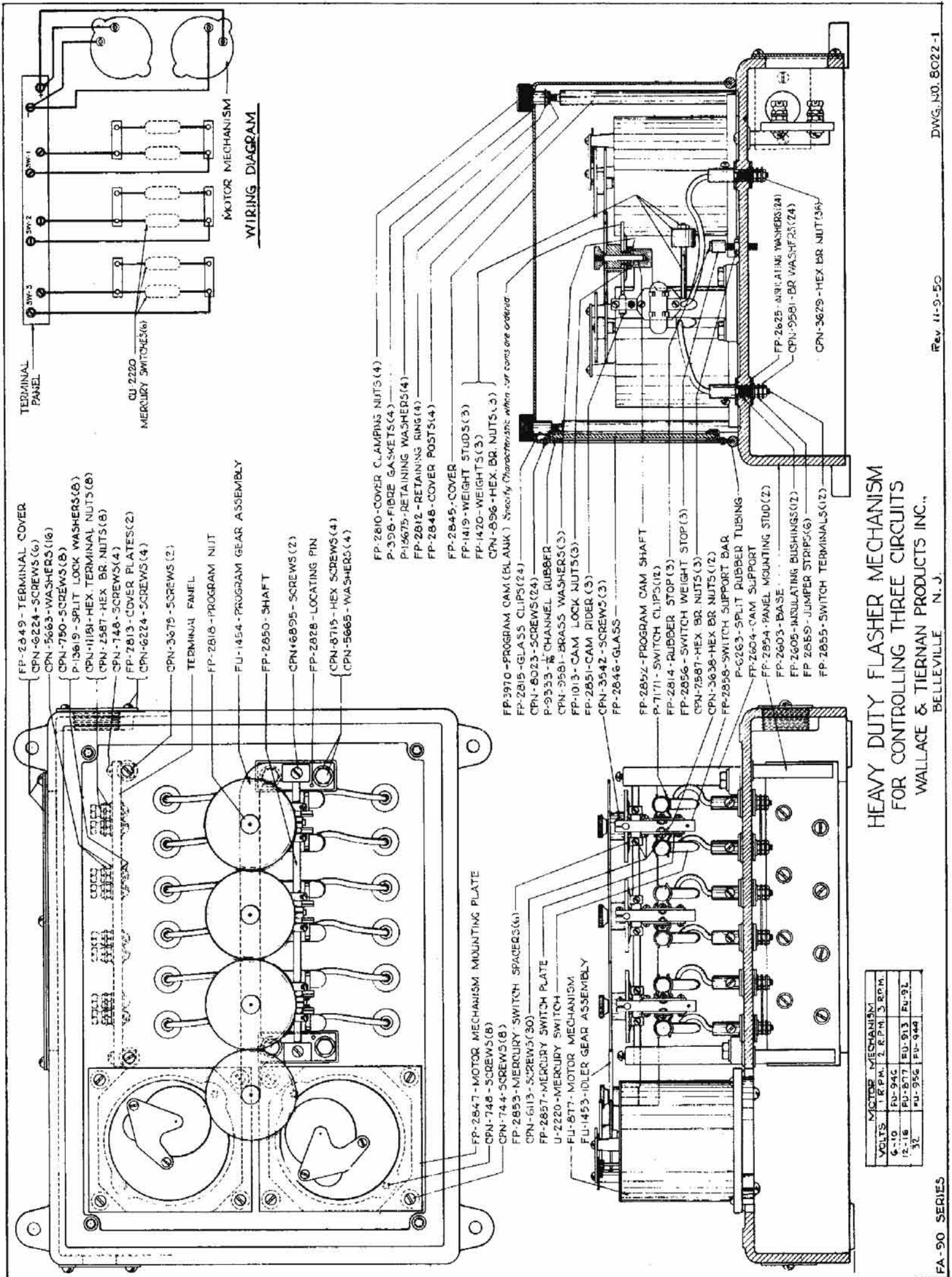


FIGURE 21-41.—Heavy duty flasher, type FA-89.



**HEAVY DUTY FLASHER MECHANISM
 FOR CONTROLLING THREE CIRCUITS**
 WALLACE & TIERNAN PRODUCTS INC.,
 BELLEVILLE N. J.

MOTOR MECHANISM	
VOLTS	R.P.M.
6-10	2 R.P.M. 3 R.P.M.
12-16	FU-94C FU-913 FU-91
32	FU-95G FU-944

FIGURE 21-42.—Heavy duty flasher mechanism for controlling three circuits.

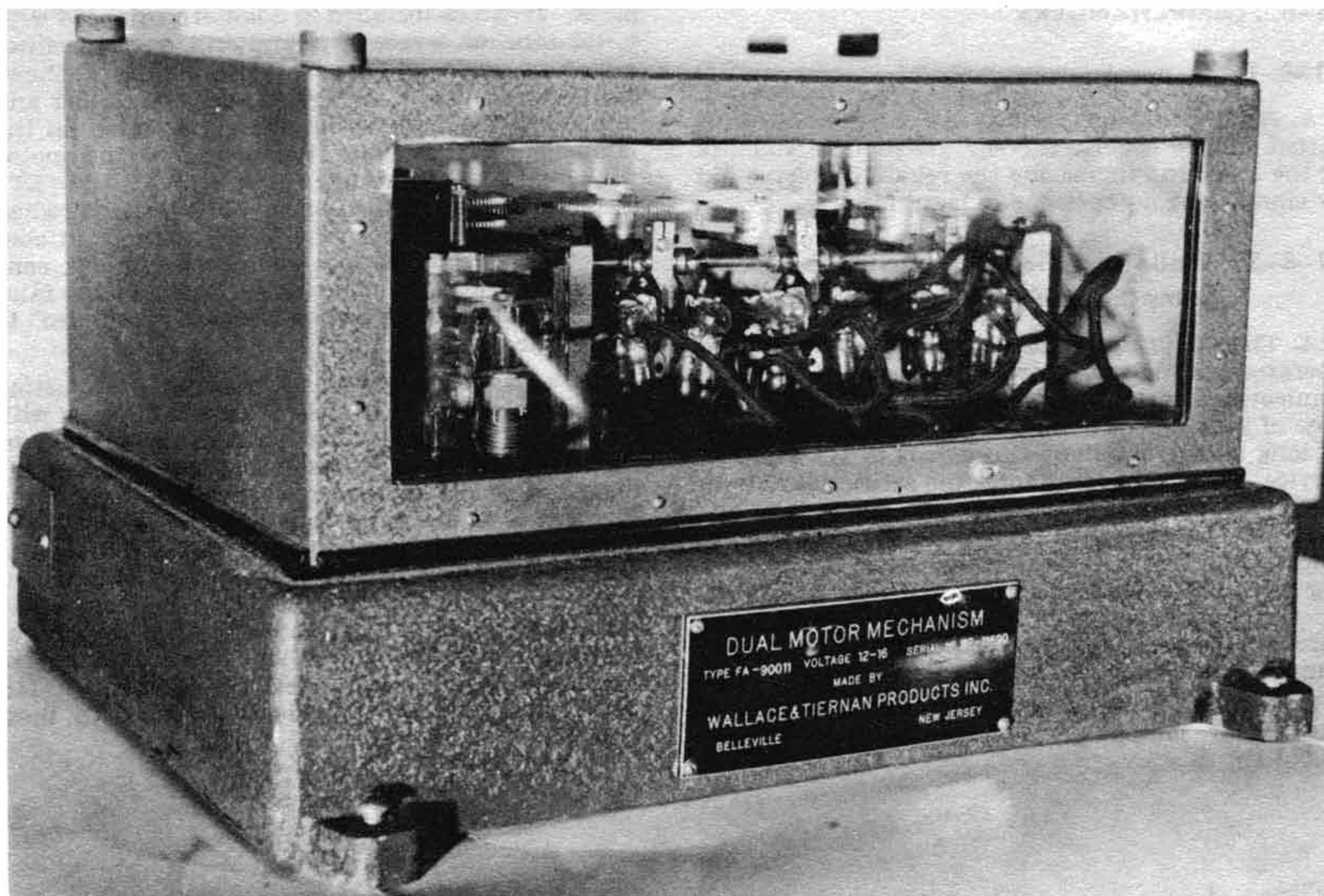


FIGURE 21-43.—Heavy duty flasher, type FA-90.

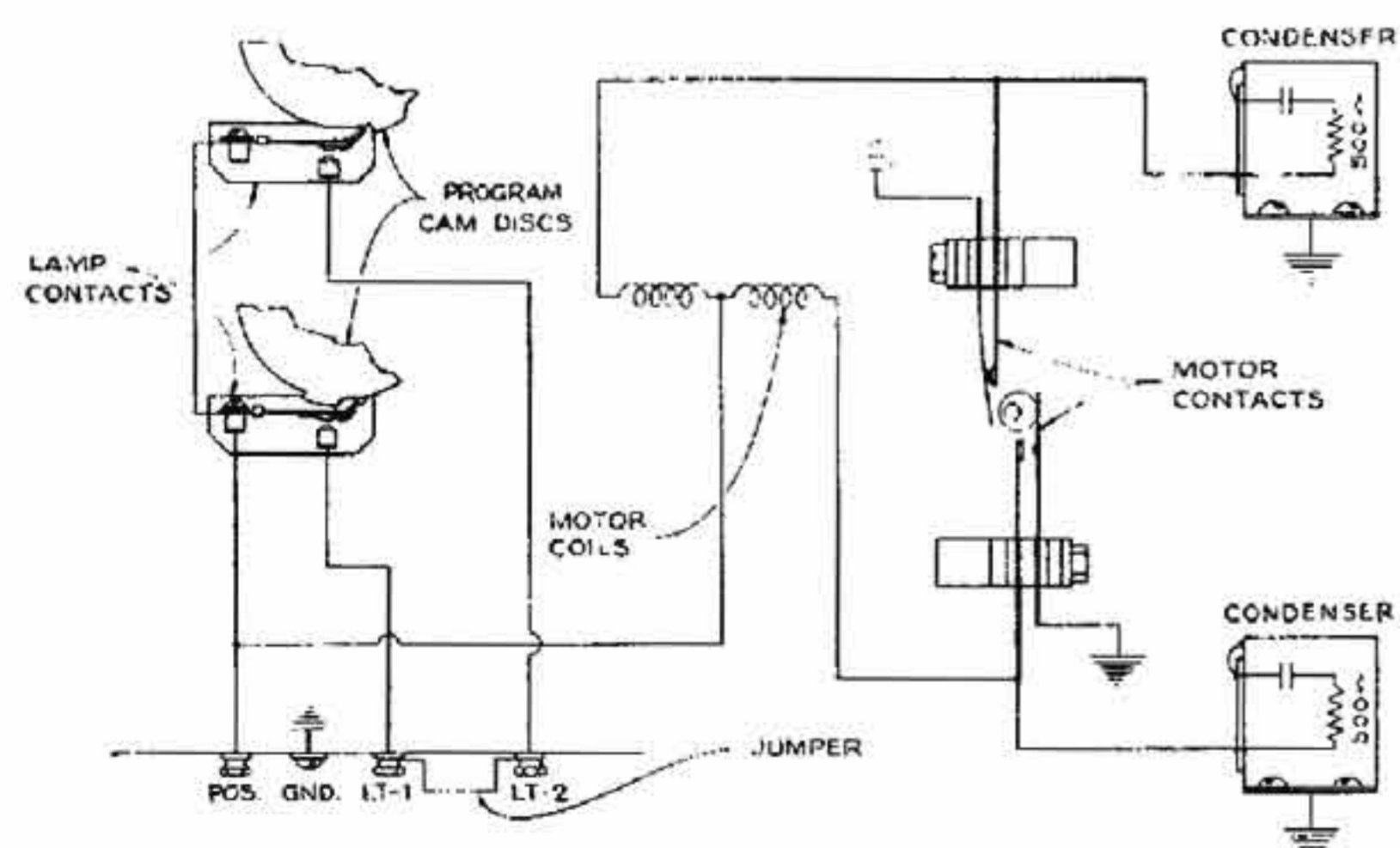


FIGURE 21-44.—Internal wiring diagram, motor mechanism, dual program cams.

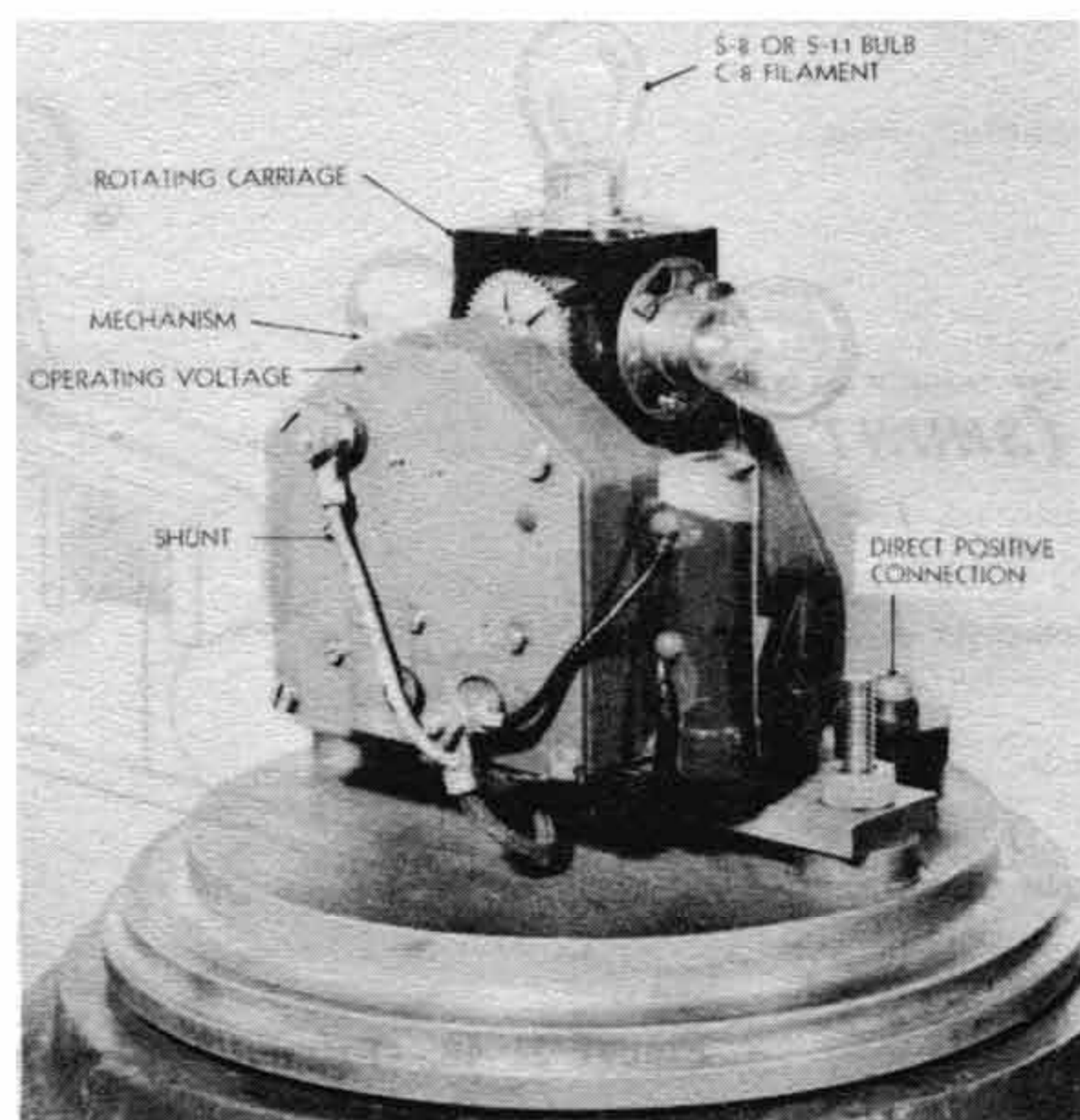


FIGURE 21-45.—Lampchanger, four lamp, type FU-1297.

21-8 LAMPCHANGERS

21-8-1 General—

A. A lampchanger permits use of a lamp until actual failure occurs, thereby getting the full life of the lamp and increasing the reliability of the aid by eliminating outages due to lamp failures.

21-8-5 Wallace & Tiernan Four-Lamp Electric Lampchanger—

A. The lampchanger is an automatic mechanism operated and driven by two relays, one of which is connected in series with the lamp in use for the purpose of keeping the circuit of the driving relay open as long as current flows through it to the lamp in service. When the lamp fails, the series relay closes the circuit to the driving relay and allows it to advance the lampchanger carriage until another lamp comes into place, after which the circuit of the driving relay automatically opens. With the new lamp in the operating position, current again flows through the series relay to the lamp until another lamp failure occurs.

B. Generally, the lampchanger is constructed to carry four lamps with prefocused bayonet-type

bases. It can be installed in a lantern equipped with a 150-mm. or larger lens and will operate either a flashing or a fixed burning light. Fig. 21-47 shows the internal lantern wiring between the flasher and lampchanger. Two terminals are mounted on the lampchanger frame for connection to the motor flasher and power source. The one for the "LT" connection runs to the flasher "LT" terminal when used. The one for the "positive" connection goes directly to a positive battery connection for continuous operating on the changer when a lamp fails. All internal negative connections are "grounded" to the frame.

C. *Focus.*—Care should be exercised in adjusting the lampchanger so that the lamp is in focus with respect to the lens. The lampchanger should be raised or lowered on its mounting bar or support by means of shims or spacer washers until the lamp filament is at the focal center of the lens. As the lampchanger is precisely constructed and the lamps are fitted with a prefocused base, it is only necessary to focus for one lamp. The other lamps will then automatically come into the focal position as the lamp carriage block rotates. (This is not true of the heavy duty lampchangers FA-147 and FA-148. The lamp must be individually focused in these changers.)

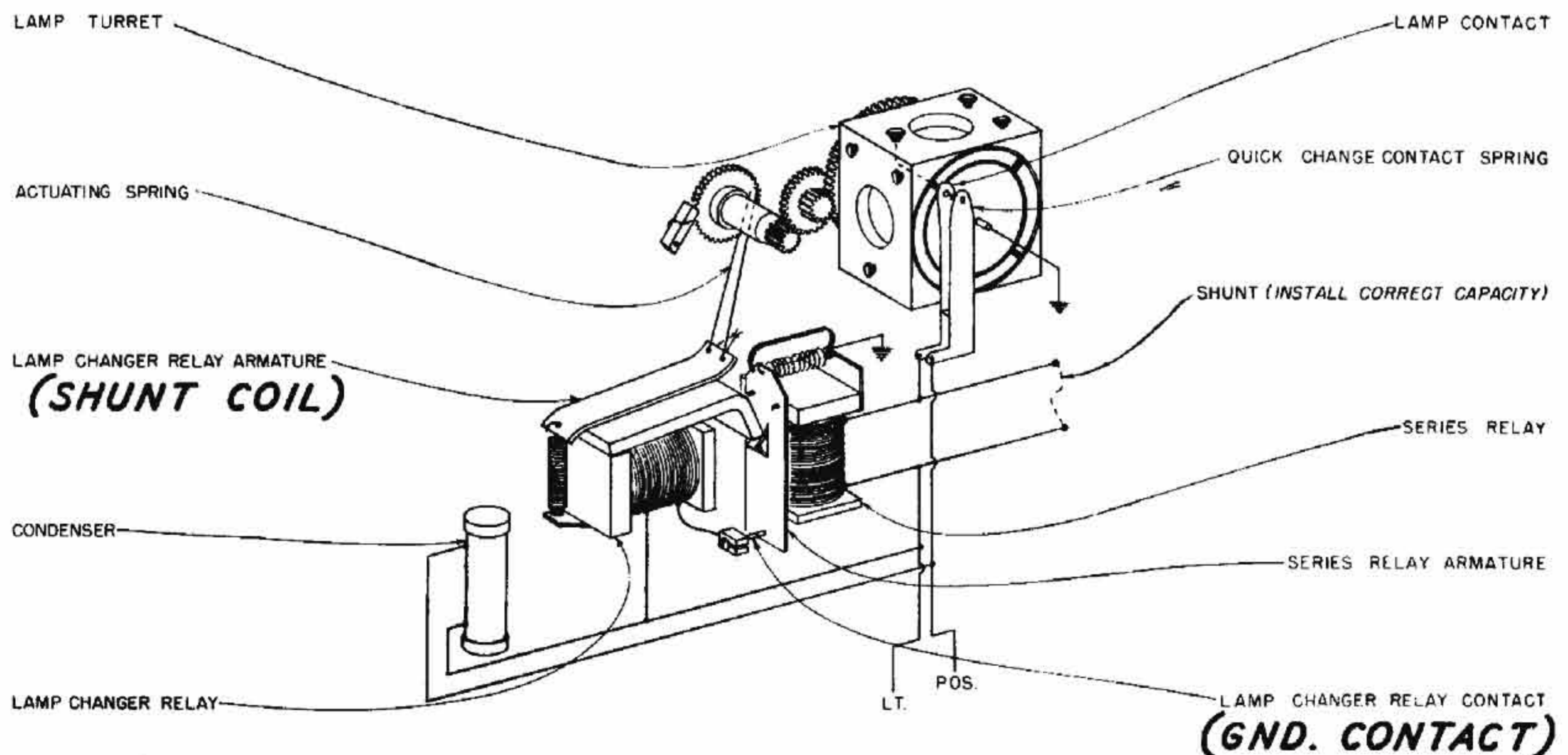


FIGURE 21-46.—Principles of operation of type FU-1297 lampchanger.

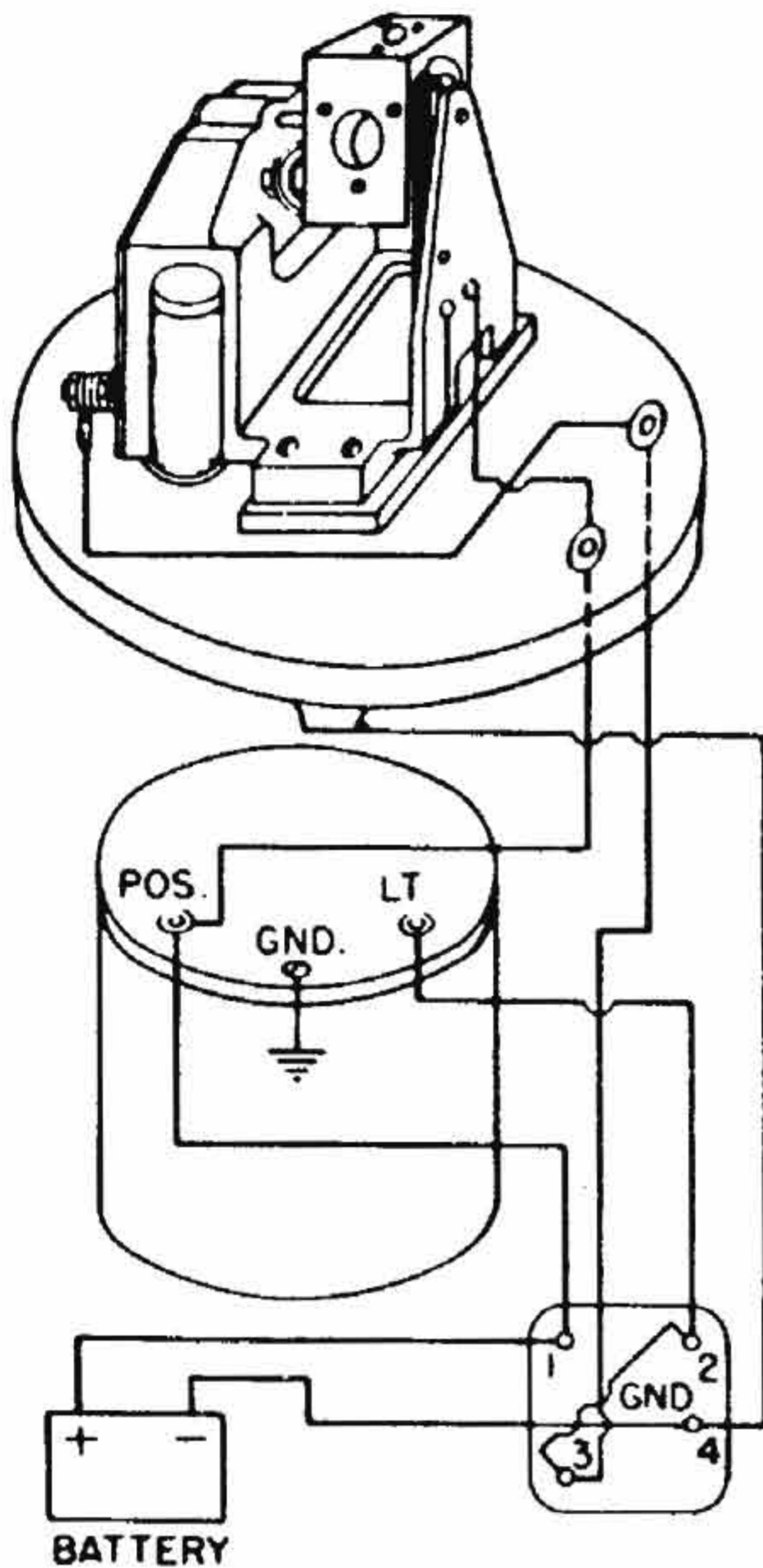


FIGURE 21-47.—Diagram of wiring between flasher and lampchanger.

D. The lampchanger may be used with all lamps having an operating voltage in the range of 6 to 16 volts d. c. It is important that a shunt corresponding to the amperage of the lamp in use be installed on the lampchanger. The shunt bypasses a large portion of the lamp current around the series relay coil and minimizes the voltage drop which otherwise would be present. The voltage drop with the shunt in place should not exceed 0.25 volt. If the proper shunt is not used, the lamp may be undervolted and cause considerable loss in beam candlepower. All shunts are marked to indicate the range of lamp with which they should be used. (See table below.) Shunts for values of up to 1.4 amperes are supplied with each lampchanger and are marked to indicate the range of lamp current with which they should be used. Shunts for higher rated lamps are available from the manufacturer. The following table shows part numbers and current values covering the range of lamps which may be used with the FU-1297 and SK-5529 lampchangers.

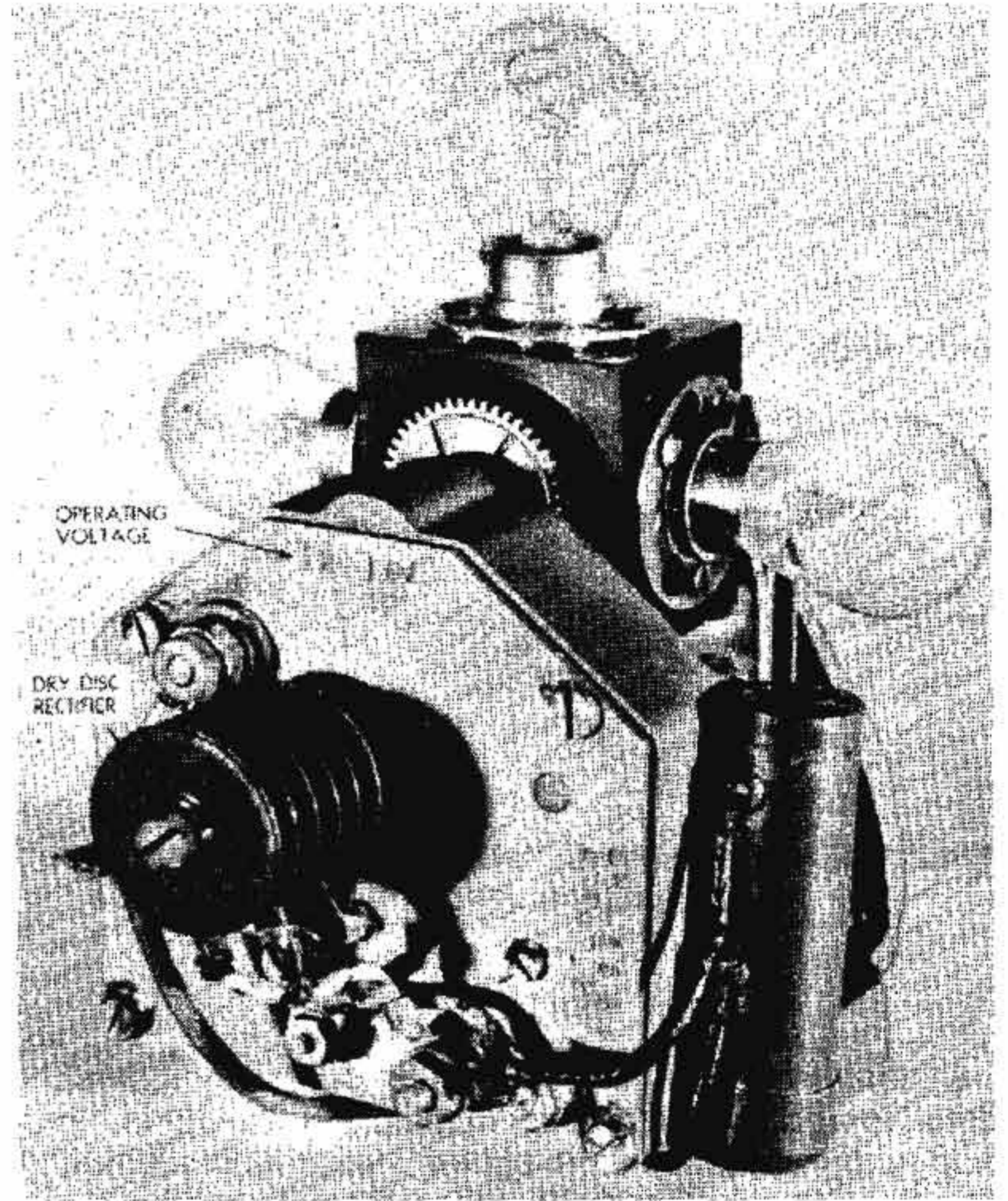


FIGURE 21-48.—Lampchanger, type SK-5529.

FU-1297 lampchanger	
Part No.	Lamp current
FU-1223.....	0.5 to 0.8 amperes.
FU-1222.....	0.8 to 1.1 amperes.
FU-1224.....	1.1 to 1.9 amperes.
FU-1149.....	1.9 to 2.8 amperes.
FU-1221.....	2.9 to 4.2 amperes.
SK-5529 lampchanger	
FU-2330.....	0.5 to 0.8 amperes.
FU-2331.....	0.8 to 1.1 amperes.
FU-2332.....	1.1 to 1.9 amperes.
FU-2333.....	1.9 to 2.8 amperes.
FU-2334.....	2.8 to 4.2 amperes.

21-8-10 Adjustment—

A. The lampchanger mechanism is factory adjusted and no other adjustments are necessary except for the use of the proper shunt to match the amperage of the lamp in use.

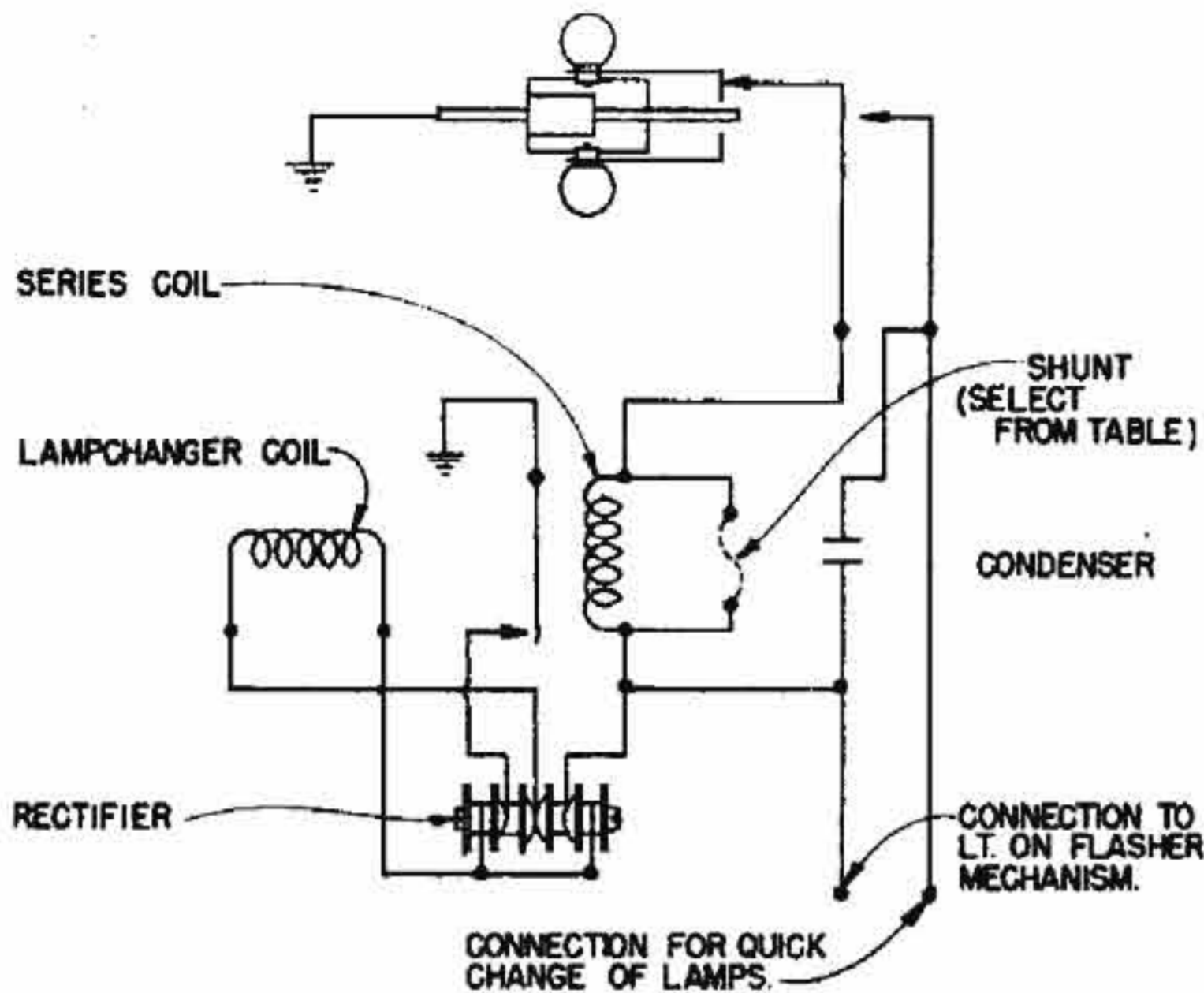


FIGURE 21-49.—Internal wiring diagram for type SK-5529 lampchanger.

21-8-15 Specific Types—

A. The type FU-1297 Wallace & Tiernan four-lamp lampchanger shown in figures 21-45 is the most commonly used in minor lights and lighted-buoys. It is designed to operate on from 6 to 15 volts d. c. and to carry lamps drawing up to 4.2 amperes. The FU-1297 lampchanger mechanism consists of a frame on which the series relay and driving (shunt) relay are assembled together with the armature, ratchet wheel assembly, pinion and gear assembly, and lamp carriage. The shunt relay has a ratchet which engages a pinion, and through the driving gears, turns the lamp carriage. The lamp carriage is an insulated block holding four lamp sockets, mounted on a shaft with a driving gear engaging a gear train and a contact for carrying current to the lamp in service. The four sockets are provided with three pins for mounting the pre-focus base lamps.

B. The two models of the W. & T. SK-5529 lampchanger are designed for operation on 6-10 and 12-16 volts a. c. or d. c. and are constructed and operated identically with the standard type FU-1297. These lampchangers use a dry-disk type of rectifier to furnish direct current for the operation of the shunt relay when an a. c. source of current supply is used.

C. The type FA-147 heavy duty lampchanger is designed for use with 32 or 115 volts a. c. or d. c. The operating voltage must be specified when ordering. The lamps are held in a spring-operated aluminum carriage and suitable adaptors and spacers must be provided to locate the lampchanger at the proper focal height of the lantern. Each lamp must be individually adjusted for proper focus by means of the three socket mounting screws. Movement of the lamp carriage is governed by means of a fiber gear and escapement, and whenever lamps are installed or replaced, the lamp carriage must be manually wound. The lamp circuit is not grounded to the frame, but one side of each lamp is connected in parallel and to a common lead running through the

center bearing to the series coil. The other side of the lamp is connected to an insulated contact mounted in the large lamp carriage operating gear. A flexible arm having a contact at the upper end is placed in such a position that it will complete the circuit to each lamp when it comes to the proper operating position. These lampchangers are usually installed in unattended large "order" lenses and in 375-mm. lanterns. A colored light is obtained by use of special shades (screens) which are placed over each lamp. Color shades are held in place by means of a support plate and wire clamps as shown in figure 21-50.

(1) Previous reference was made to the FA-147 lampchanger as "spring-operated". This means that the rotation of the lamp turret is actuated by a driving spring which is wound manually at time of servicing by holding in a release push button and turning the lamp turret by hand in a clockwise direction (when facing the release button) until a definite stop is reached. This will bring the number one lamp past the correct operating position but when power is supplied, the lamp will move to the correct focusing position.

(2) In operation, the lamp turret is maintained in proper position by means of a stop pin attached to an escapement gear. This stop pin is held by a latch pin attached to the armature of a lampchanger coil. As long as the lampchanger coil remains de-energized, the turret is prevented from rotating. The lampchanger coil circuit is opened by the action of the armature of an electro-magnet coil assembly in series with the lamp filament as long as the lamp in focus is good. When a lamp fails, the armature of the filament series coil acts to close the circuit of the lampchanger coil, whose armature unlatches the escapement stop pin, allowing the turret to rotate. When a new lamp is brought into proper focal position, the armature of the filament series coil opens the circuit of the lampchanger coil. This allows the armature latch to engage the escapement stop pin, thus stopping the rotation of the turret in the correct position. Since the lampchanger coil releases the escapement gear only upon being energized, when used with flashing lights, the movement of the lampchanger turret will be intermittent, i. e., when the flasher contacts are closed.

(3) The shunt relay armature also closes a micro-switch contact, operating an external alarm circuit, when used, while a new lamp moves into position. Should all the lamps burn out, the alarm circuit will continue to close each time a normal light period occurs until the lamps are replaced. A dry disk-type rectifier is connected in the shunt relay circuit to provide direct (rectified) current for the operation of this relay when the changer is used on alternating current.

(4) The following lamps may be used in the type FA-147 lampchanger:

- 32 volt 36 watt A-19 bulb LCL (light center length) $2\frac{3}{16}$ inches.
- 32 volt 60 watt A-21 bulb LCL 3 inches.
- 32 volt 100 watt A-21 bulb LCL 3 inches.
- 32 volt 250 watt P-25 bulb LCL 3 inches.
- 115 volt 100 watt P-25 bulb LCL 3 inches.
- 115 volt 250 watt P-25 bulb LCL 3 inches.

(5) Before installing a type FA-147 lampchanger in a 375-mm. or 5th order lens, particularly when shades are used, make a careful check to see that the over-all shade height is not greater than $17\frac{1}{2}$ -inches. When installed in a lens, suitable mounting supports must be provided to bring the lamp to proper focal height. A mounting ring is usually provided for installation in a 375-mm. lantern. In the event a lantern mounting ring is not available, a suitable substitute may be constructed from a plate 10 inches in diameter, drilled for the four 10-32 flasher screw holes located inside the lantern base. The plate in turn is drilled and tapped for the two $\frac{1}{2}$ -inch cap screws for holding the lampchanger. Suitable additional spacers may be used as required to raise the lampchanger to the correct focal position.

(6) When installing the FA-147 lampchanger where 115-volt a. c. commercial current is used, be sure to connect the *hot* side of the line to the *positive* terminal of the lampchanger. If a plug-in type attachment is used, a polarity-type plug is recommended. While the lamp circuit is not grounded to the frame, the contact spring arm lifting pin does ride on the large lamp turret operating gear (which is common to the frame) during rotation between lamps, causing a short circuit. If the polarity precaution is not taken, the blowing of fuses upon the changing of a lamp would result, unless of course the whole unit were insulated from its mounting. (The above applies only when the contact lifting pin is not insulated from the spring arm, as in the early models. Since late 1949 the lifting pin has been insulated from the spring arm, making precaution as to polarity unnecessary.)

(7) When installing the FA-147 to a d. c. source of power, connect to the terminals as marked.

D. The type FA-148 lampchanger is designed to operate on 110 volts a. c. or d. c., using mogul base screw-type lamps. The construction is otherwise identical with the type FA-147.

E. The type FU-847 lampchanger commonly known as the "Daisy Chain" is no longer standard, although a few installations are still in use.

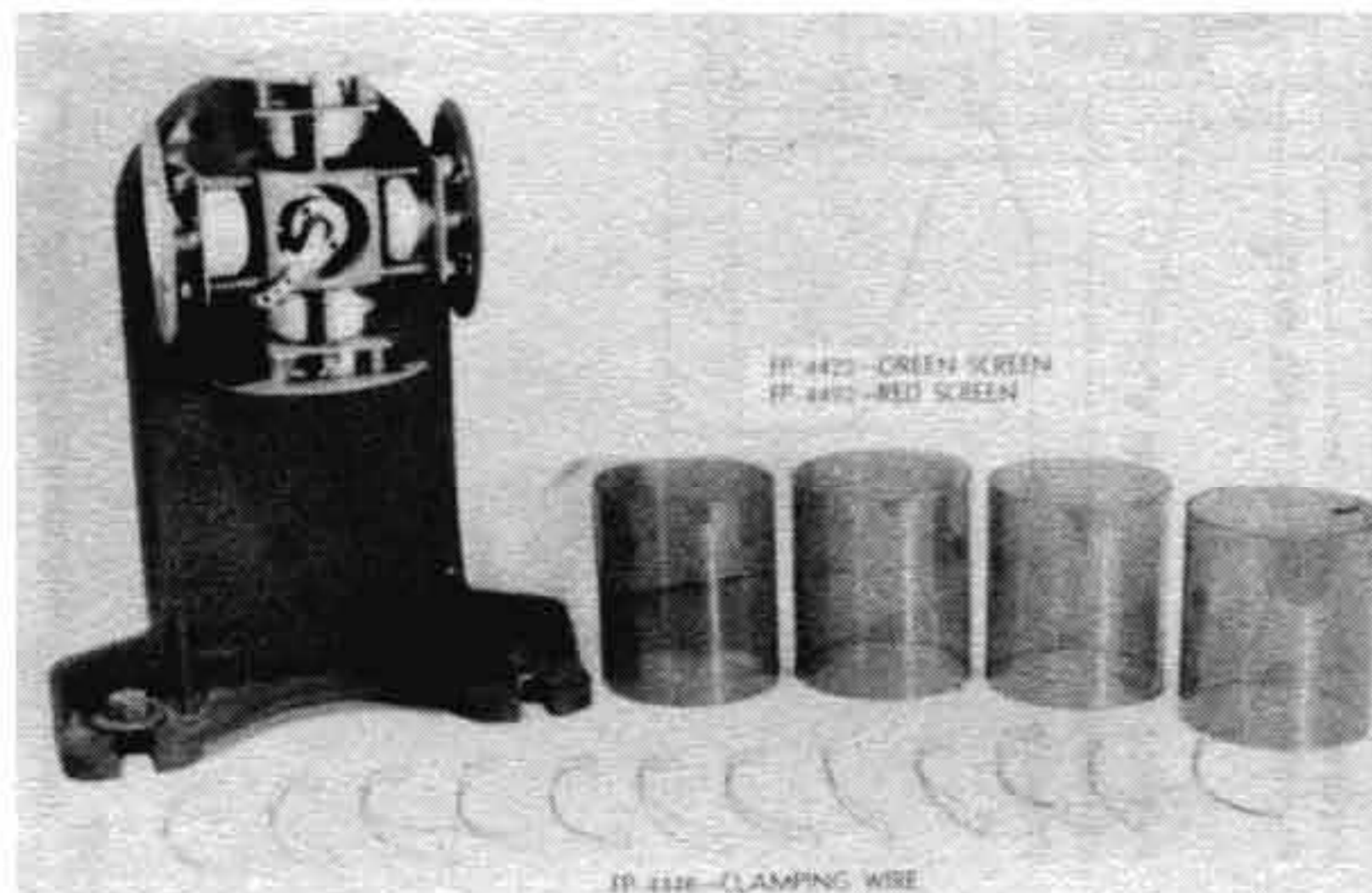


FIGURE 21-50.—Lampchanger, type FA-147.

21-9 CURRENT SAVING DEVICES

21-9-1 General—

A. The electric assembly may include means for turning on the light with approach of darkness and vice versa. This is accomplished by means of either a time clock or a light-sensitive control device. Either spring- or electrically-wound escapement-type clocks are suitable. Synchronous electric clocks should not be used since power interruption or frequency variations will shift the operating period.

B. *Light-sensitive control devices* are of two types: those in which the response is photoelectric, and those depending on absorption of heat. The first is available in a variety of types. No restriction as to design is stipulated, but reliability is paramount. A desirable feature should be that failure will occur only in the lighted position. The second type, the sunrelay, depends on absorption of heat from the light rays. Its mechanical design is similar to that of the sunvalve for controlling gas lights.

C. A feature common to all light sensitive control devices is their *delicate operation*. They are not suited for handling large currents and manufacturers' specifications for current rating must not be exceeded. Auxiliary power relays are required in all cases where they are to handle 32- and 115-volt lamps. The sunrelay performs best in low latitudes because the transition from light to dark and vice versa is more rapid than in higher latitudes. Slow operation prolongs the "chattering" of the contacts during the actual transition period.

D. Current savings of up to 38 percent may be effected with these devices. Light sensitive controls are usually justified only in the case of high candle-power lights since in this case appreciable savings will result. The criterion for determining whether or not the device should be installed, is the time it would take for the savings in energy to amortize the cost of the device. Four years is the presently accepted figure. No device that would take longer than 4 years to pay for itself should ever be installed.

21-9-5 Sunrelay—

A. The automatic sunrelay is a device serving the same purpose as a sunvalve for acetylene lights, that is, to conserve the source of power supply by extinguishing the light during sunlight hours. However, instead of operating a gas valve, the sunrelay actuates a switch or contact. When lamps of 2-amperes or 25-watt a. c. and 1.5-amperes or 10-watt d. c. or less are used, the sunrelay may be connected directly in series with the lamp circuit. For lamps of higher rating or where commercial current is used, always connect it through a protective relay.

B. *Construction.*—In construction, see figure 21-55, the A. G. A. sunrelay consists of three round bars about five-sixteenths inch in diameter and about 7 inches long, spaced equidistantly in a circle and secured to a base which forms the top of an electrical contact housing. The top of the bars are secured to a flat disk about $\frac{3}{8}$ -inch thick, the whole

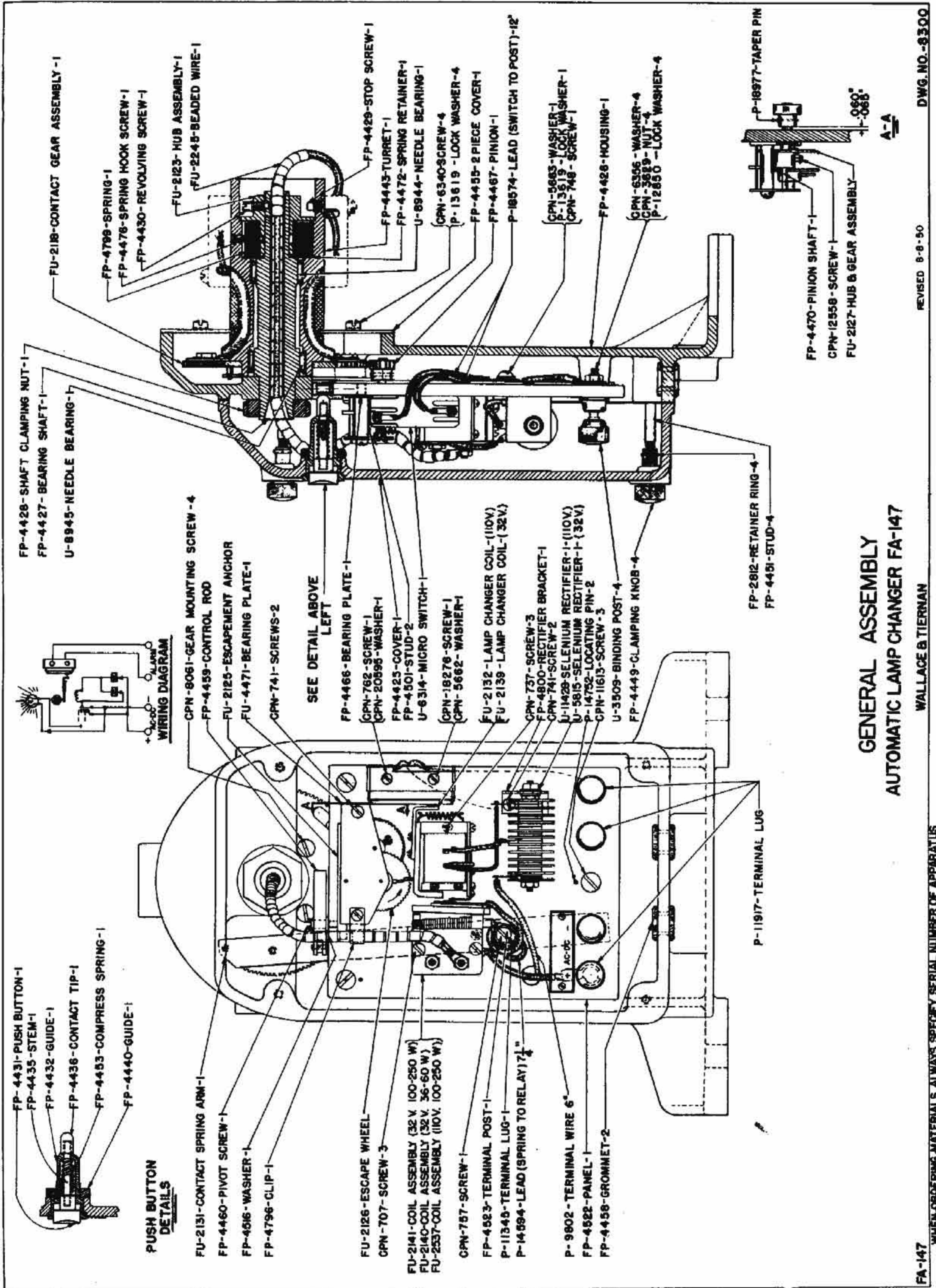


FIGURE 21-50A.—General assembly, type FA-147 lampchanger.

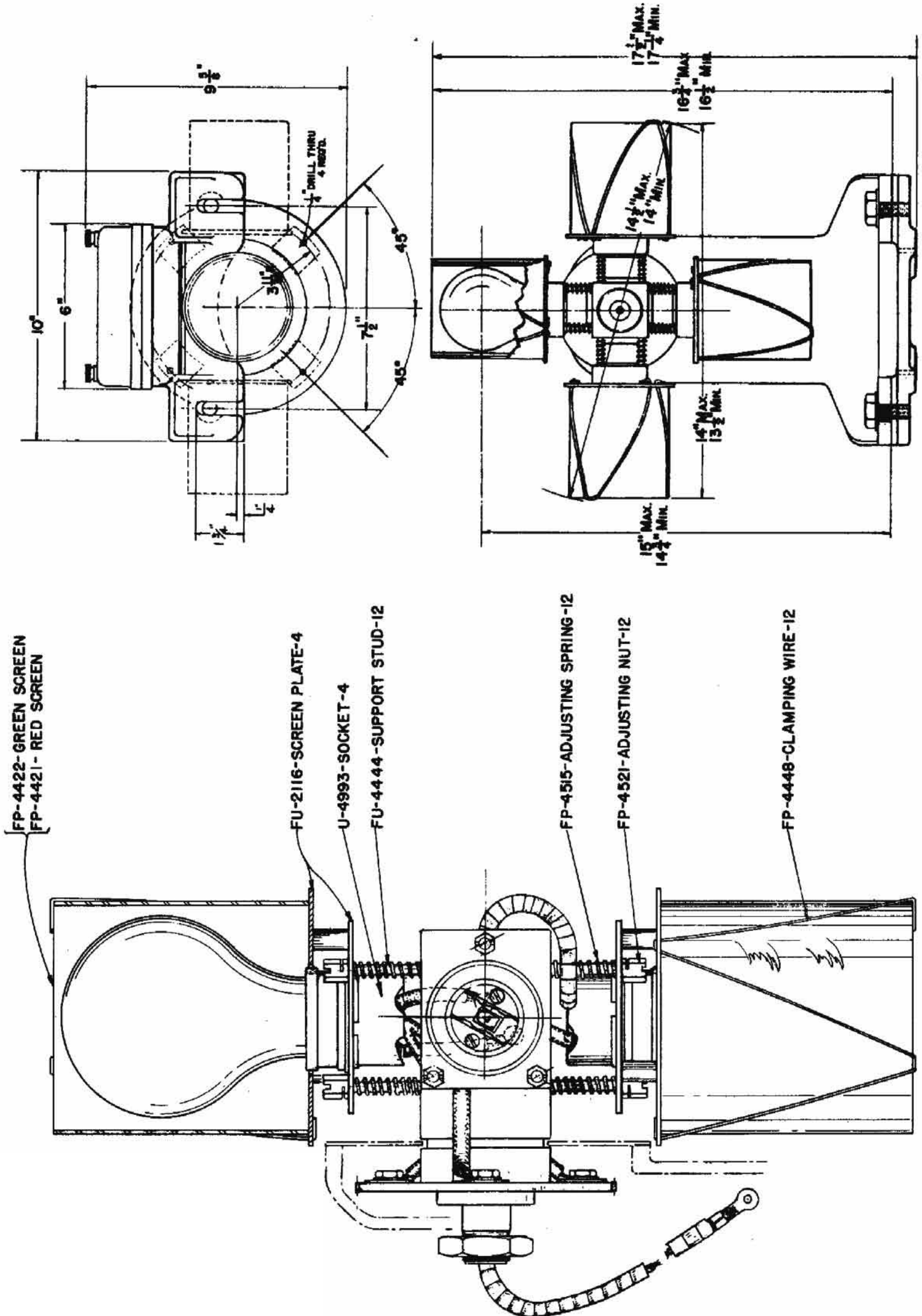


FIGURE 21-50B.—Socket and color screen details and general dimensions, type FA-147 lampchanger.

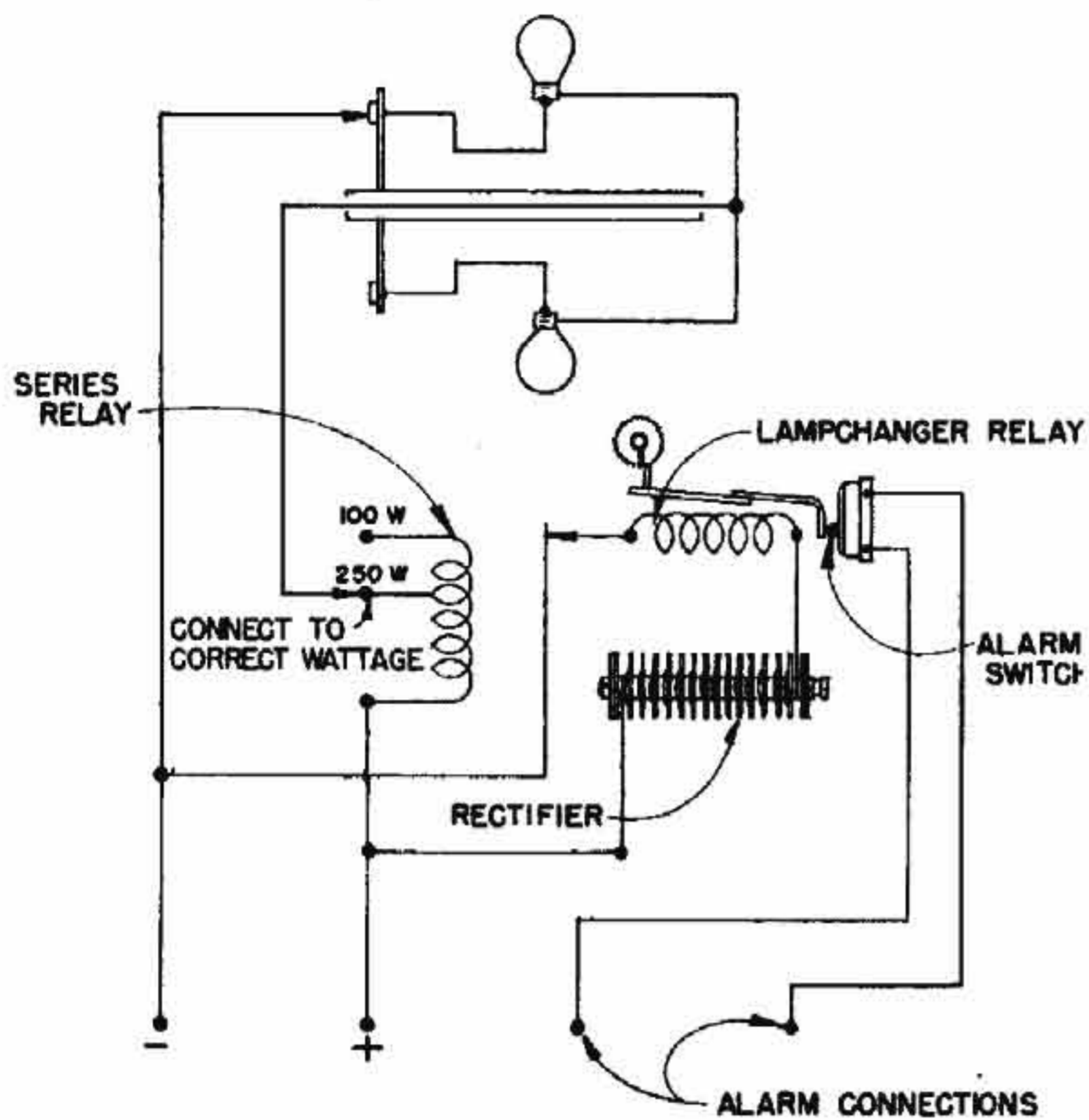


FIGURE 21-51.—Internal wiring diagram, 110-volt a. c.-d. c. arrangements for type FA-147 lamp-changer.

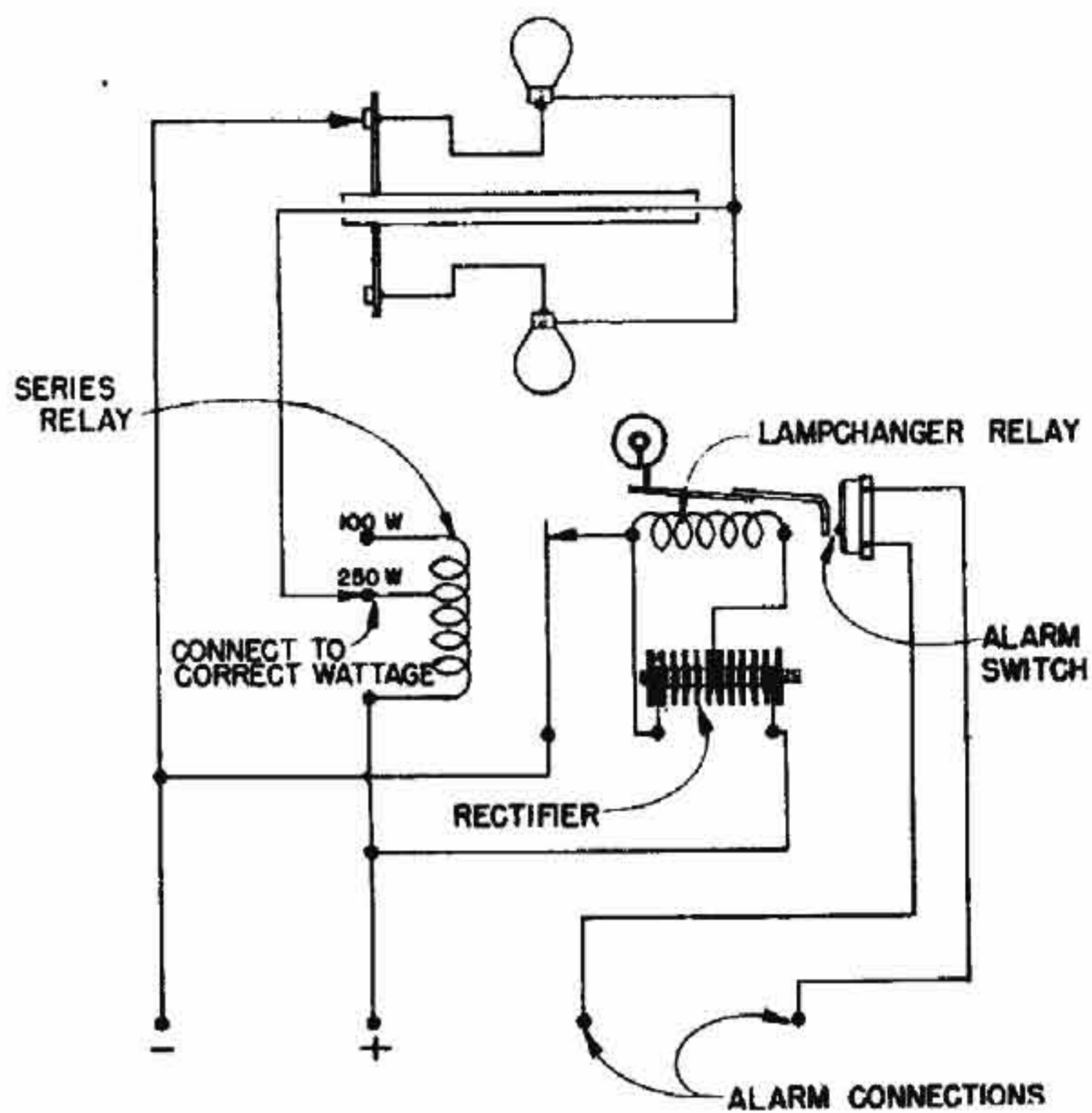


FIGURE 21-52.—Internal wiring diagram, 32-volt a. c.-d. c. arrangements for type FA-147 lamp-changer.

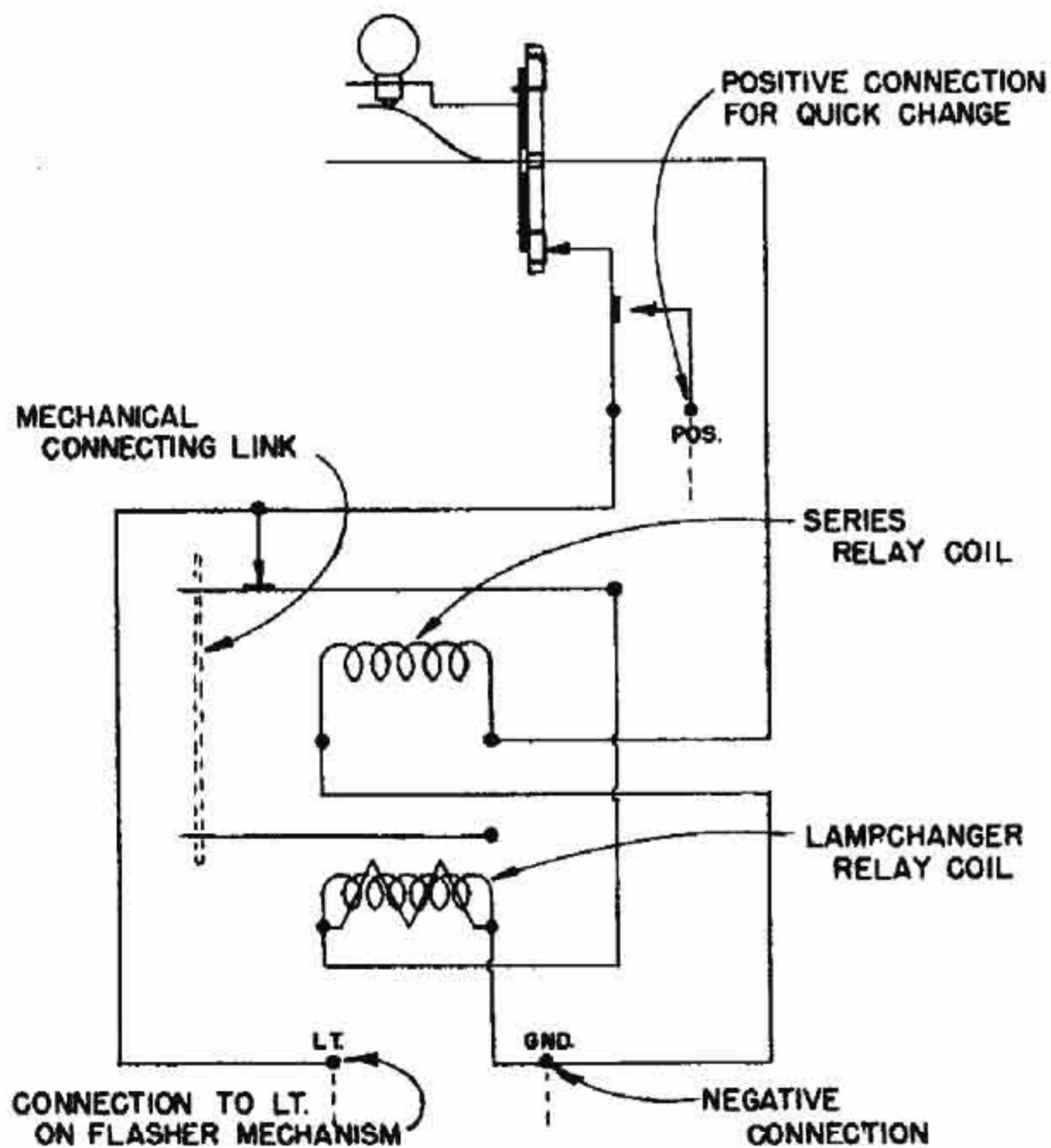


FIGURE 21-53.—Internal wiring diagram for type FU-847 lamp-changer.

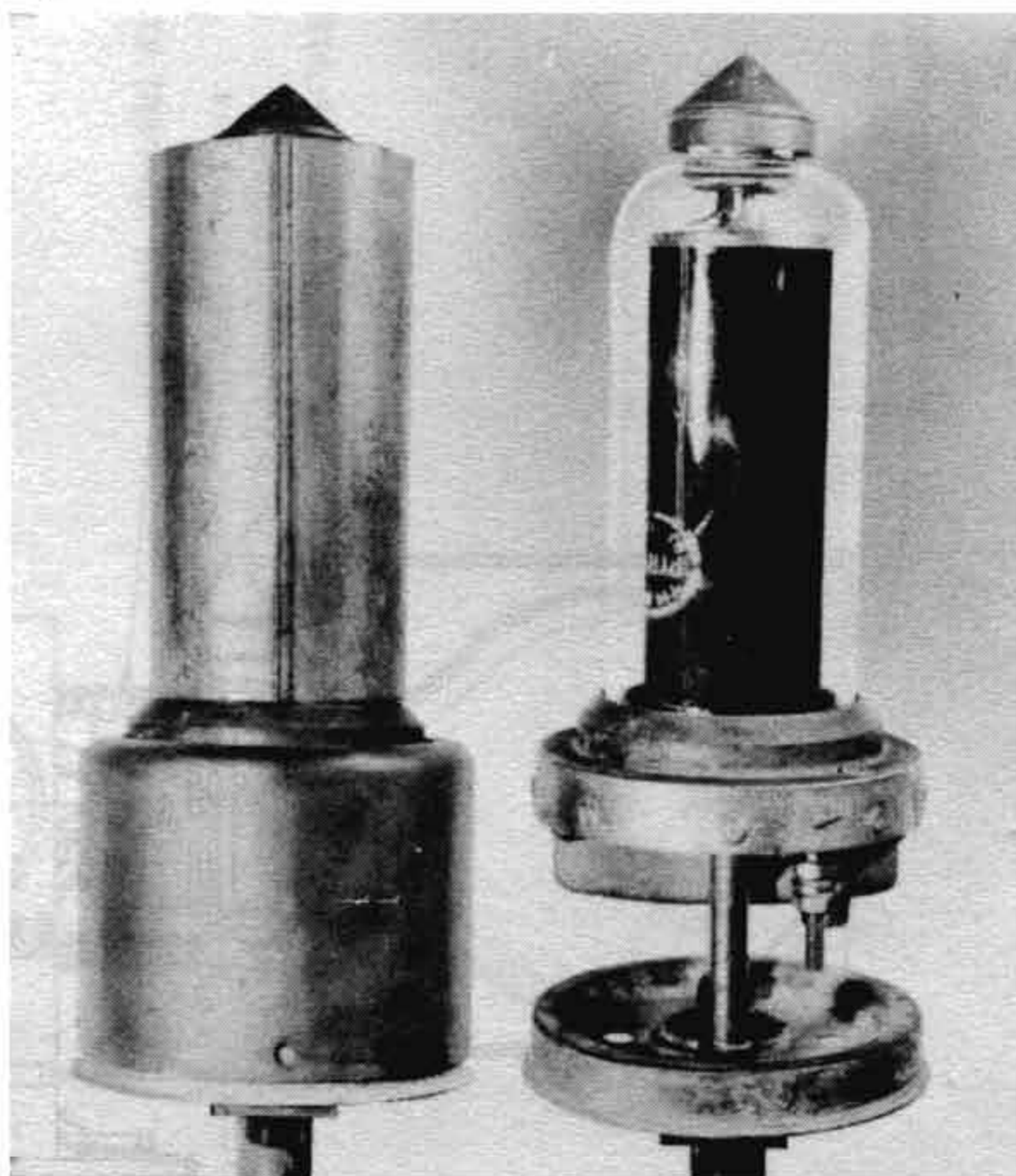


FIGURE 21-54.—A. G. A. sunrelay.

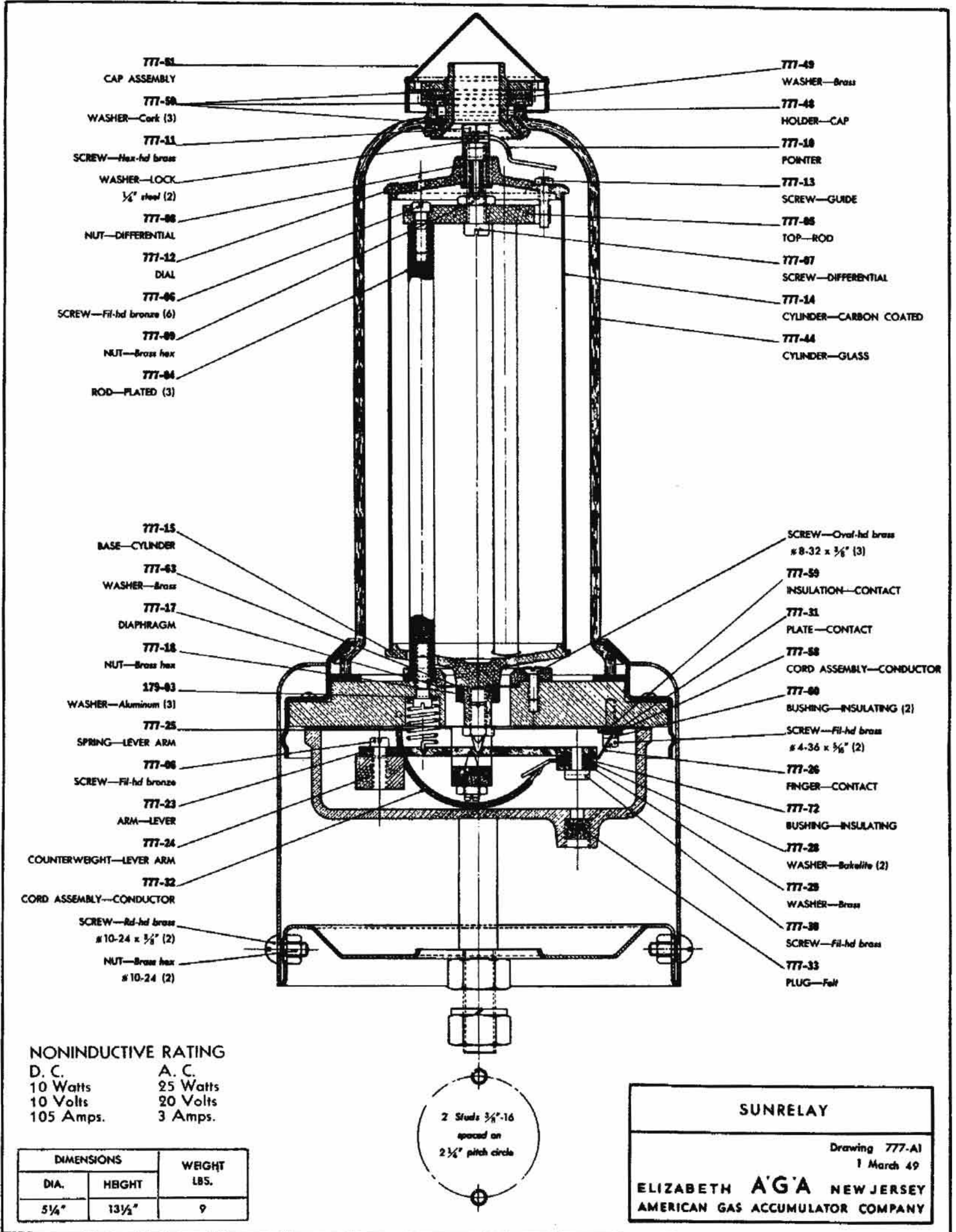


FIGURE 21-55.—A. G. A. sunrelay.

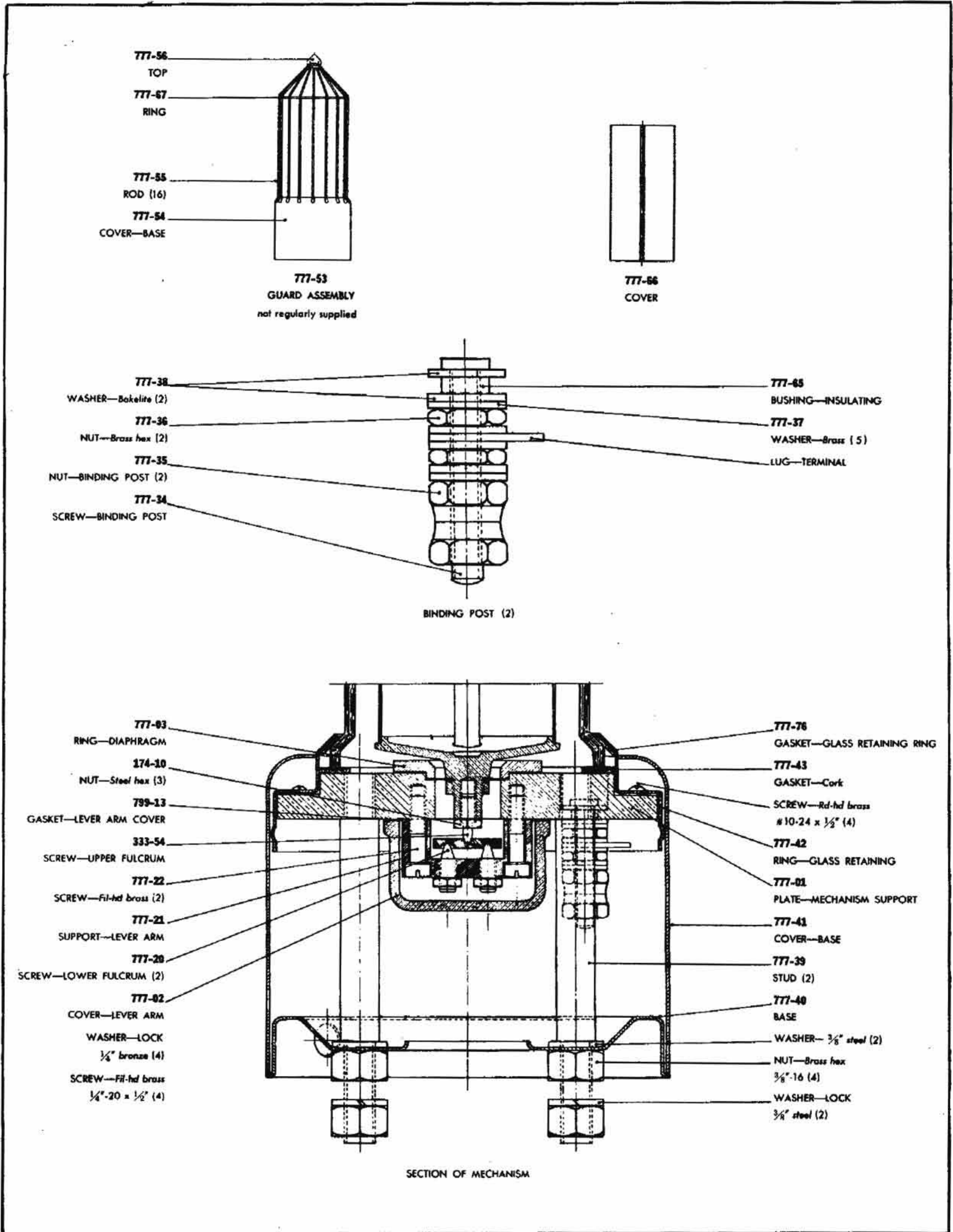


FIGURE 21-56.—A. G. A. sunrelay parts assemblies.

forming a rigid framework. Entirely surrounding (and shielding) the three rods is a blackened cylindrical tube which is the expanding member. This cylinder is retained at the top of the rigid framework and the bottom is capped by a disk-like casting containing in its center a pointed screw, which is fixed to a metal diaphragm and set into the top of the chamber. The pointed screw is carried through the diaphragm, part 777-17, and rests upon a balance lever which operates an electrical contact, see figures 21-55 and 21-56. Clearance holes are provided in the bottom of the tube casting for the shielded bars, permitting a freedom of downward expansion on the part of the cylinder. Two mounting studs, threaded three-eighths inches—16-thread on a $2\frac{1}{4}$ -inch pitch circle, are provided at the under side of base.

C. Operation.—The principle of operation is that of a number of rods or bars, all of the same material and length, having the same rate of expansion, one of which is blackened so as to absorb light and the others shielded from the light. The absorption of light by the blackened rod will cause it to expand while the shielded bars will retain their original length. The movement of a longitudinally expanding light-absorbing bar, which is incorporated into a framework of nonexpanding shielded bars of the same length and material (or same rate of expansion) may be transmitted into mechanical movement of considerable latitude by appropriate linkage, and such movement utilized in turn for the operation of other devices. In operation, light is absorbed by the blackened cylinder which expands downward (the top of the cylinder being retained at the top of the framework) overcoming the tension of the diaphragm and causing the pointed screw to act upon the contact lever (part 777-23) in such a manner as to open the circuit. As the daylight falls, reverse action takes place and eventually the contacts are again closed. The degree of expansion necessary to actuate the lever may be controlled by adjusting the tension of the metal diaphragm by means of an adjusting screw at the top of the framework. This is the sensitivity control. It should be clearly understood that when the sun device is covered or in the dark, the contact is closed, permitting the light to operate.

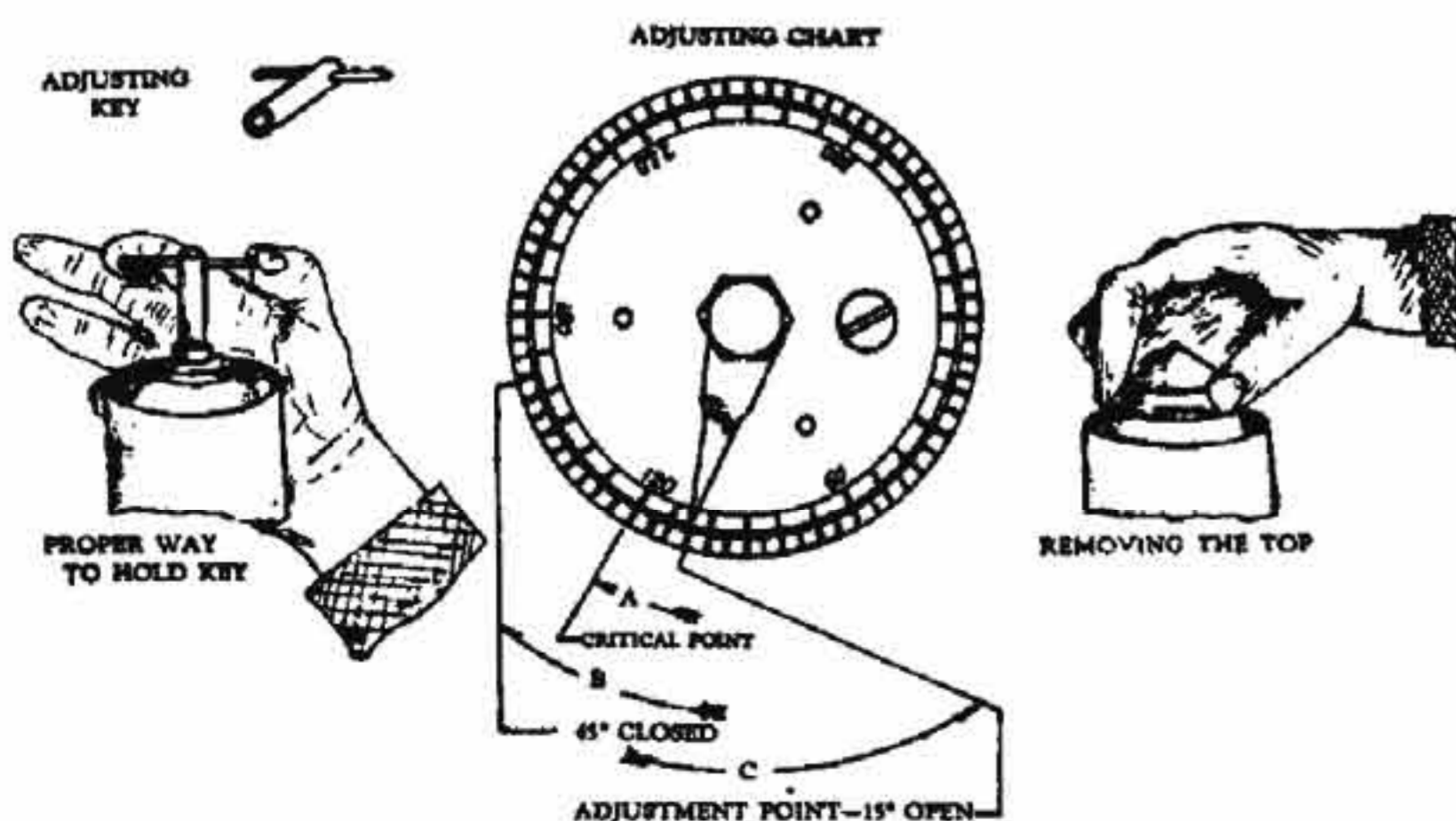


FIGURE 21-57.—Sunvalve and sunrelay adjustment.

D. Adjustment procedure.—Sunrelays should be covered for a period of 2 hours before and during adjustment. To adjust, proceed as follows:

(1) Be sure that the light itself is operating properly. This may be checked by installing a jumper on terminals 2 and 3 in the lantern terminal box (in Wallace & Tiernan lanterns) or across the terminals of the sunrelay. The light should continue to operate.

(2) Remove the jumper.

(3) Remove the cap at top of the glass.

(4) Insert the socket adjusting wrench—*keep the weight of the hand off the wrench.*

(5) Turn the wrench clockwise until the light goes out; observe the position of the pointer over the graduated disk.

(6) Continue to turn the wrench in the same direction until the pointer registers an additional 45° .

(7) Turn back in a counterclockwise direction until the light comes back on. Note the exact point at which this occurs. This will be the critical point.

(8) Continue to turn in a counterclockwise direction for an additional 15° . *This will be the point of adjustment.*

(9) Remove the wrench and replace the cap.

(10) Remove the protection shield.

E. Time delay.—A certain amount of lag will be found between the time the cover is removed and the time the device operates to shut off the light. This will depend upon the sensitivity of the adjustment. The reason why sunrelays should be covered for 2 hours before making adjustments is that, if the apparatus has been exposed, the amount of expansion is unknown and an accurate adjustment cannot be made if the actuating tube is partially expanded. After being covered for 2 hours or more, the tube is fully contracted. It is from this known position only that an accurate setting can be made for proper operation. It will be found that on brilliant days, or when the sun is directly overhead, the protection shield, being open at the top, permits sufficient light to enter thus preventing the normal functioning of the device. Under these circumstances the entire top should be covered by use of one's hat or other means at hand.

F. It is not essential that sunrelays be adjusted at the time of installation. They should be adjusted in shops, at depots, or on board tenders, prior to field installation. Once properly adjusted, they may be stored as spares for use when necessary. *Handle these units with care and do not jar, particularly while making adjustment.*

G. Mounting.—Sunrelays should always be mounted on the light structure in a position of convenient access and free from shadow.

H. Maintenance.—Generally, no field maintenance is required other than the cleaning of the external surfaces. Repairs beyond the replacement of a broken glass cylinder or the recoating of the carbon cylinder should not be attempted at depots.

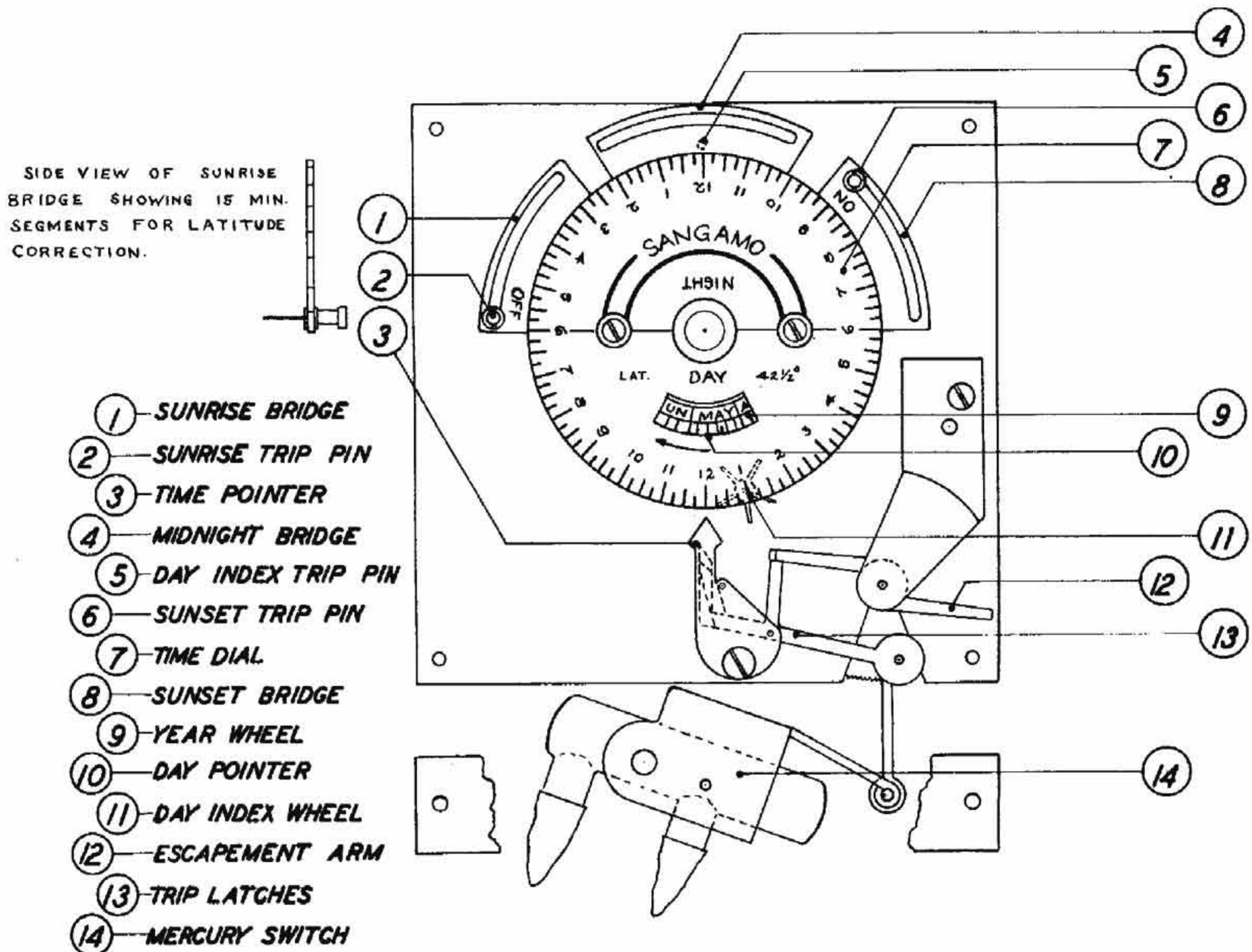


FIGURE 21-58.—Sangamo astronomical time clock.

winding period, the clock will operate for about 12 hours. If failure occurs immediately after a winding period, clock operation for 52 hours will be had. A season changing device is available on the type MSD unit. As in the case of the Sangamo clock described above, the latitude must be specified when ordering.

While the construction differs somewhat from the Sangamo clock, the essential operating parts are similar and perform the same general functions, and the same general description applies. The procedure of making the initial adjustments in placing the unit in operation differs only in application to the particular time dial.

F. Installation.—To place the Anderson type MSD time switch in operation, observe the usual precaution of making sure the power is on and the clock is running. (The winding motor will start as soon as power is applied.) Determine the prescribed on and off periods prior to sunset and after sunrise. Assuming that it is desired that the switch operate to turn on the light at 7 p. m. and off at 5:10 a. m. and that the initial adjustment is made on September 3 at 12 noon, proceed as follows (see fig. 21-58A):

(1) First, set the switch to the time of day in the following manner: Grasp the 24-hour night and day dial across the outer edges with thumb and

fingers firmly and turn to the left (direction of arrow) until the time of the moment (12 noon) comes directly in line with the white line (J). It will be observed that the bright half of the dial shows 6 a. m. to 6 p. m. (day) and the dark side shows between 6 p. m. and 6 a. m. (night). If the time markings involved in the setting of the night and day dial are obscured by the season changing device, the corresponding time must be read by the lower time indicating pointer (E).

(2) Now adjust for month and day; with thumb and forefinger, turn propelling wheel (C) (day index wheel) until the number of the month (9) on the month dials (A) line up with dial pointers (D). This brings us to September 1. In turning the propelling wheel, distinct stop positions will be felt, each stop representing 1 day's movement of the month dials. Now push the propelling wheel to the left an additional three stops to September 3 as required.

(3) Next, adjust the time ON and OFF operation. This is done by moving a. m. pointer (G) and p. m. pointer (H). These pointers are moved by grasping firmly with thumb and forefinger of one hand and holding night and day dial with the other. The total movement of these pointers is up to 1 hour before sunset for pointer (H) and up to 1 hour after sunrise for pointer (G). The setting in figure 21-

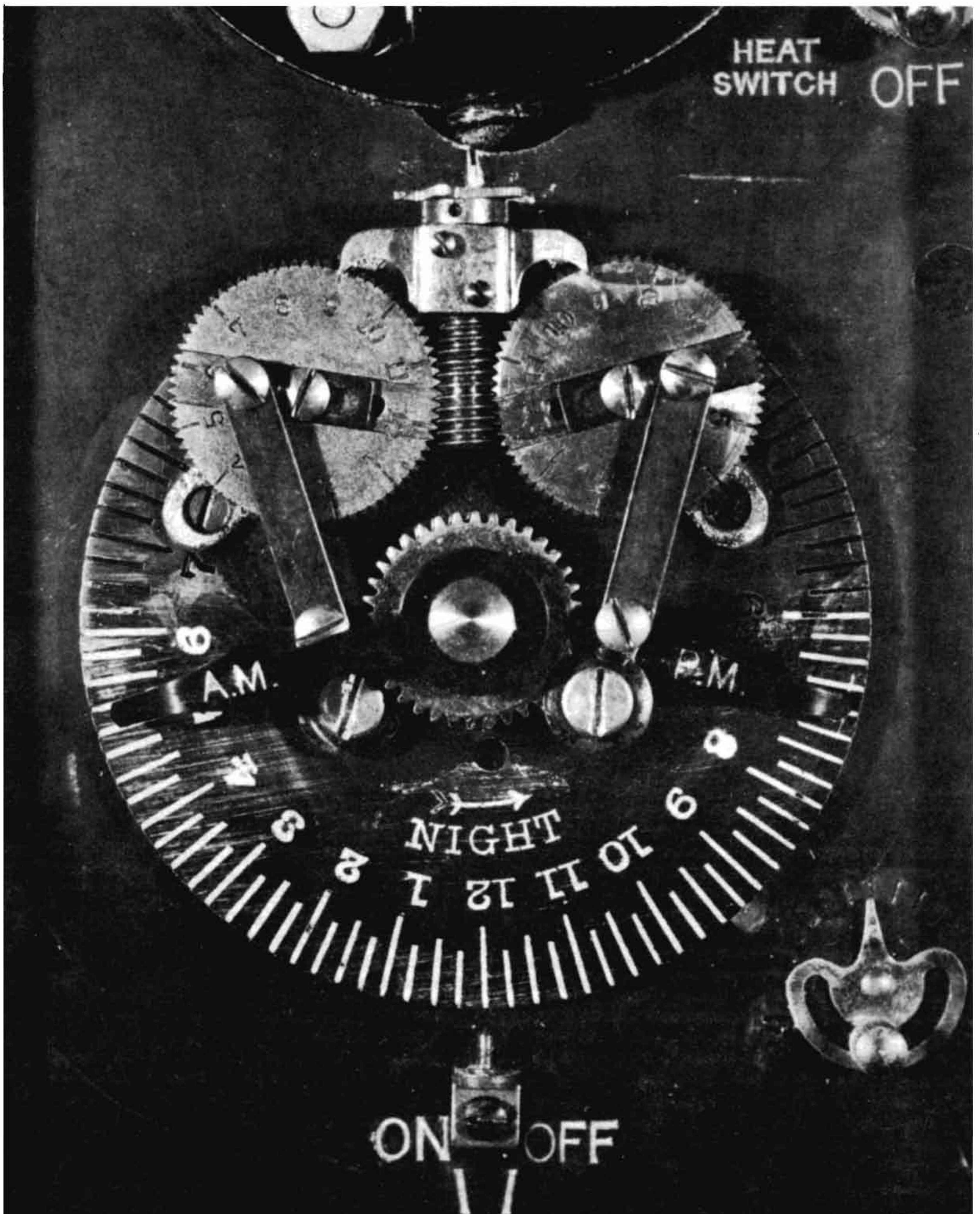


FIGURE 21-58A.—Anderson type MSD time switch.

58A indicates according to pointer (H) that the light will be turned on at 7 p. m. and according to the setting of pointer G, will be turned off at 5:10 a. m. When correctly set in accordance with the above directions, the time switch will follow the sunset and sunrise within practical limitations throughout the year.

G. A small heater will be found mounted in the housing of the time-switch, powered from the same source. The operation of this heater is manually controlled by a toggle switch. The heater should be turned ON when the time switch is subject to temperatures lower than 20° F. and turned off when the temperature is above 20° F.

H. *Manual Operation.*—Just below the lower time pointer (E) will be found a small knob carrying a pointer movable between indicated ON and OFF positions. This knob serves to manually operate the mercury line switch. Be sure that the indicator is left in the OFF position if adjustments have been made during daylight hours.

I. *Maintenance.*—There are no maintenance factors to be observed in connection with the Anderson time switch. Failure of the clock to run is about the only thing that could happen. In this event, the whole unit should be returned to the manufacturer for repairs.

J. While the astronomical time switch performs the same general function as a sunrelay, and its use is considered to result in greater economy, it lacks the feature of the sunrelay which will allow the light to operate during periods of low visibility.

the focal plane. This is the proper plane on which to view an aid for proper focus. If in figure 21-59 (3) the observer's eye were raised or in (4) it were lowered, the aid would appear in focus whereas it actually was not. Aside from the close-up test shown in figure 21-59 (6) (to be discussed later) the observation for focus should always be with the observer's eye on the focal plane, or as close thereto as may be permitted. A properly focused light situated on a high bank and viewed from a skiff fairly close to shore, will appear out of focus. The light layer is above the observer's eye. Should the skiff be rowed away from shore a reasonable distance, the light will soon show properly. On a vessel close in and under a light, it will appear out of focus to those on deck, but to those on the bridge, close to the focal plane, the light will appear in focus.

21-10-10 Divergence—

A. The ideal focusing condition is shown in figure 21-59 (2). If the light be only a point size, and the lens without any errors, the light proceeding to the observer will be a flat layer of height (H), and for the 200-mm. fresnel lens, equal only to 6 inches. To see the signal, the observer (E) must be within this relatively thin layer. Obviously, such a condition would be impractical, and it becomes necessary to have some divergence in the layer so that it will include the observer.

B. For the ideal condition shown in figure 21-59 (2), divergence could only be achieved by proper design of the fresnel lens. Practically, divergence is obtained by using a light source larger than a point. This is not difficult since a point of light source is impossible to achieve. All electric lamp filaments have width and height, hence are not point light sources, and in a lens produce a diverging layer of light. The usual divergence obtained can be easily understood by superimposing figure 21-59 (3) on (4). The two unfavorable conditions shown in figure 21-59 (3) and (4) have now been added together resulting in a favorable condition of divergence. Since an overlap of rays occurs at the midheight of the lens, the signal is strongest in this plane. Above and below this plane, the signal is weaker. For example: The actual divergence of a standard low-voltage marine signal lamp (0.7-ampere, 6.2-volt) used in a 200-mm. lens is about 3° vertically above and below the horizontal plane at 15 percent of maximum candlepower. For 6° total divergence, the total thickness of the light layer at 1 mile is 2×277 feet, or 554 feet as shown in figure 21-59 (5). The best signal intensity for this combination occurs throughout the central 2° angle, 1° above and below the focal plane. For the 2° part total divergence, the thickness of the light layer at 1 mile is 2×92 or 184 feet. Candlepower data for this combination is as follows:

21-10 FOCUSING

21-10-1 Fresnel Lens—

A. A simple light source radiates light in all directions, and as a signal to be observed from a distance, is usually quite inefficient, since most of the light is not thrown directly toward the observer, but everywhere else, as shown in figure 21-59 (1). A fresnel lens picks up and directs toward the observer much of the wasted light, as shown in figure 21-59 (2). The light radiating into the top and bottom of the lens is wasted, and cannot be utilized with the simple fresnel lens. Any lighted aid using a fresnel lens must be properly focused to be efficient. Proper focus is obtained only when the light source is located in the focal point of the lens. In a common fresnel lens, the focal point is located at the midheight (looking horizontally) and in the center (looking downward). The horizontal plane through the midheight of the lens is the focal plane.

21-10-5 Mis-focusing—

A. The effects of mis-focusing are shown in figure 21-59 (3) and (4). In figure 21-59 (3) the light source is below the focal plane, throwing the emitted beam upward over the observer. In figure 21-59 (4) the light source is above the focal plane, throwing the emitted beam below the observer. These two errors are very commonly made, both inadvertently and unwittingly. In figure 21-59 (1) to (4), inclusive, note that the observer's eye has been shown on

	<i>Beam power (as given by the lens)</i>
3° above the focal plane.....	5
2° above the focal plane.....	20
1° above the focal plane.....	38
On the focal plane.....	50
1° below the focal plane.....	38
2° below the focal plane.....	20
3° below the focal plane.....	5

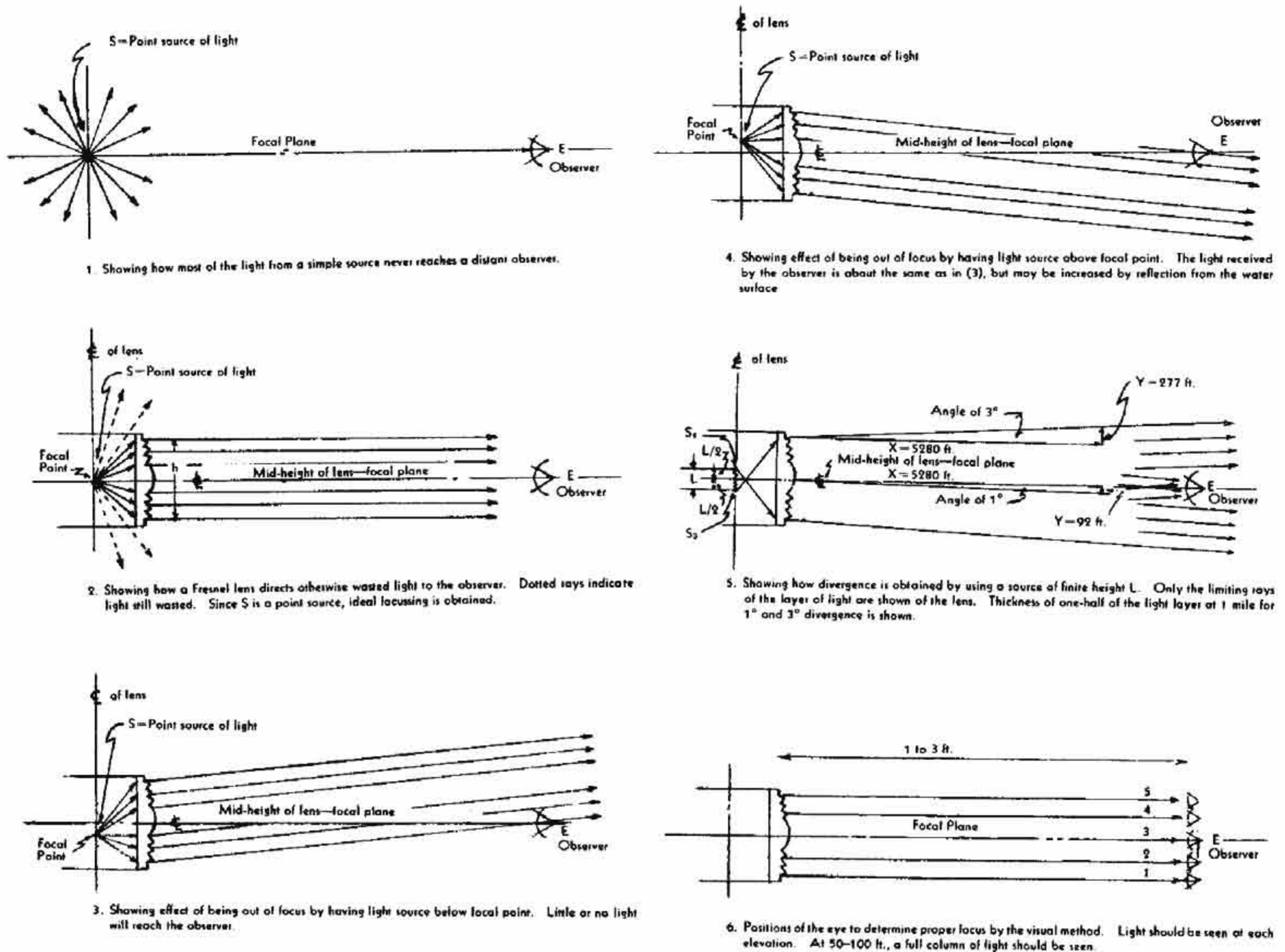


FIGURE 21-59.—Focusing diagrams.

C. If in figure 21-59 (5) the lamp (filament) is raised or lowered, the diverging layer of light will be thrown upward or downward as in figure 21-59 (3) or (4), and the observer will only see the upper or lower fringe of the layer. The light intensity in this fringe being in the range of 0-5 candlepower, only a poor indication reaches the observer. It becomes imperative to establish and insist on proper focusing procedure. In the case of electric lamps, the proper location of the filament is mechanically obtained.

D. Although electric lamps have been mentioned and given for examples in the foregoing, it should be remembered that the principles of focusing are equally as important to the proper operation of acetylene and oil lights.

21-10-15 Procedure—

A. *Visual method.*—This method is based on the visual appearance of the lens and light. When properly focused and viewed on the focal plane, a drum lens will show a full column of light as high as the effective height of the lens. If no light shows at the bottom, the lamp is set too high. By raising or lowering the lamp, proper focus will produce the full column of light. Figure 21-59 shows how the close-up observer must view the beam. Since close-up observations may be subject to error, other ob-

servations should be taken at a distance (which varies from 6 feet for a 200-mm. lens to 50 feet for a first-order lens) in order to view the full column of light.

B. *Measurement method.*—By measuring from the focal plane of the lens to some reference plane such as the lantern shelf, and measuring from the reference plane to midheight of the filament, proper focus can be obtained. In the case of smaller lenses such as the 90-mm. with 3.5- or 4.3-volt lamps, a tin can may be cut for a peep-sight arrangement. The can replaces the lens, and the sight arrangement is set at the filament midheight. A ruler or measuring stick can be marked for proper focal height of various type lanterns and kept with other servicing tools.

C. A *height gage (surface gage)* is illustrated in figures 21-60 and 21-60A. With the lantern on a level surface, adjust the pointer of the height gage to the center of the lantern lens. Open the lantern and move the pointer above the lampchanger carriage. The distance between the surface of the carriage and pointer should be $1\frac{1}{8}$ inches plus one-thirty-second of an inch. Make the necessary adjustments by use of washers or mounting bars.

A handy focal height gage can be made to accurately fix the center point of the filament by removing the glass and filament of a pefocus lamp

and inserting in place a distance piece of a height equal to the LCL (light center length) ($1\frac{1}{8}$ inches). Inserted in the lampchanger carriage in place of a lamp, the focal point is quickly established. (See fig. 21-60A.)

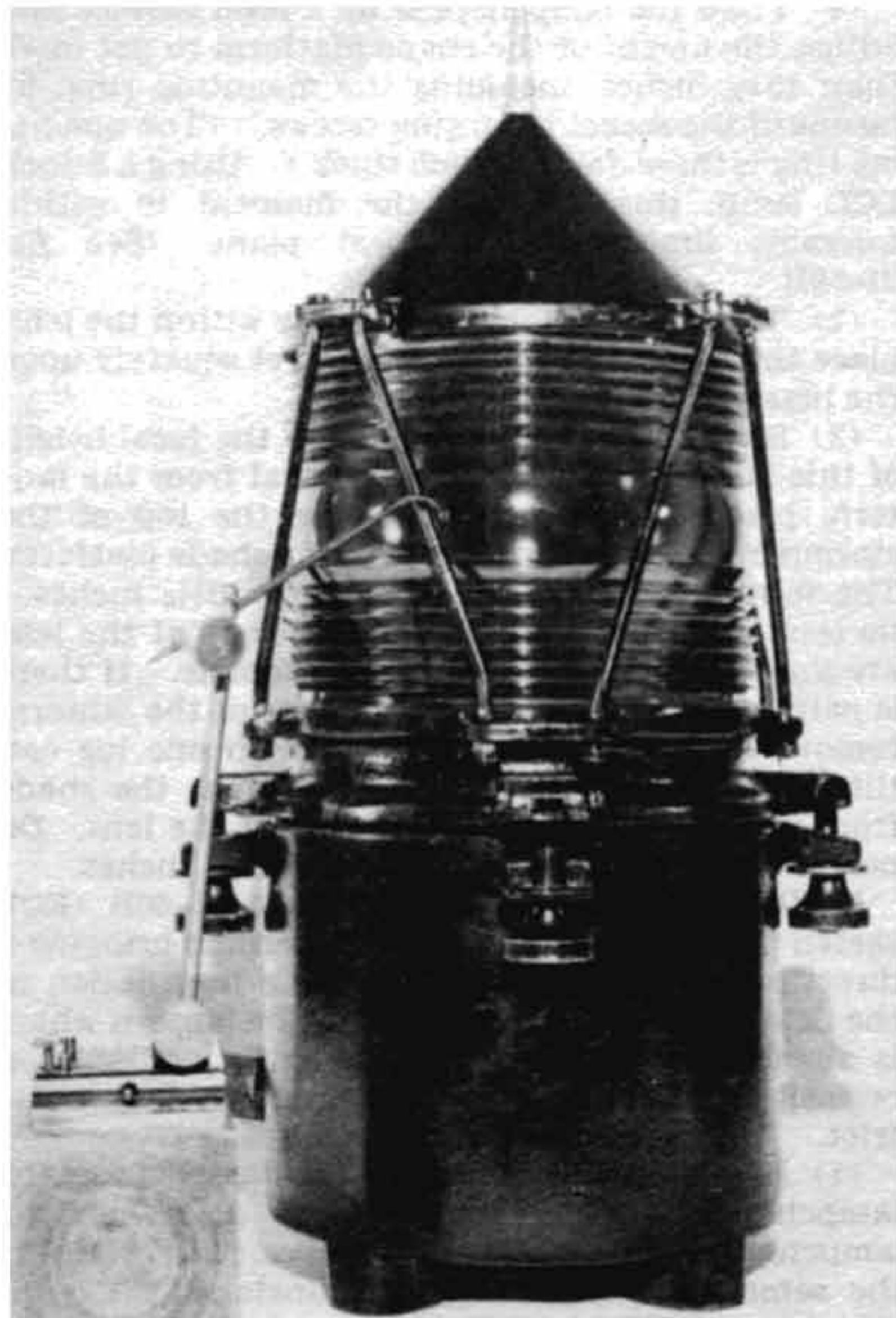


FIGURE 21-60.—Focal height gage, lantern closed.

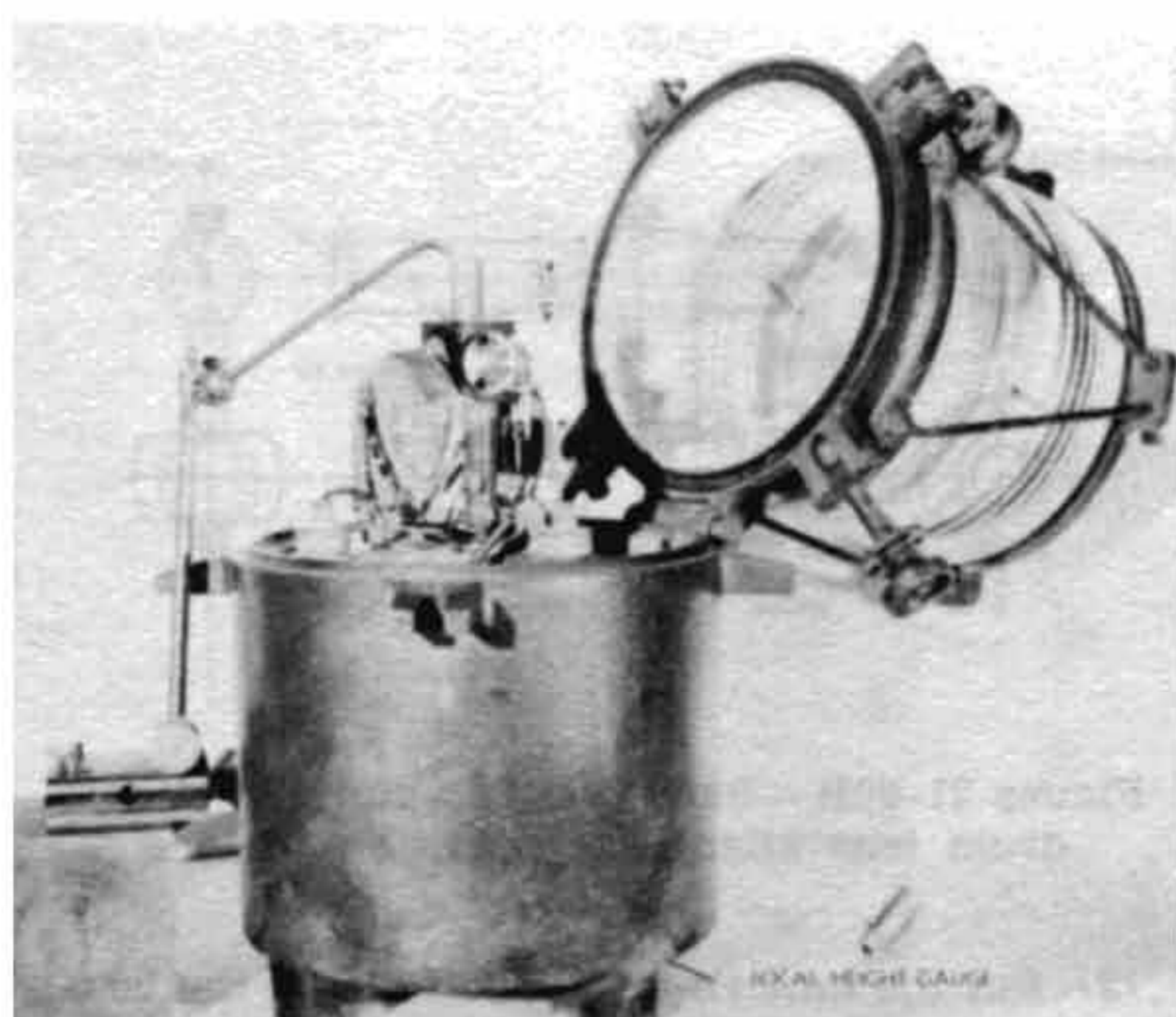


FIGURE 21-60A.—Focal height gage, lantern open.

D. *The O method.*—The 200-mm. lens has an O moulded at four points on the midbelt section. The O's were originally provided as a focusing device, it being intended to paint a black circle around the O and observe the filament setting across the established line of sight (the observer sighting closely through the two O's). This is a good method, but the paint must be removed after every sighting, thus becoming a nuisance. If the ball of the left index finger is placed over the farther O and the eye placed close against the nearer O, the filament can be sighted against the ball of the finger with about the same accuracy. With a flashing light, the hot filament will show high, low, or on the center of the finger ball, which can be seen clearly.

E. *Night vicinity observations.*—Much can be learned about focusing by observing the projected layer of light as it falls on the wings or parts of the superstructure, or on a background of rocks or trees. A thin fog or mist shows excellently the light distribution from the lens, whether too high, or low, or on the focal plane, and the divergence is very apparent. These observations should be made on the focal plane, however, to avoid being deceived by an illusion. Any method should be checked for a full column of light by an observer at a distance.

F. *Device for determining correct focal plane.*—The following has been suggested as an inexpensive and simple device (hand level) to determine the center of a light source to its correct focal plane.

A lensless telescope, about 2 inches long, equipped with a horizontal bulb and center spot, is held in the hand and one end laid against the central belt of the dioptric lens, having a 4-point contact which automatically positions the telescope normal and 90° to the vertical axis of the lens. A double check as to the telescope's being in a horizontal position is then made by observing the level bulb. Two 12-inch celluloid rulers, joined at midcenters, equipped with a clamping device attached to the near end of the telescope, are allowed to operate scissor-fashion, which then automatically determines the mid-section of any varying width of the center belt course of the lens, as the symmetrical edges of each ruler touch the upper and lower horizontal offset of the adjoining dioptric prisms. Six-inch rulers are used for 200- and 300-mm. lanterns in place of the 12-inch rulers. Looking through the tiny hole in the telescope, the center spot determines if the filament or burner is centered horizontally and vertically in the lens. Detaching the telescope, the device may be used as an ordinary level to determine if the lens table is horizontal.

21-10-20 General Notes—

A. Although these notes have been prepared with automatic electric equipment primarily in mind, the reasoning is applicable to *all aids using a fresnel lens*. Generally speaking, the larger the source of light, the more divergence is obtained in the lens, and the focusing is not so critical. This can readily be observed from a commercial electric lantern with 200-mm. lens using a 60-watt, A-19, inside frosted 115-volt lamp. Conversely, the smaller the source,

as with low-voltage lamps, the less the divergence obtained, in which case great care must be taken in focusing.

B. Need for mis-focusing.—Occasionally it may be necessary to defocus an aid to make it show properly for some unusual condition. In figure 21-59 (5), suppose the light and focal plane are on top of a hill 300 feet above the water. At 1 mile distance, 3° divergence has only brought the light down toward the water 277 feet. The observer would have to rise (disregarding height of observer's eye) 300 minus 277, or 23 feet, to see the light even on the edge of the 3° divergence, and higher yet for a better indication. If small vessels were to be protected at one mile, it would be proper to defocus the light by raising the lamp slightly above the focal plane, throwing the light layer downward to the water's surface. Such instances must be carefully observed and checked at night to procure the proper result.

C. It should be apparent that all lanterns should be set and maintained in a true vertical position. Lantern shelves should be carefully set with a level, and stations should be well braced to prevent leaning due to settlement and wind forces. Leaning lanterns should be straightened as a routine maintenance item.

D. Adjustment of 150- and 200-mm. lanterns.—The W. & T. 150- and 200-mm. lanterns are adjusted for focal height by using washers placed between the mounting plate and the lampchanger mounting bar. Care must be taken that an equal number of washers be used on both sides so that the lampchanger remains level. The Service-type 150-mm. lantern is adjusted for focal height by placing the correct size spacer pieces between the lamp stand and lampchanger. If correct spacer pieces are used it is not necessary to use any washers for raising the lampchanger. The old style Service-type 200-mm. lantern has adjustable mounting studs which carry a mounting bar to which the lampchanger is attached. Lamps in the C. G. standard (new style Service-type) lanterns are adjusted by thickness pieces placed under the lampchanger mounting bar. Take care to keep the lampchanger level.

E. Shop adjustment.—In servicing and setting up lanterns in the shop, some means should be provided to adjust the lamp to proper focal height. See the height gage shown in figures 21-60 and 21-60A which is suggested for this purpose, as it makes the adjustment quickly and accurately.

(1) With the lantern on a level surface, adjust the pointer of the height gage to the center of the lantern lens. Open the lantern and move the pointer to a point above the lampchanger carriage. The distance between the surface of the carriage and pointer should be $1\frac{1}{8}$ inches (light center length of lamp). Make the necessary adjustments by use of washers or mounting bars.

(2) In the case of 300- and 375-mm. lanterns, the procedure is somewhat different, inasmuch as the lenses do not hinge back. Take a straight edge and measure from across the top of the stormpane to the center of the lens then adjust the filament center to this point.

F. W. & T. type FA-147 lampchanger.—Particular care must be taken in installing the W. & T. FA-147 lampchanger in a 375-mm. lantern due to the minimum of available clearance when colored shades are used.

(1) Place the lampchanger on a level surface and adjust the height of the shade platform to not more than $13\frac{1}{2}$ inches, including the mounting ring, by means of the socket mounting screws. (The mounting ring is three-fourths inch thick.) Using a 3-inch LCL lamp, this will put the filament to within tolerable limits of the focal plane. (See fig. 21-50B.)

(2) To locate the lamp centerwise within the lens, place the lampchanger mounting feet squarely upon the lugs of the mounting ring.

(3) Should it be desired to adjust the focal height of this lampchanger without removal from the lantern, place a straightedge across the top of the stormpane and measure down to the shade platform. The minimum dimension should be $13\frac{1}{16}$ inches—no less. Be sure that the astragal bars of the lens are lined up with those of the stormpane. If there is paint on top of the lugs in the base of the lantern, remove it; a relatively thick lump on one lug can tilt the lampchanger enough to prevent the shade from rotating past the bottom ring of the lens. Do not use a lamp with a LCL of less than 3 inches.

G. Directional drum lens.—Figure 21-60B (ECV sketch 637) shows a device which permits bringing a directional drum lens to an existing installation in the field, and installing the lens in the lantern which is already on the job. This device is available on requisition from Commander, 13th Coast Guard district. To install, proceed as follows:

(1) Remove the lantern top and lamps from the lampchanger. Install the sighting device on the lampchanger by the use of the prefocus collar in the same manner as a lamp is installed. Extend the plunger of the device and orient the lens until the center of the bull's eye ("hot spot" portion of the lens) is in alignment with the center line of the plunger. (See Fig. 21-60C.)

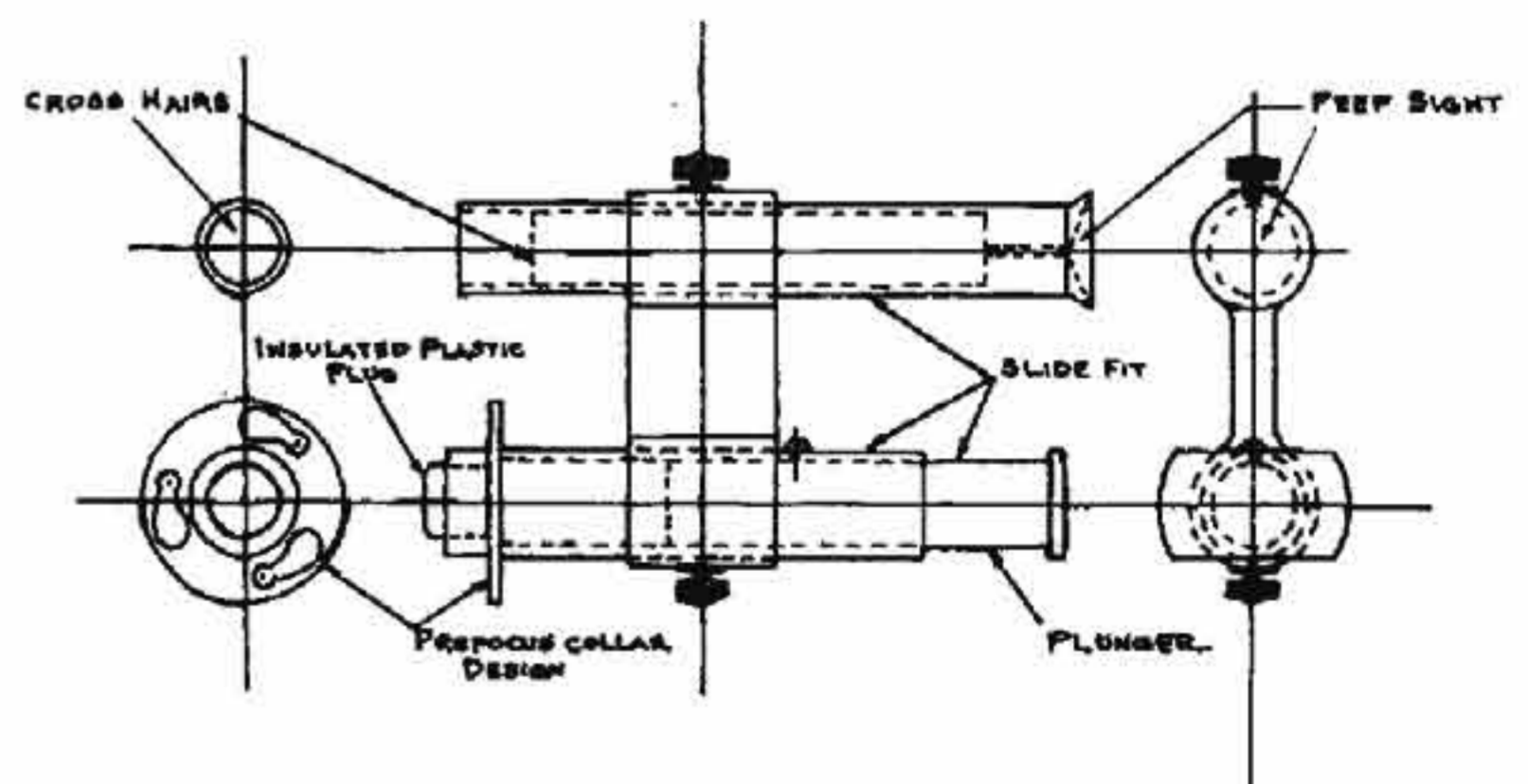


FIGURE 21-60B.—Sketch of 200-mm. directional drum lens alignment (sighting) device.

(2) Put the lantern top on and secure the lens in the lantern without disturbing the alignment. Open the lantern at the hinge and rotate the lampchanger 180° with the sighting device still in place. The set-up will then be as shown in Figure 21-60D.

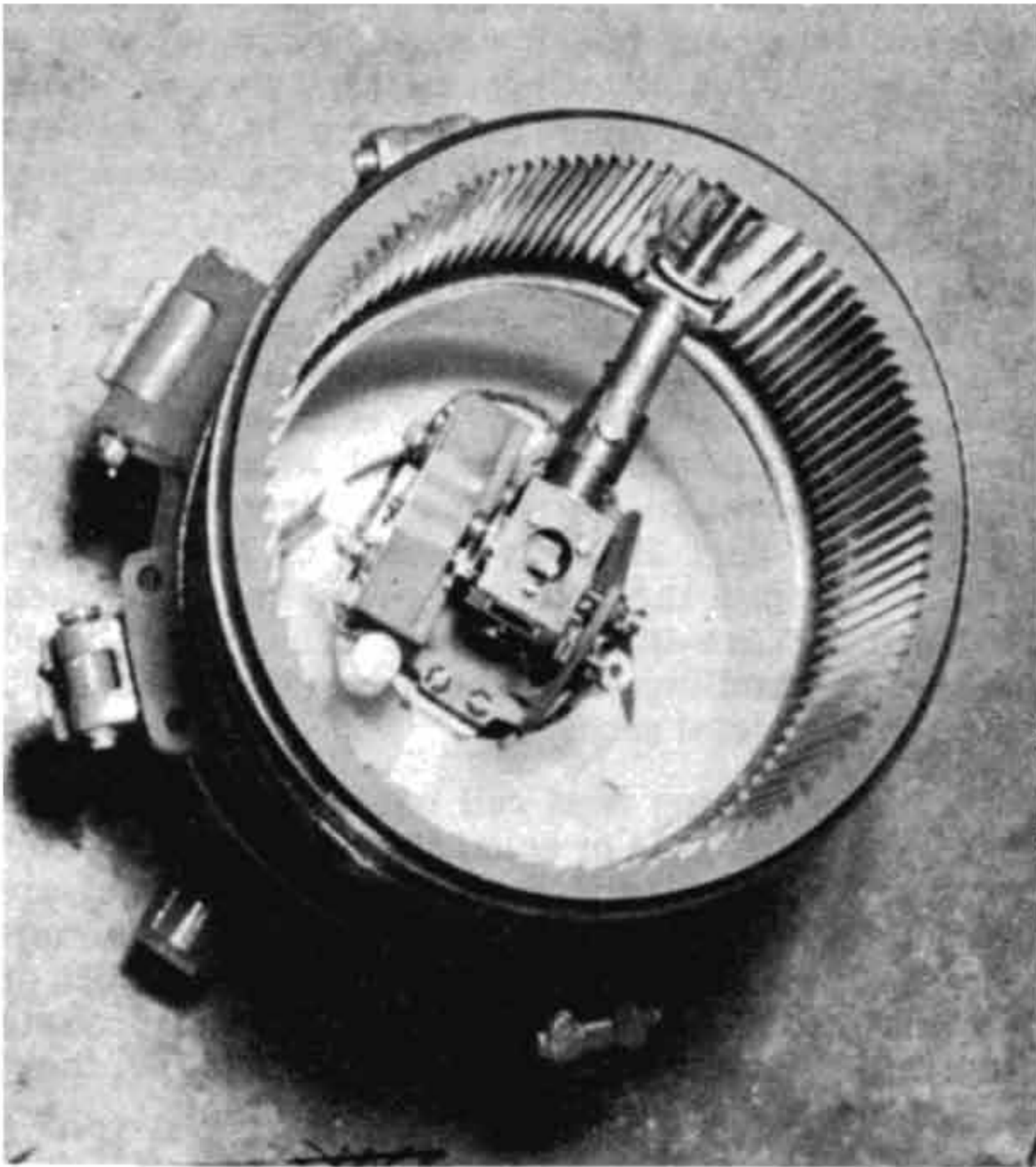


FIGURE 21-60C.—Plan view of device shown in figure 21-60B, installed in lantern with plunger extended.

(3) Next, orient the entire lantern and lens assembly until the sighting tube, with its peep hole and cross hairs, is lined up with the direction in which the "hot spot" is to be beamed. (See fig. 21-60E.) This presupposes that a trial buoy, or similar object has been set up previously to mark the intended direction of the beam.

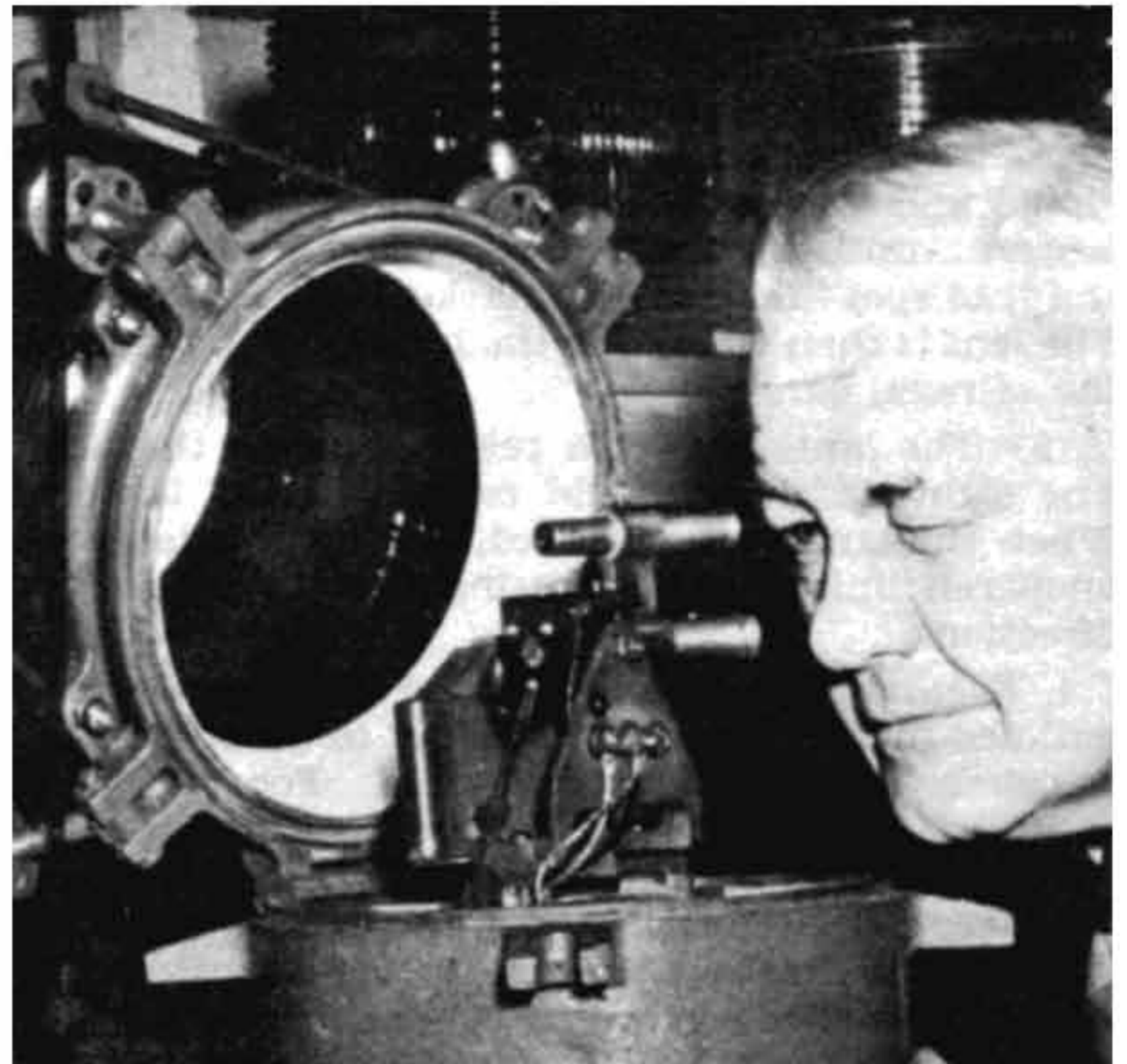


FIGURE 21-60E.—Sighting through directional drum lens alignment device.

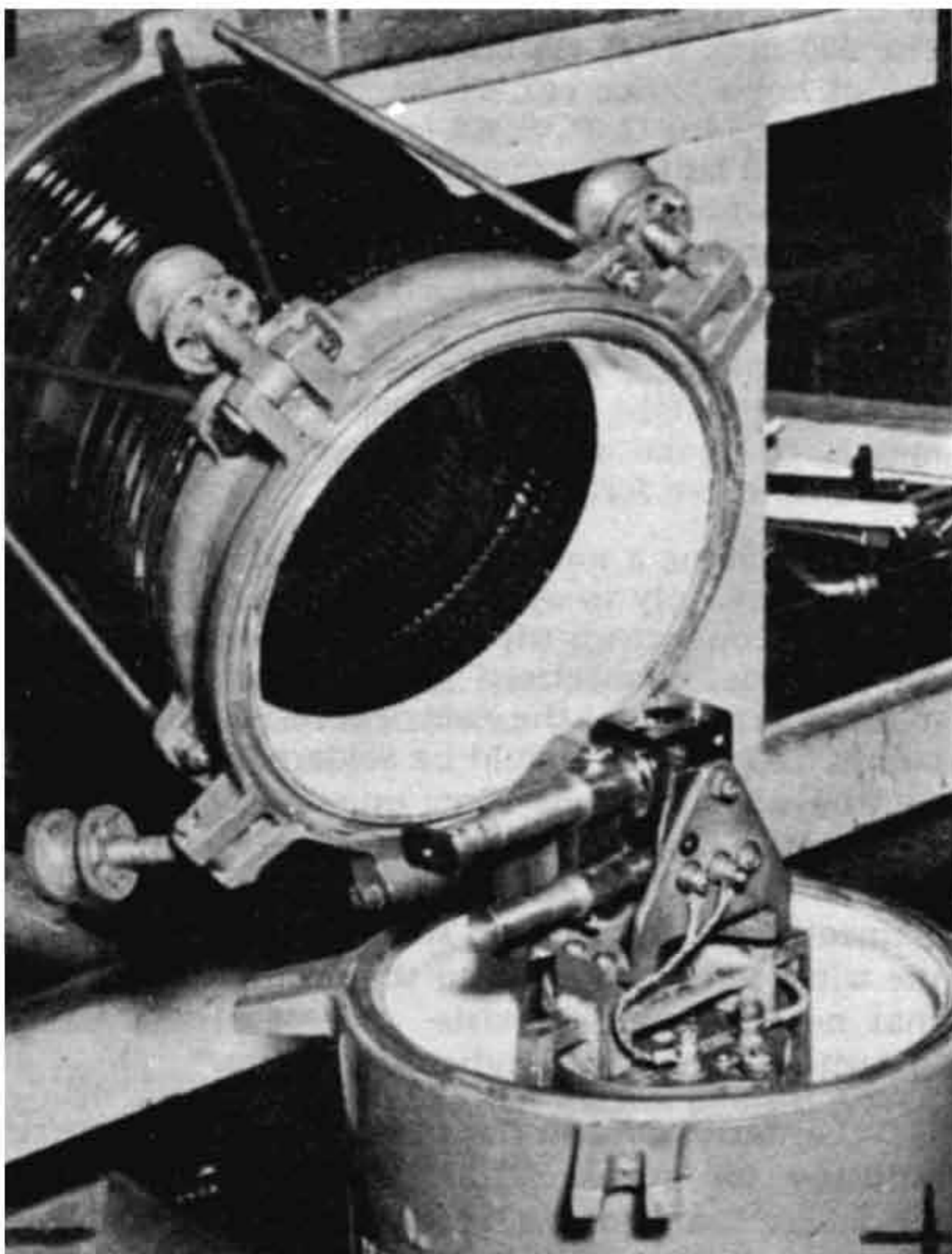


FIGURE 21-60D.—Directional drum lens sighting device after rotating 180°.

H. Another directional drum lens sighting device.—This is a method wherein the alignment of the lens into the lantern can be made in the shop and the entire assembly then taken out to the job site. This device is available on term contract. It consists of 2 threaded plugs, 1 containing a peep hole and the other, cross hairs (see Fig. 21-60F). Proceed as follows to use the device:

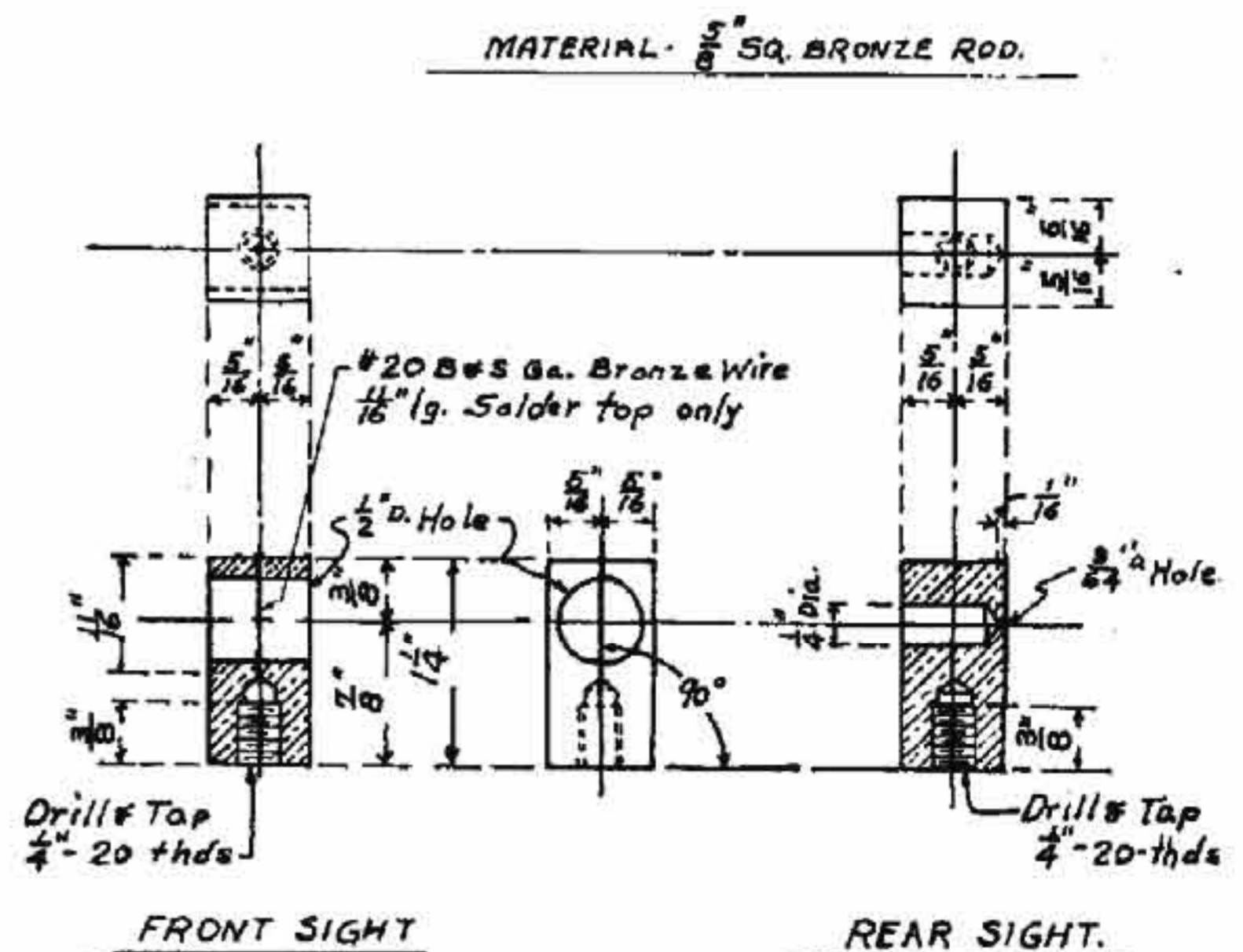


FIGURE 21-60F.—Another type of 200-mm. directional drum lens alignment device

(1) The directional drum lens is set up in the standard 200-mm. lantern and the sighting devices screwed into position on the studs which fasten the lampchanger supporting bar.

(2) The assembly is mounted rigidly in a location in the shop where sighting distance to a vertical wall of about 5 or 10 feet is available. The lantern is left opened.

(3) The spot on the wall which is located by sighting through the devices is marked by a vertical line.

(4) Power is then supplied to the lantern, the top closed and the lens centered (without moving the lantern) until by actual observation the center of the "hot spot" falls on the marked spot on the wall. The lens is then secured in the lantern by tightening the astragal bars.

(5) The lantern is now ready to go to the field. The sighting plugs should remain in the lantern. When the lantern is installed, it may be orientated by merely lining up the sighting plugs in the desired direction.

I. Focusing range lanterns.—Focusing methods outlined in the foregoing have had to do with cylindrical or so-called drum lenses. Focal adjustments of lamps in range lanterns, with particular reference to the battery-operated types such as the Wallace & Tiernan type FA-47 and General Railway Signal types SA and W, are factory adjusted and since prebased or prefocused lamps are used, further adjustments in the field should not be necessary. Usually being located ashore, these lanterns are not so subject to damage and consequent disarrangement of the internal parts. The alignment of these lanterns on the range is done as follows:

(1) *The W. & T. range lantern type FA-47* is focused on the range by means of leveling screws mounted on the bed plate which permits the lantern to be tilted $3\frac{1}{2}^\circ$ from the vertical and 10° in azimuth for proper adjustment on the range line. Sighting is done with a V-type rear sight and bead front sight, both mounted on the top center of the lantern housing.

(2) *A G. R. S. type-SA lantern* is focused on the range horizontally by turning the mounting base before tightening the hold down bolts. Slotted holes allow approximately 12° in azimuth. Vertical adjustment is made by tipping the housing up or down using a long adjusting stud and two lock nuts. Sighting is accomplished by using a rear peep sight and a front set of cross hairs mounted on top.

(3) *The G. R. S. type-W range lantern* is focused on the range by adjusting screws on the base, allowing a vertical adjustment of approximately 8° , and horizontally by turning the case on the threaded supporting pipe in the required direction. Sighting is accomplished by using a V rear sight and a bead front sight, both mounted on the top center of the lantern.

21-11. INSTALLATION, MINOR LIGHTS

21-11-1 General—

A. Minor lights are mounted on a variety of structures from a steel or wooden tower with a battery house at its base, to pile dolphins, to formerly at-

tended light towers. If batteries are used, a suitable and well ventilated housing must be provided. The lights will be found on breakwaters, islands, shore lines, stone piles, river banks and other various locations, wherever they will best serve navigation.

21-11-5 Batteries—

A. Batteries will be found installed in banks of lead cells, primary cells or air cells, connected to provide appropriate voltage and amperage hour capacity to meet the operating requirements of the light. (See par. 21-4 for details of storage batteries.) Despite the fact that metal cans are often provided for low-discharge lead cells, care should be used in handling since shock can be transmitted through the metal case.

B. In connecting lead cell banks, standard leads such as Willard T-14 or equal should be used. These leads are No. 8, stranded, rubber covered, and are provided with connectors. Air cells may be connected by use of No. 14 solid leads, either rubber or fabric covered. Leads should be cut to adequate length for neat bends and ends should be thoroughly cleaned for use in battery terminals.

21-11-10 Lanterns—

A. A firm level mounting should be provided for the lantern. All lanterns except the 200-mm. C. G. Standard lantern are provided with four $\frac{3}{4}$ -inch x 10 tapped holes in the bottom of the base casting. The 200-mm. C. G. Standard lantern has 4 slots in lieu of holes. (See par. 21-10-20 (I) for alignment instructions for G. R. S. SA- and W-type range lanterns.) All lanterns are provided with heavy gaskets to insure watertightness. These should be carefully checked and when tightening the gasketed joints, turn the clamping bolts evenly, particularly when tightening the lens between the top and lens ring casting. The base casting of W. & T. lanterns contains a watertight terminal box with sufficient terminals to make all connections to the lantern, including those for a sunrelay.

B. In placing a new W. & T. lantern in service, it is necessary only to open the terminal box and attach the connecting wires to the proper terminals. All electrical connections should be made securely in order to minimize the electrical resistance at these points. All splices should be soldered. If the connecting wires are long, they must be of ample size so as not to cause a voltage drop due to wire resistance. When a lantern is being installed, the final connection to the battery should be made last and the wires lightly touched to the terminals to insure that no short circuit exists. Severe arcing at the instant of contact will indicate a "short."

C. Lanterns shipped from the factory are properly adjusted for focus. Thus, unless the adjusting screws are changed, the lantern will remain in focus. The lamp is brought into focus by raising or lowering the complete lampchanger by rearranging the spacer washers on the supporting mounting bar. See paragraph 21-10-20 (D).

21-11-15 Flashers and Lampchangers—

A. At the present time, Wallace & Tiernan flashers and lampchangers are standard in the Service for low voltage lights. W. & T. lanterns may be purchased with or without flasher and lampchanger units installed.

B. 150 and 300-mm. Service-type lanterns.—In the 150-mm. Service-type lantern, a support of cast bronze is used for holding the flasher and lampchanger and for focusing the lamp. (See fig. 21-61.) Four mounting studs are used in conjunction with this support. The same support is also used in the 300-mm. Service-type lantern, however, studs of proper dimensions must be used.

C. 200-mm. Service-type lantern.—In this lantern, a set of three mounting bars and an adaptor bar is furnished with the lantern. (See fig. 21-61.) The lamp in the lampchanger in this arrangement is not automatically focused as in the case of the

150- or 300-mm. lanterns. Focal adjustment is made by use of adjusting nuts on the mounting bars. In the event a lampchanger is not used, a prefocus lamp stand is available.

D. 150- and 200-mm. W. & T. lanterns.—Terminals in the lantern junction boxes, including dual purpose and duplex, are identified as follows:

No. 1—Positive battery connection.

No. 2—From LT terminal on flasher.

No. 3—To lampchanger, either direct or through protective relay.

No. 4—Negative battery connections.

The lamp circuit from flasher to lampchanger is brought down through terminals 2 and 3, and completed by use of a jumper across these terminals. A sunrelay is inserted in this circuit, when used. Sunrelay installations are readily made by removing the jumper and connecting sunrelay leads instead.

The Service-type lantern is not fitted with a terminal box.

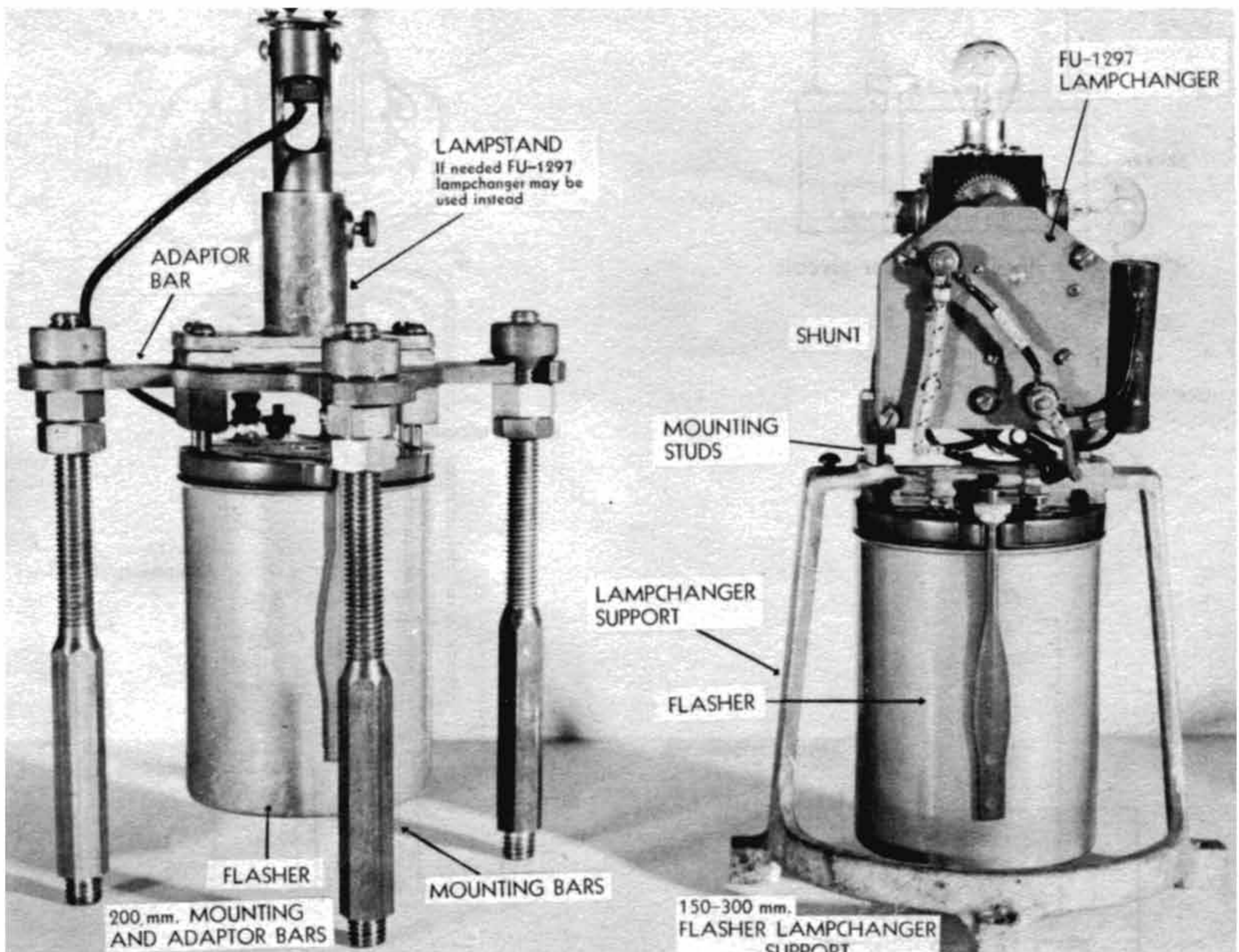


FIGURE 21-61.—Flasher-lampchanger supports.

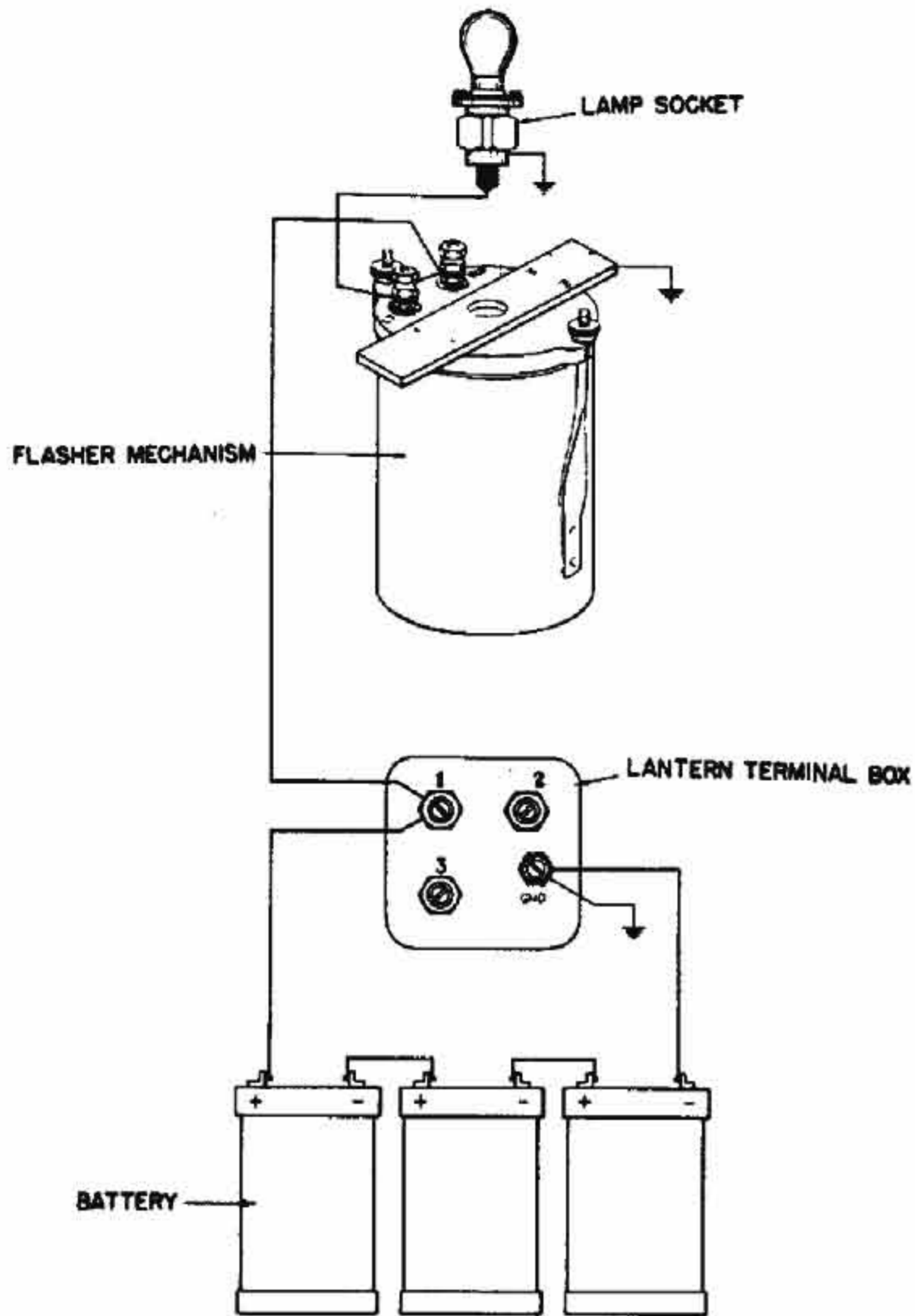


FIGURE 21-62.—Flasher circuit.

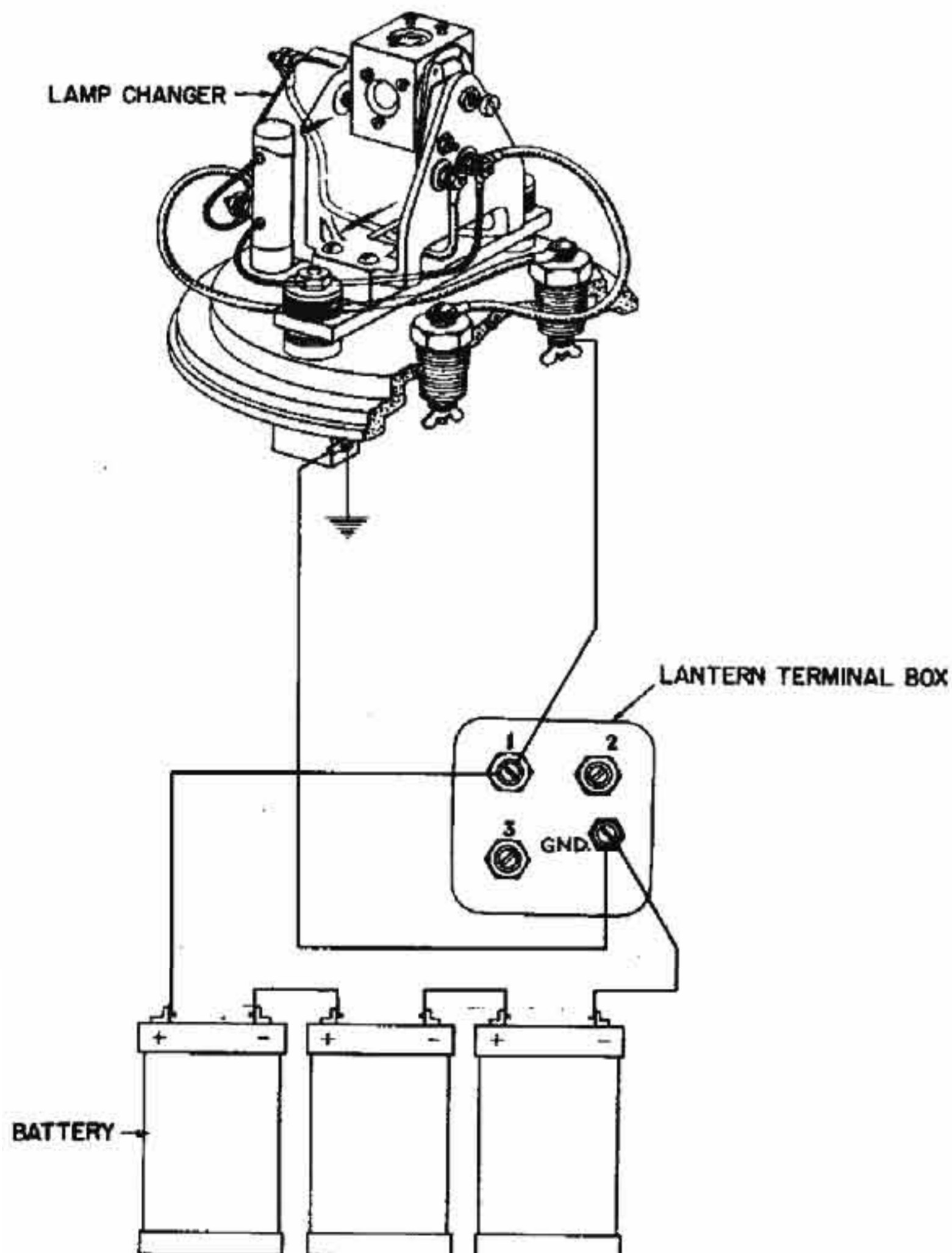


FIGURE 21-63.—Lampchanger circuit.

E. Flasher-lampchanger wiring.—Figures 21-62 to 21-77 illustrate various wiring diagrams.

(1) Figure 21-62 shows a simple flasher diagram without the use of a lampchanger. Terminals 2 and 3 are not used in this hookup.

(2) Figure 21-63 shows a simple lampchanger diagram without flasher. This is, of course, for a fixed light. Terminals 2 and 3 are not used.

(3) Figure 21-64 shows a diagram using both flasher and lampchanger. This is the hookup most commonly used. Note the jumper across terminals 2 and 3 as used in W. & T. lantern; it is removed when a sunrelay is used. In the Service-type lantern, the wire leading to terminal 3 would go directly to the "LT" terminal on the flasher as shown on figure 21-65.

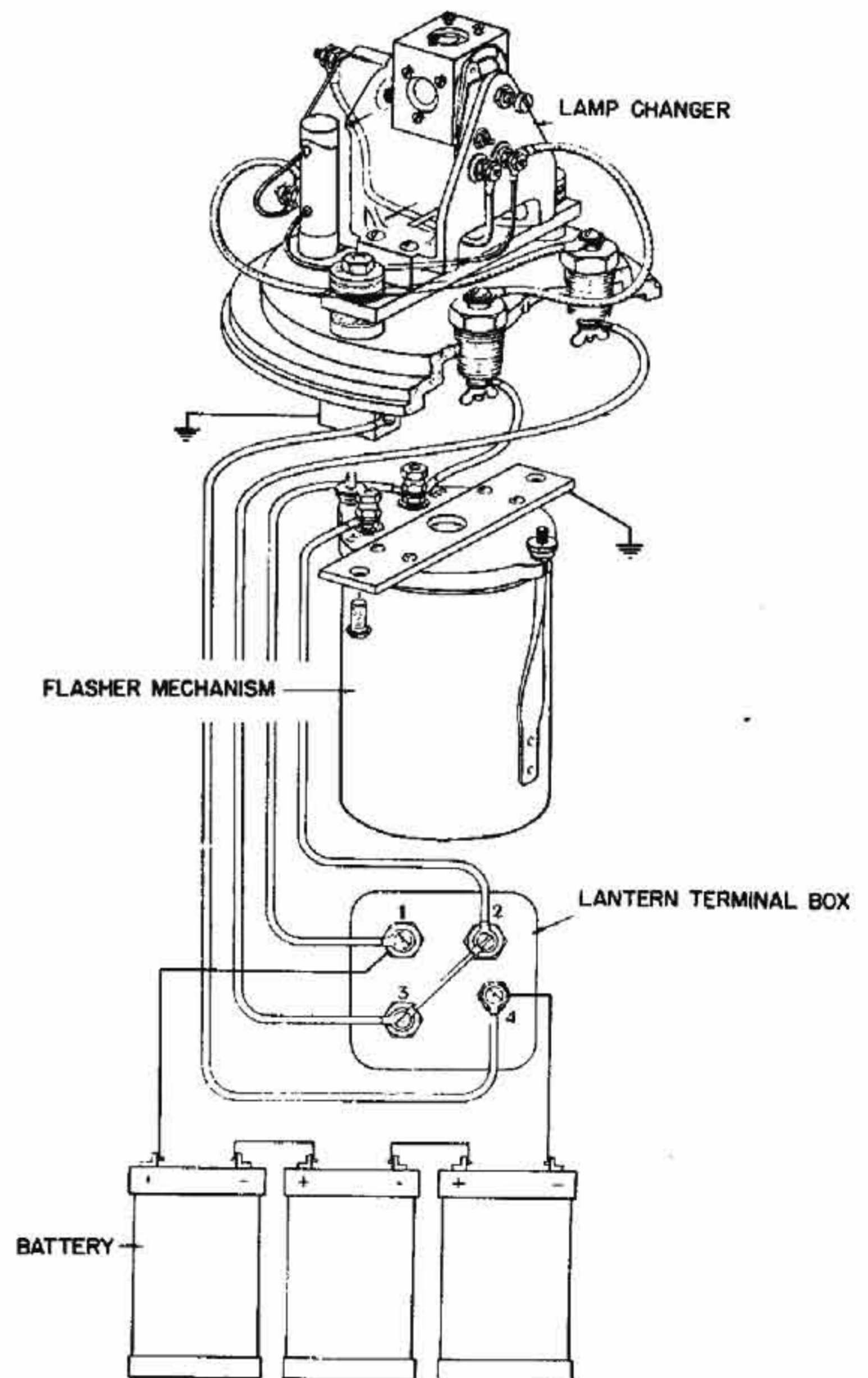


FIGURE 21-64.—Flasher and lampchanger circuit.

(4) *Protective relay.*—Figure 21-65 shows a flasher-lampchanger combination using a protective relay. The relay is placed in the circuit for the purpose of preventing excessive current from going through the flasher contacts when a high current lamp is used.

(5) *Sunrelay.*—Figure 21-66 shows a flasher-lampchanger combination using a sunrelay. It will be noted, by referring to figure 21-64, that the installation of the sunrelay is accomplished by simply removing the jumper across terminals 2 and 3, and shunting the sunrelay across the same terminals. It will also be seen that the flasher itself is always in the circuit and will operate continuously with sunrelay contacts open or closed.

(6) Figure 21-67 shows a flasher-lampchanger combination with both protective relay and sunrelay.

(7) *Alternating current lampchanger.*—Figure 21-68 shows a flasher-lampchanger combination with protective relay. The flasher is operated by direct current, and the lampchanger by alternating current by the use of a copper oxide rectifier and a step down transformer. It is emphasized here that flashing mechanisms are not designed for operation on unrectified alternating current.

(8) Figure 21-69 shows a rectified a. c.-operated lampchanger with protective relay and sunrelay, and a step down transformer. This arrangement is seldom used. It will be noted that by use of a protective relay, the flasher is wired in such a manner that the flasher contacts are entirely out of the filament circuit. That is, instead of breaking the filament circuit, the flasher energizes the protective relay which closes a pair of contacts in the filament circuit. Thus, lamps with a heavier current drain than the flasher contacts are designed to carry may be used.

(9) *Service-type lantern.*—Figure 21-70 shows a wiring diagram of a Service-type lantern without a sunrelay or a protective relay. The wiring is extremely simple with a minimum of connections. In the event a sunrelay is used, the wire from the LT terminal on the flasher to the lampchanger is removed, and a pair of wires is brought out through a watertight connector to the sunrelay terminals.

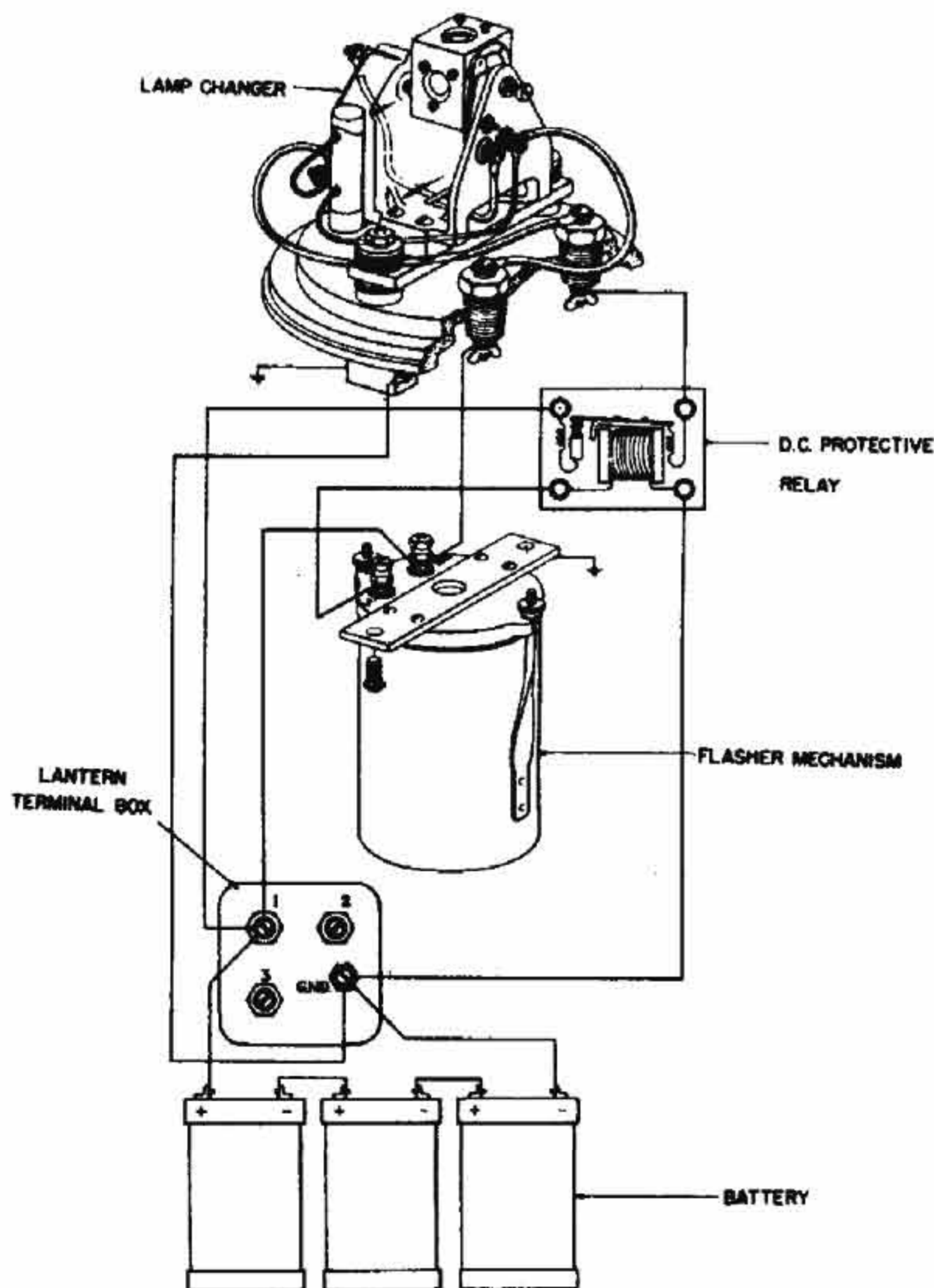


FIGURE 21-65.—Flasher and lampchanger circuit with protective relay.

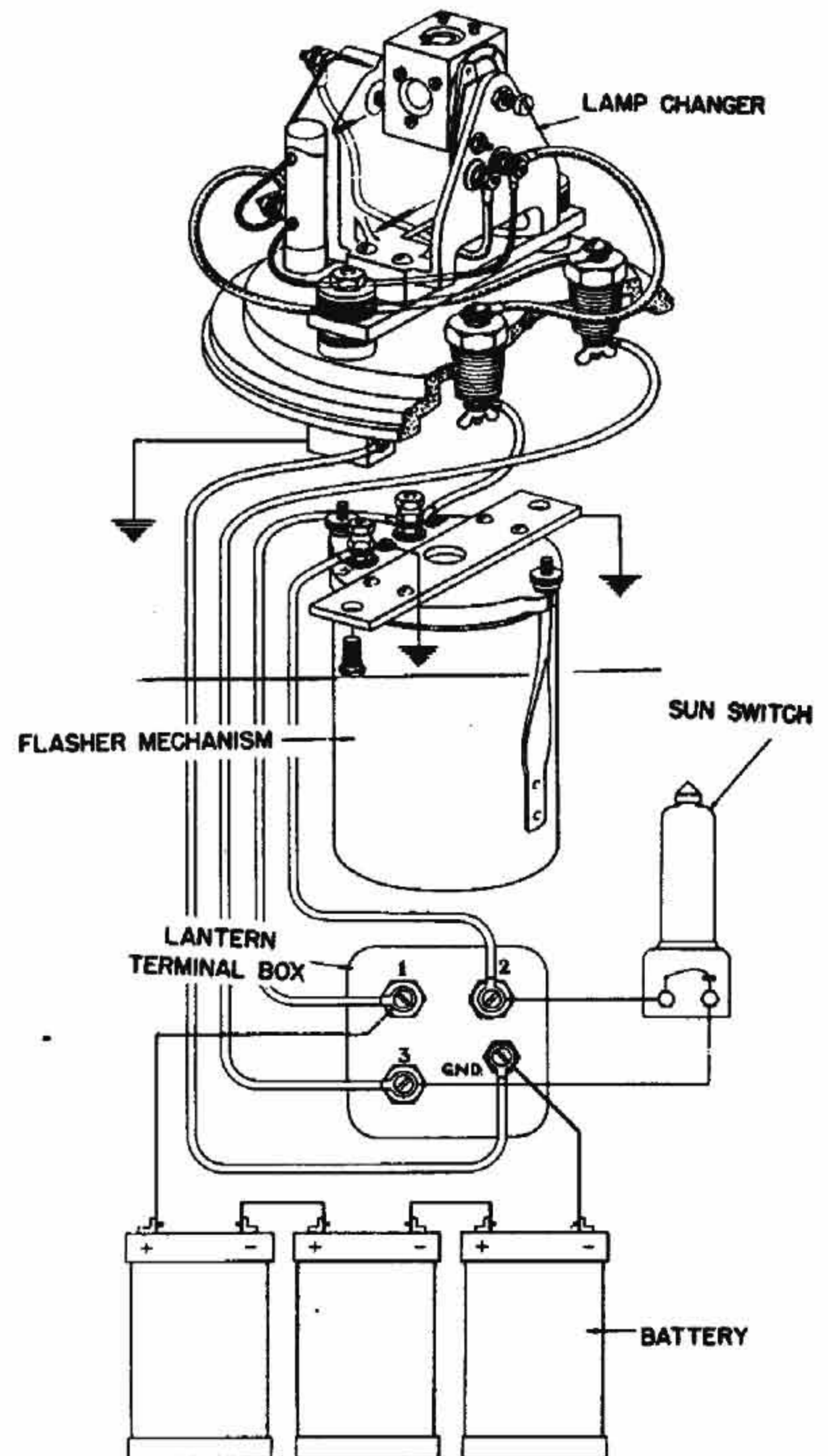


FIGURE 21-66.—Flasher and lampchanger circuit with sunrelay.

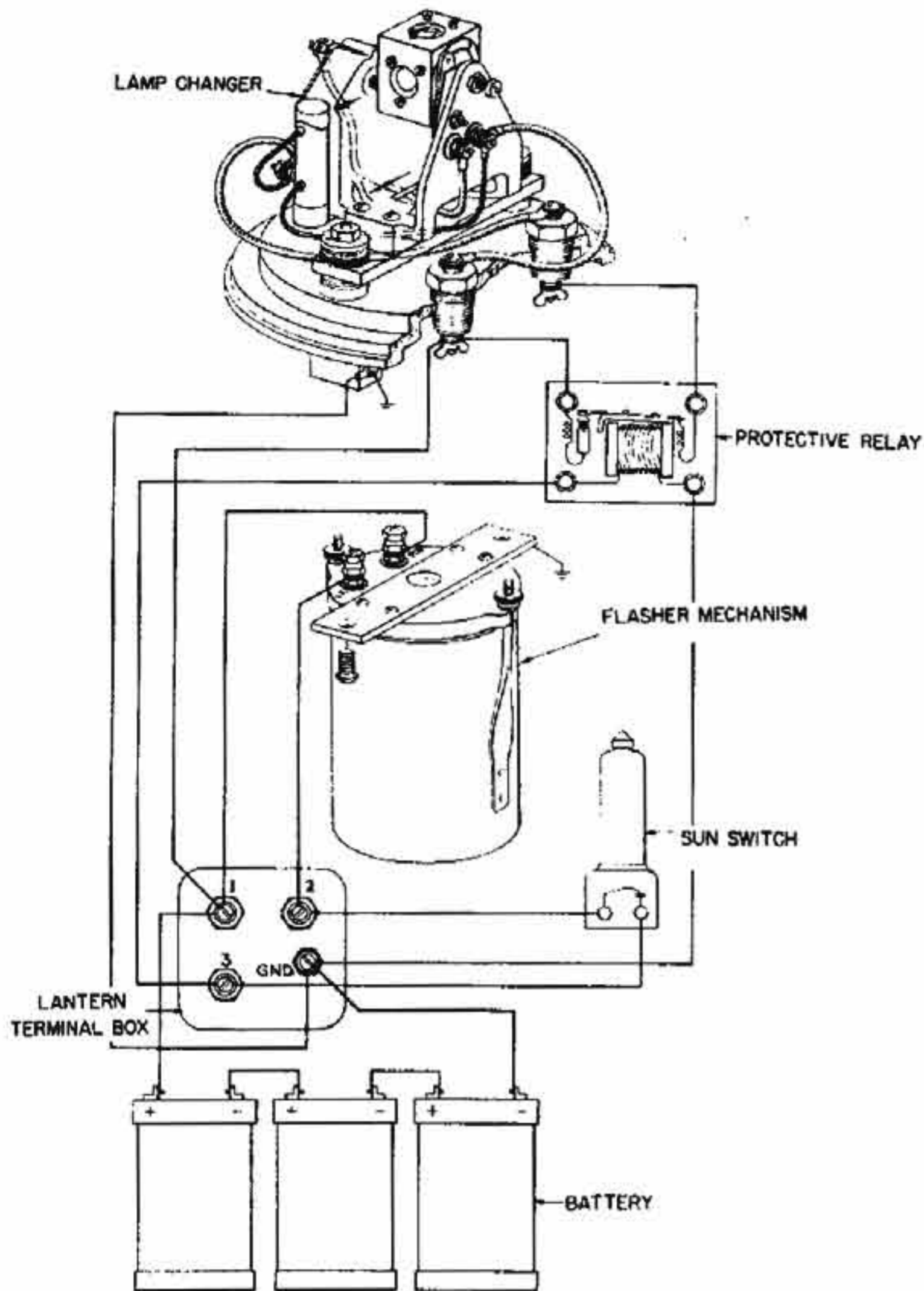


FIGURE 21-67.—Flasher and lampchanger circuit with sunrelay and protective relay.

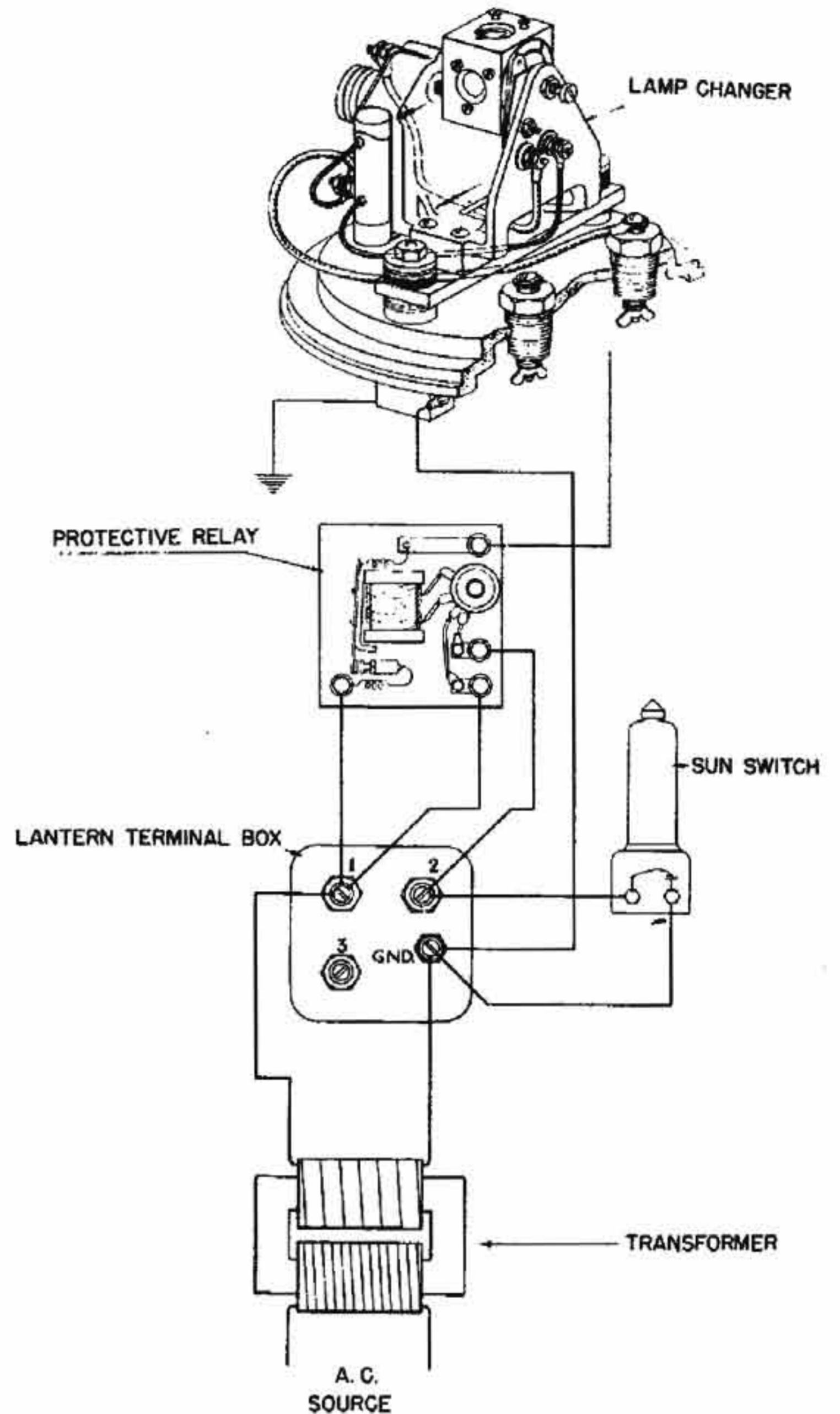


FIGURE 21-69.—AC-operated lampchanger.

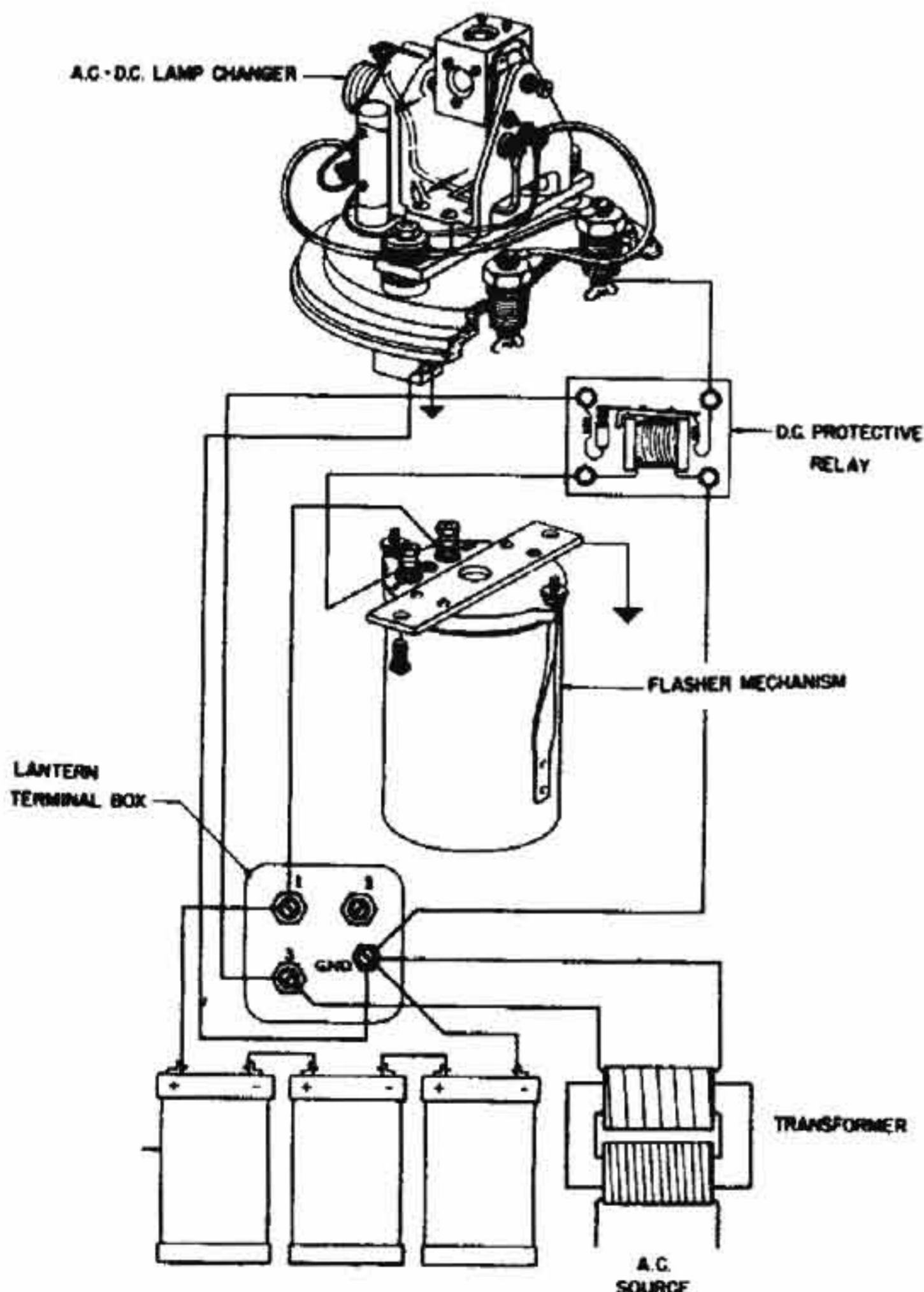


FIGURE 21-68.—DC-operated flasher and AC-operated lampchanger.

(10) *G. R. S. range lanterns.*—Figure 21-71 shows wiring diagrams for G. R. S. type SA and W range lanterns. Always leave plenty of slack wire inside the lantern so as to be able to remove the inner unit. When installing the flasher in the housing, be sure to enter the terminal side of the flasher first, otherwise flasher terminals will be grounded on the housing.

(11) *W. & T. range lantern.*—Figure 21-72 shows a schematic diagram of the W. & T. FA-47 range lantern. The flasher is installed within the housing, secured to a brass angle bracket. The lampchanger is mounted on a cast bronze bracket which slips over a round bar, which is fastened to an adjusting plate. The lamp is focused by means of adjusting screws controlling the position of the plate and mounting bracket. As shown in the diagram, the negative lead is grounded to the lantern housing. The lampchanger is not adapted for a direct positive lead for continuous operation of the lamp carriage. Special rebased lamps are used.

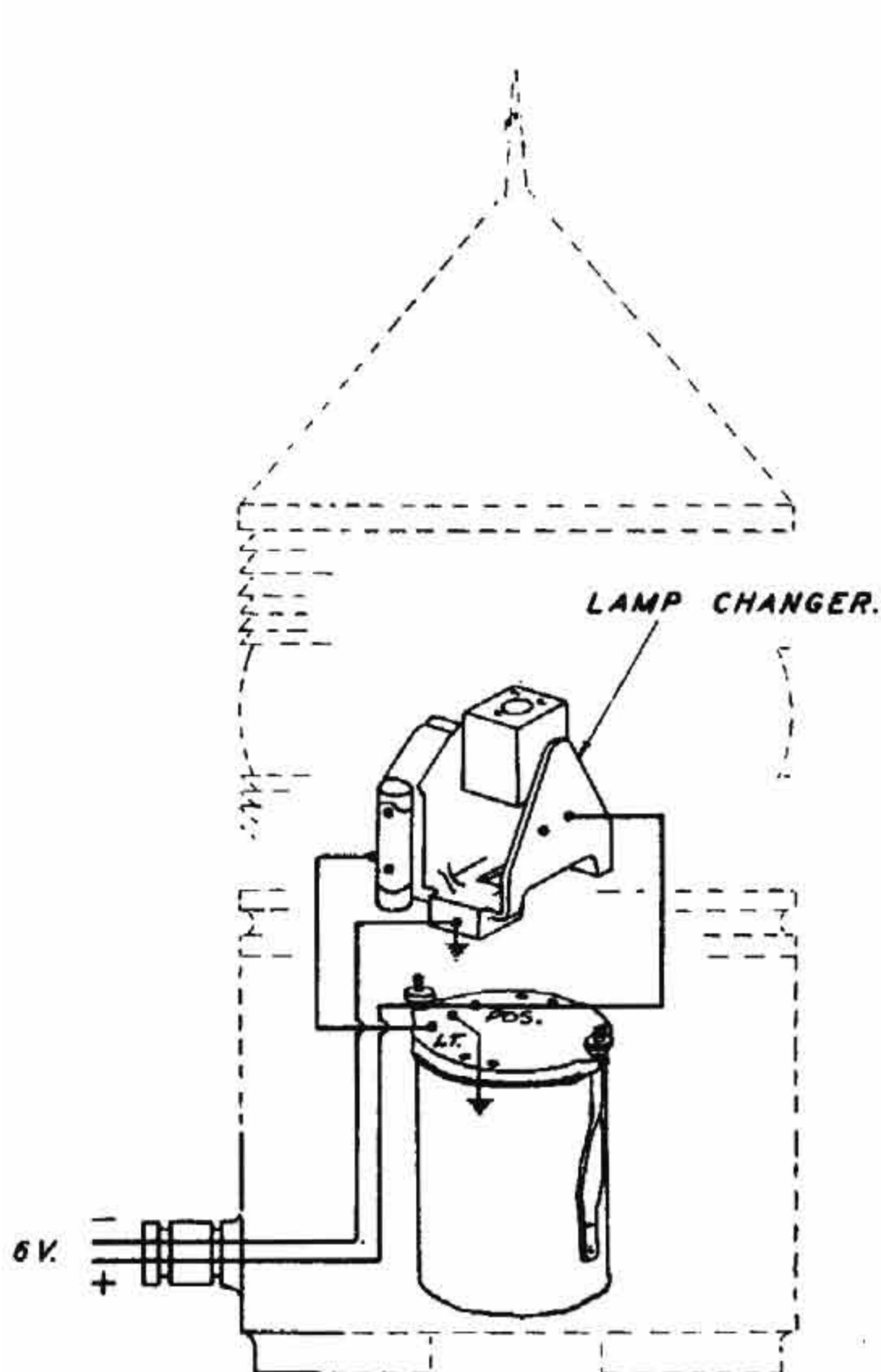


FIGURE 21-70.—150-, 200-, and 300-mm. Service-type lantern schematic internal wiring diagram.

(12) *W. & T. dual-purpose duplex lantern.*—Figure 21-73 shows the wiring diagram for the W. & T. FA-98 dual-purpose lantern, using the double program disc flasher, also adaptation for duplex lantern operation, such as the FA-137 and FA-138. For duplex operation, remove the direct, positive lead as indicated. If this lead is not removed, failure of a lamp in one lampchanger will cause the other to burn fixed until a good lamp is brought into position. The action of the lampchanger in changing lamps will be intermittent.

(13) *High voltage lanterns.*—Figures 21-74, 21-75 and 21-76 show typical wiring diagrams involving the use of high voltage, time switch, emergency lamp relay, and stand-by equipment. Figure 21-74 shows a wiring diagram for apparatus exhibiting a fixed light. Figure 21-75 is similar, except that a flashing mechanism is inserted. Figure 21-76 shows a non-flashing circuit with a battery stand-by light. Use of relays of manufacturer shown is not mandatory. A time delay relay in the main light circuit is recommended for flashing lights.

(14) Figure 21-77 shows the type FA-147 lampchanger as installed in a 375-mm. lantern and operated from 115-volt commercial AC line current,

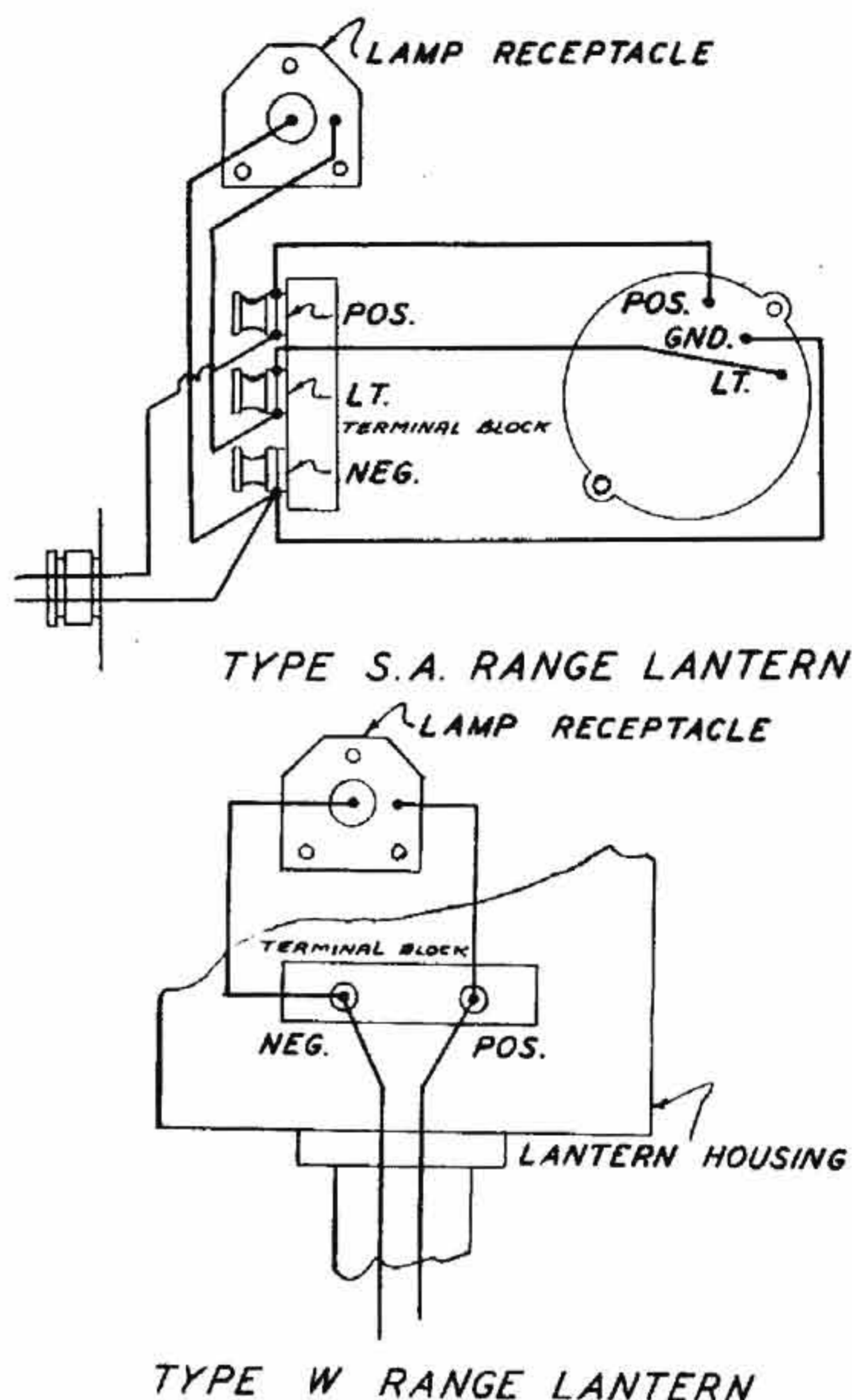
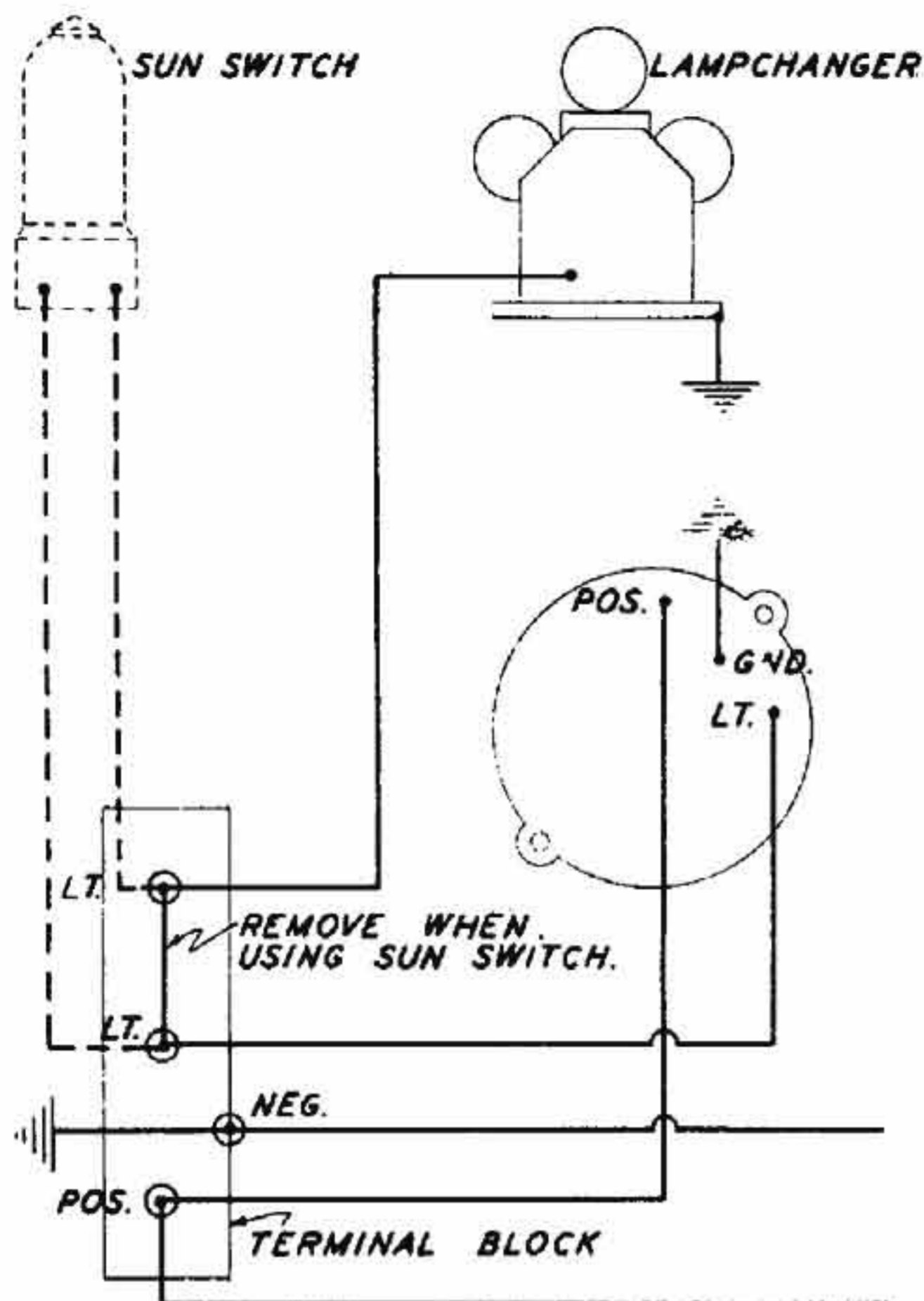


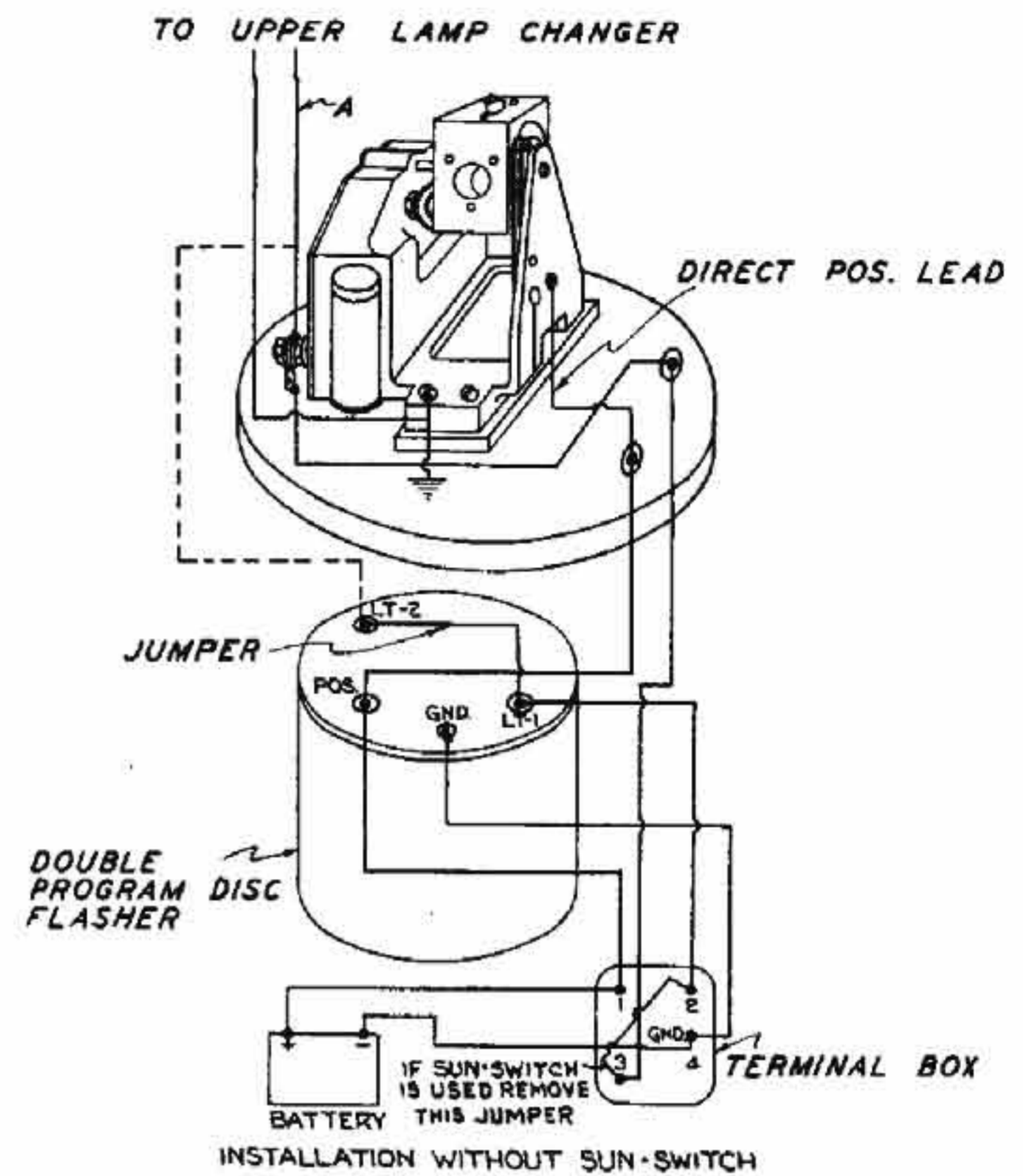
FIGURE 21-71.—Internal wiring diagrams, types SA and W range lanterns.

with a battery stand-by and alarm circuit. The wiring diagram shows the flasher, lampchanger, power transformer and change-over relay for 32-volt AC-DC operation. A 32-volt AC tap is taken off the power transformer to one side of the change-over relay. The 32-volt DC stand-by voltage is connected to the opposite side of the relay and the center tap of the relay is connected in series with the heavy-duty flasher and lampchanger. An additional 10-volt AC tap is taken off the power transformer leading to a rectifier on the change-over relay. This 10-volt circuit keeps the relay energized during AC operation. Upon AC line failure, the holding coil in the relay, which acts to hold the 32-volt AC contacts closed, becomes de-energized, allowing the contacts to the DC stand-by circuit to close. It will be noted that the heavy-duty flasher is operated from 32 volts DC. Flashers designed for 12-16 volt operation may be used by taking off the required voltage from the batteries. The alarm circuit is usually separate and may consist of No. 6 dry cells connected to a 6-volt bell or buzzer.



NOTE: NEGATIVE SIDE OF FLASHER, LAMPCHANGER AND BATTERY LEAD GROUNDED TO LANTERN.

FIGURE 21-72.—Internal wiring diagram, type FA-47 range lantern.



WIRING DIAGRAM FOR FA-98 AND FA-138 WALLACE AND TIERNAN DOUBLE PROGRAM DISC FLASHER & LAMP CHANGER CIRCUIT.

NOTE: WHEN USED WITH TWO (2) LAMP CHANGERS (DUPLIX) CONNECT LAMP CHANGERS IN PARALLEL AND REMOVE DIRECT POS. LEAD. WHEN ALTERNATE FLASH IS REQUIRED REMOVE JUMPER LT-1 TO LT-2 AND CONNECT A TO LT-2.

FIGURE 21-73.—Internal wiring diagrams, types FA-98 and FA-138 lanterns.

F. Leads and connections.—Leads to lanterns should be No. 12 stranded wire. Rubber covered portable cable of this size is recommended. When making connections on terminals, use a lug (Packard No. 217 or equal) rather than a twisted loop. Solderless-type lugs may be used if proper tools for assembly are available.

21-11-20 G. R. S. Type SA Range Lantern—

A. Installing flasher.—Upon receipt of a new lantern, inner unit (part 9), figure 21-30, will be found separately packed. Before installing in housing, remove bar (28) and discard the nuts used to keep screws (27) in place during shipment.

(1) Fasten flasher (15) (standard W. & T. flasher) to bar (28). The flasher is tapped to receive screws (27) (10-32 x 1/2 inch round head brass machine screws). Wires (21, 23, and 26) are not supplied by the manufacturer of the range lanterns.

(2) Secure the necessary wire, cut to proper length, and make connections as shown in figure 21-30, from the flasher terminal to the terminals on block (24).

(3) Replace bar (28) with flasher attached. In order to adapt lanterns already in service for flasher installation, it will be necessary to remove and discard the cover plate on the underside of the inner unit. Make up the flasher mounting bar as shown on figure 21-31.

(4) Remove terminal block (24) and install an additional 1/4 inch x 2 inch brass screw and nut; then rewire as shown in figure 21-30. See Figure 21-71 for wiring details.

B. Installing color disc and lamp.—If a color disc is required at (13), figure 21-30, procure a disc of the specified color.

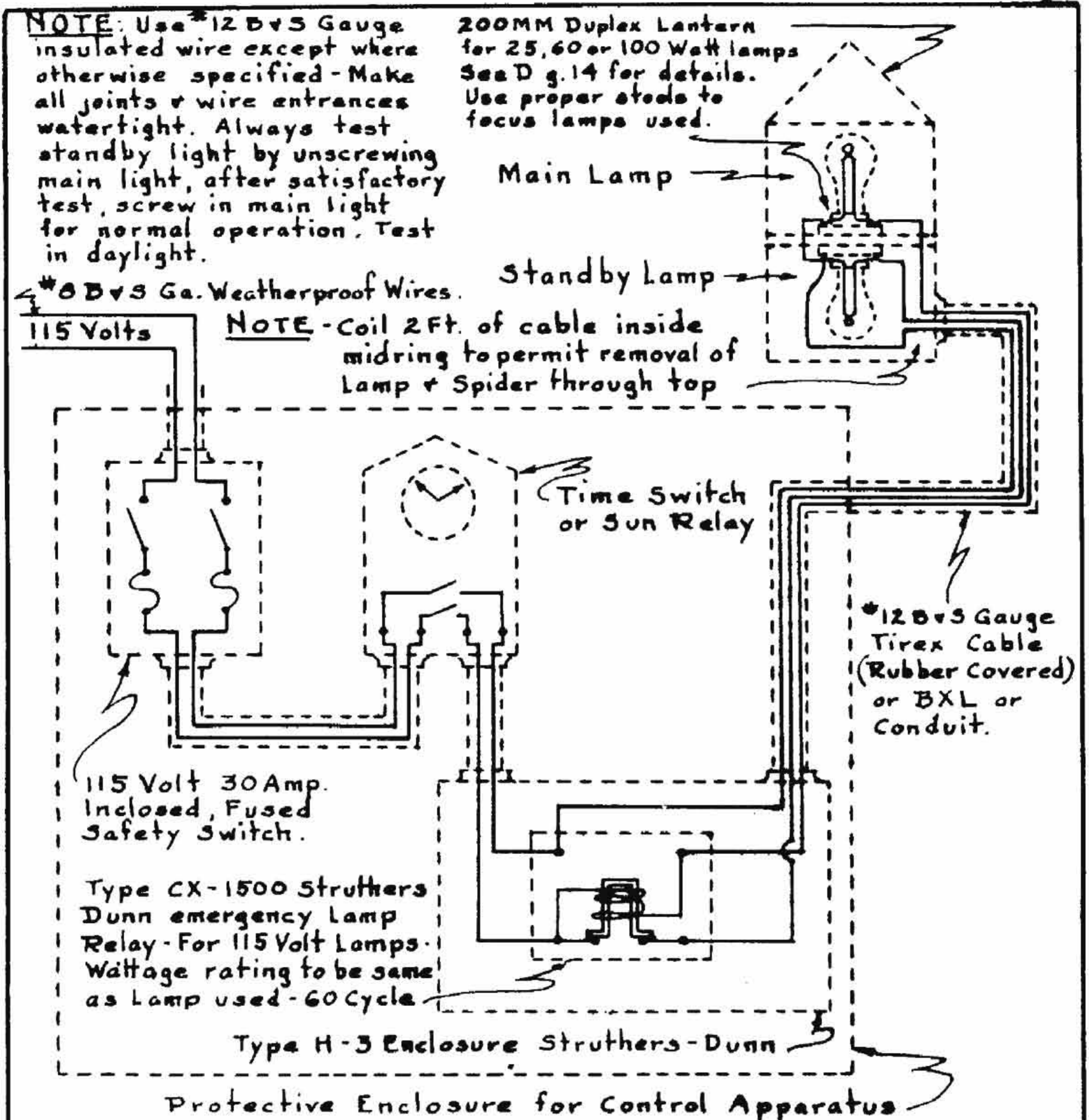
(1) Remove reflector holder (1) by turning it clockwise until it unlatches, and then withdraw it.

(2) Remove disk holder (2), insert the proper color disk at (13), and fasten it in place, being careful to replace the washers on screw (3). See that the reflector is clean, insert proper lamp, and replace reflector holder, turning it counter clockwise to latch it in place.

C. Inserting inner unit in housing.—After the external energy wires have been brought into the housing and before they are attached to terminals on block (24) figure 21-30, the inner unit may be inserted.

(1) Place the inner unit in the housing so that hangar (6) enters track (5) as shown in the small view at top of figure 21-30.

(2) Shove the inner unit forward until locking cams snap into place behind locking pins (8). Support (10) should enter the groove in lug (11).



EXPLANATION OF OPERATION

Main entrance switch controls on and off operation of light with fuse protection against overload or short circuit. Time switch or Sun Relay turn light on or off according to setting; on in evening; off in morning. CX-1500 Relay has open contacts when main light is operating; on failure of Main Light Relay drops, closing contacts and lighting standby lamp. The standby lamp is controlled by main switch and time switch exactly as main lamp is controlled

REVISION	DESCRIPTION	BY	DATE	APPROVED
UNIT:	ALL UNITS ST. LOUIS DISTRICT	Dr. R.R.K. CK. H.D.S.		
TITLE:	WIRING DIAGRAM DUPLEX LANTERN-NON FLASHING			
UNITED STATES COAST GUARD ENGINEERING		SCALE	No Scale	
ST. LOUIS DISTRICT ST. LOUIS, MO.		DATE	Sept. 10, 1941	
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		DRAWING NO.		
		229		

FIGURE 21-74.—200-mm. duplex nonflashing lantern wiring diagram.

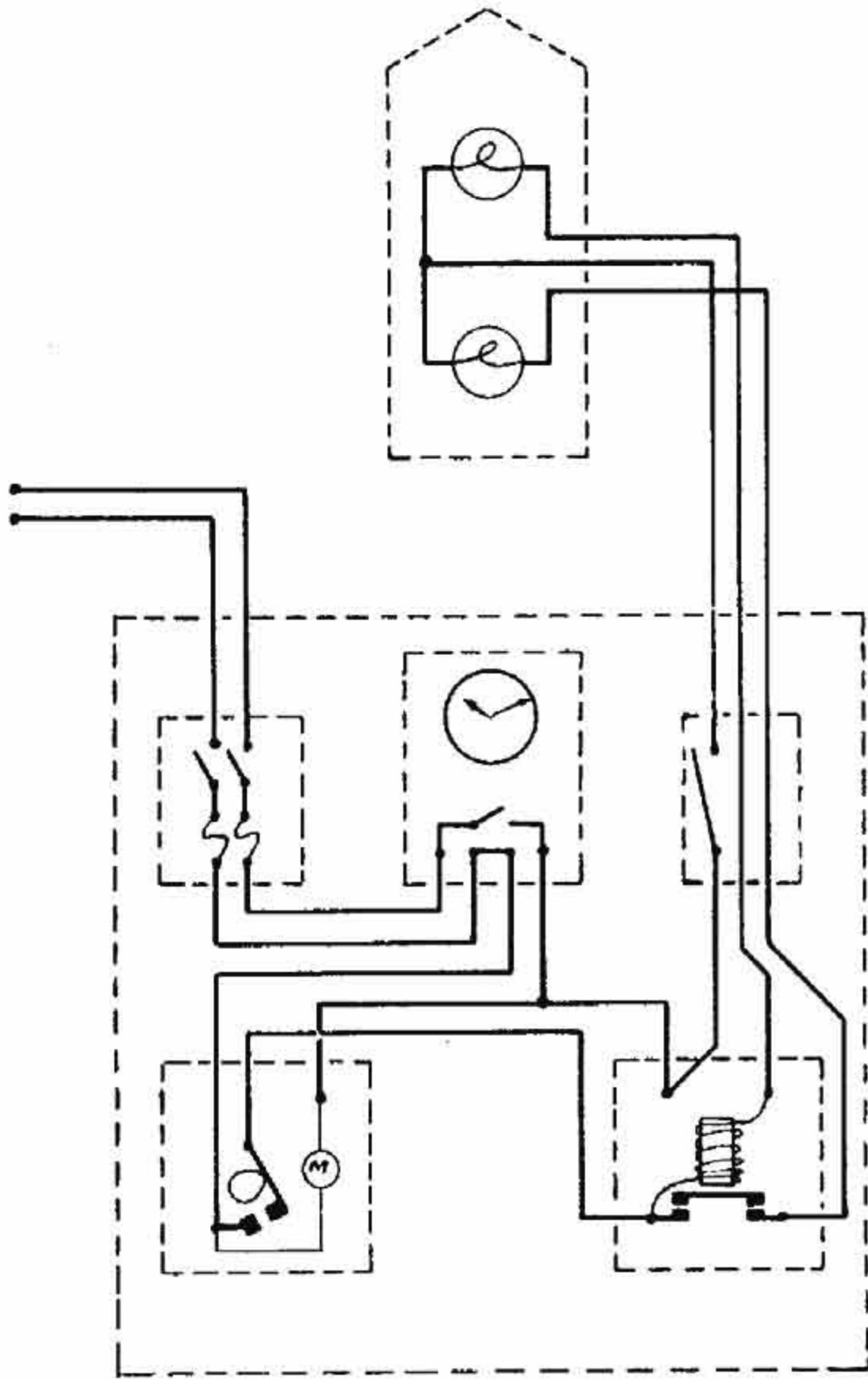


FIGURE 21-75.—200-mm. duplex flashing lantern wiring diagram.

**375 MM LANTERN
OPERATED ON 115 V. A.C. SUPPLY
WITH 32 V. BATTERY STAND BY.**

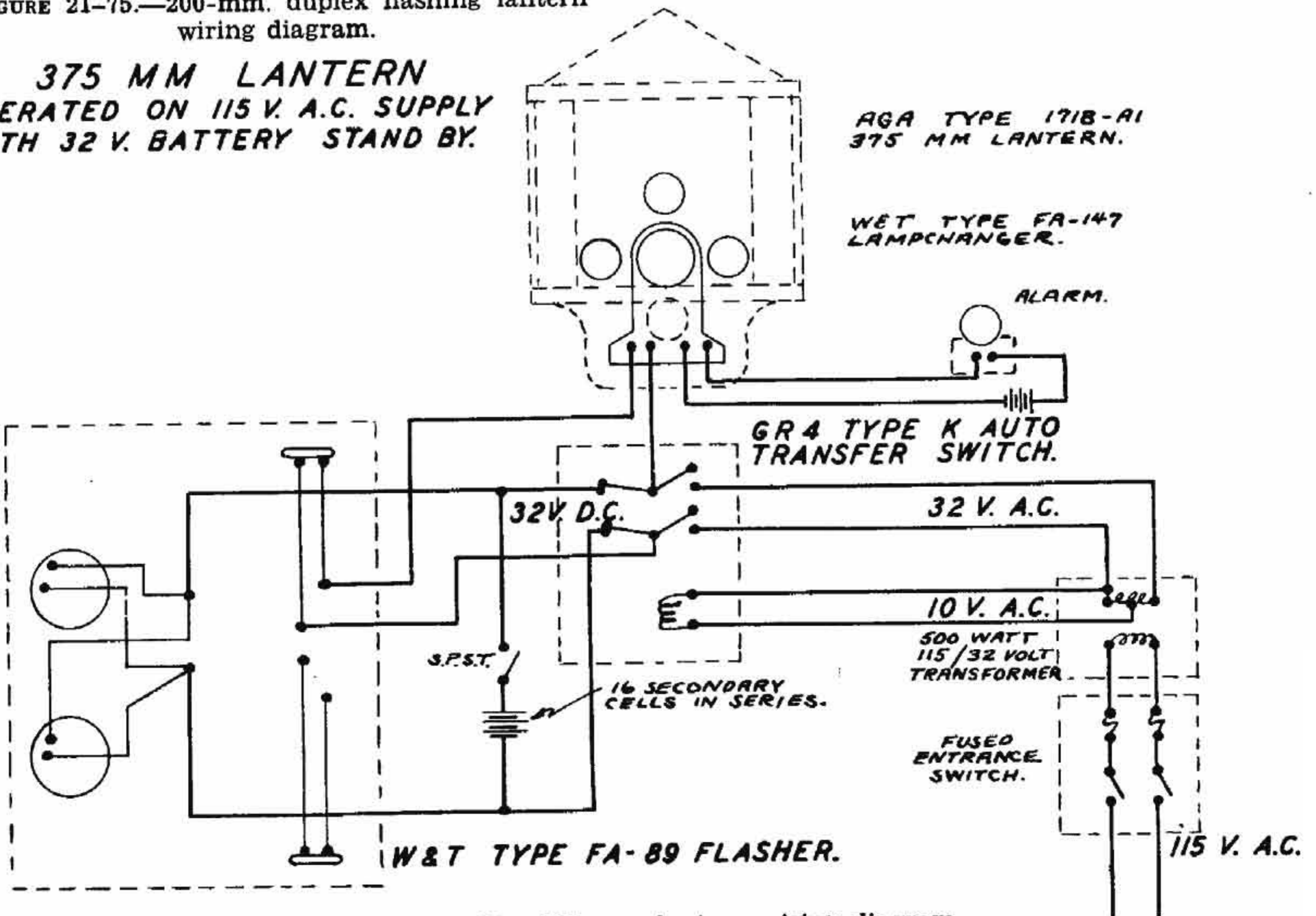


FIGURE 21-77.—375-mm. lantern wiring diagram.

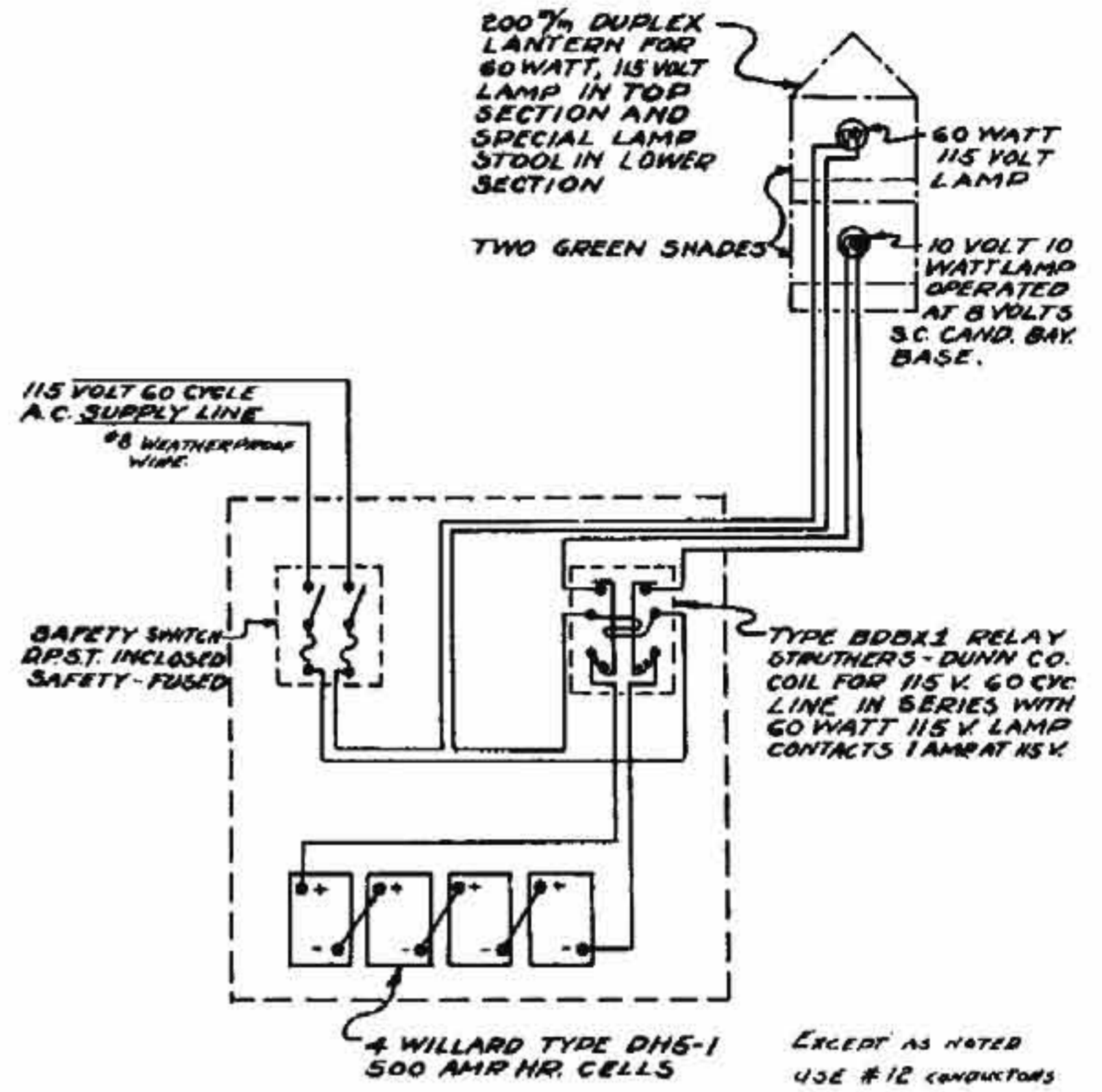


FIGURE 21-76.—Typical wiring layout for 200-mm. duplex lantern (Second CGD).

(3) Press both locking cams (7) down at the same time to make sure that the inner unit is solidly in place. See that the three matching surfaces, two at the top and one at the bottom of the inner unit, are in firm contact. Those matching surfaces are not shown in the cutaway view of figure 21-30, but are readily apparent when installing the inner unit.

(4) External energy wires may now be cut to length and connected to terminals (22) and (25) as indicated in figure 21-30. See also figure 21-71 for wiring details.

D. Installing outer convex roundel.—If an outer convex spreadlite or reflecting roundel is required, secure the proper roundel, a bezel ring (19) and 4 screws (20), figure 21-30.

(1) Remove outer ring (14) on which the hood is mounted. Be careful that the lens does not fall out.

(2) Apply a waterproof sealing compound to both machined edges of the bezel ring (19) and assemble outer roundel in the bezel ring. *Arrows molded in the glass indicate the direction in which the beam will be spread or deflected.*

(3) Place outer ring (14) over the roundel and fasten the assembly to the housing as shown in Figure 21-30. Tighten the screws evenly around the ring to avoid damaging the roundel.

E. Installing outer flat roundel.—If a flat roundel is required, secure the proper roundel, three bezel rings (19) Figure 21-30, and four screws (29) of sufficient length to fasten the ring (14) and the three bezel rings (19) to the housing.

(1) Remove outer ring (14) on which the hood is mounted. Be careful that the lens does not fall out.

(2) Apply a waterproof sealing compound to the machined edges of each of the three bezel rings, assemble them in a stack, and insert the roundel in the outermost bezel ring. Position the roundel with the flat side out so that the flutes will be parallel to the vertical axis of the lantern.

(3) Place outer ring (14) over the roundel and fasten the assembly to the housing as shown in Figure 21-30. Tighten the screws evenly around the ring to avoid damaging the roundel.

F. To mount the G. R. S. type SA range lantern, proceed as follows:

(1) Fasten base (12) (fig. 21-30) (with housing (16) attached) to mounting surface with four holding down bolts, three-fourths inch diameter. Should it be necessary to provide mounting bolt holes for this lantern, a pitch circle of $5\frac{5}{8}$ inches should be scribed, and either four $\frac{7}{8}$ inch through holes or four $\frac{3}{4}$ inch tapped holes, spaced equidistantly on the foundation with a centerline between the holes on the axis of the range. Leave the holding down bolts loose until the horizontal alignment on the range has been accomplished.

(2) A factory-adjusted peep sight is provided for alignment of the lantern. Do not disturb the setting of this peep sight.

(3) Center the cross hairs of the peep sight in the same manner as a rifle telescope.

(4) Adjust horizontally by turning the mounting base as required and tighten the holddown nuts.

The slotted holes allow a horizontal movement of about 12° of arc.

(5) Adjust vertically by tipping the housing up or down by means of nuts on the adjusting stud.

21-11-25 G. R. S. Type W Range Lantern—

A. Wiring.—Wires are brought into the unit through the supporting base and pipe. After removing the small rear door A (see fig. 21-32), the wires can be readily attached to the terminal posts found. Removal of the door also exposes the adjustment for the lamp receptacle. See figure 21-71 for wiring details.

B. Lamp.—The lamp is inserted in its socket by opening the front door (J) (fig. 21-32), bearing the hood and cover glass. The door is opened by backing off the locking screw (F), holding the door in the meantime so it will not be damaged by dropping open. With the door open, the reflector and lamp are exposed. Be sure the reflector is clean and that the lamp is properly seated in its socket before closing the door and tightening the locking screw at the top.

C. Lenses.—This range lantern is provided with a deep parabolic reflector and a plain convex cover glass with gasket. The cover glass is furnished in clear glass unless specifically ordered in color. If a change in color is desired after the lantern has been installed, the existing plain cover glass should be replaced with one of the proper color. If spread beam is desired, the plain cover glass should be replaced with a clear cover glass having the proper spread. If both spread beam and color are desired, two cover glasses with gaskets usually must be used, although occasionally a spread-type color glass may be available. With door (J) open (fig. 21-32), the spread beam cover glass should be placed in the door casting first and fastened with the four clips provided. Place the plain clear or colored glass on top of it and fasten with the second set of four clips. If the clear spread beam glass is flat instead of convex, reverse the mounting order, place the plain convex clear or colored glass in the door casting first, followed by the flat spread beam cover glass. *Do not tamper with reflector or socket adjustment as this has been factory set.* In event the adjustment has been disturbed, the lantern may be refocused by removing rear door (A) and adjusting the position of the lamp receptacle by means of 3 nuts on studs projecting through its supporting plate which is held against the adjusting nuts by means of coil springs. *This adjustment is difficult and should not be attempted in the field.*

D. Mounting procedure.—This lantern is provided with a small subbase for platform or foundation mounting using four $\frac{3}{8}$ -inch holddown bolts spaced $1\frac{1}{2}$ inches by $3\frac{1}{2}$ inches. This subbase should be securely fastened to the foundation. Horizontal alignment is accomplished by turning the case on the threaded supporting pipe and locking it in position with a lock nut. Vertical adjustment of about 8° up or down is accomplished by loosening nuts on the forward side of the base and tightening nuts on the after side or vice versa until the desired vertical angle is obtained.

E. *Caution* must be exercised when servicing a range lantern not to disturb the alignment of the lantern to the axis of the range. Do not disturb the mounting or holddown bolts except on specific orders.

21-11-30 Adjustable Resistors for Minor Light Circuits—

A. One district has made valuable use of adjustable resistors in the lamp circuits in minor light equipment. By reducing the voltage of the lamp, the candlepower output of an aid may be reduced to a desired amount. Thus, an 8.0-volt 0.25-ampere lamp in a G. R. S. type SA lantern will provide the following candlepower output when the lamp voltage is reduced to amounts shown.

Lamp	Voltage	Candlepower
8v. 0.25a.....	8.0	6,000
8v. 0.25a.....	7.5	4,800
8v. 0.25a.....	7.0	3,800
8v. 0.25a.....	6.2	2,400

Application of this principle makes possible the use of desired candlepower intensities on the various range lights.

B. Reduced lamp voltage also increases the lamp life. This factor is important in the case of range lights not equipped with lamp-changers. The use of adjustable resistors thus permits the installation of higher candlepower lamps for operation at reduced voltage.

C. The adjustable resistor is easily installed, as indicated in figure 21-77A, and paragraph (D) below. (The location of the resistor as indicated on figure 21-77A is not mandatory and field tests may develop a more desirable location.)

D. Instructions for installation of adjustable resistors for reduced lamp voltage in type SA and W range lanterns are as follows:

(1) Various voltages of less than maximum designed voltages are obtainable for range lanterns by the installation of a 10-ohm—10-watt adjustable resistor, Mallory or equal. This may be done by installing the adjustable resistor inside the range lantern as shown in figure 21-77A. (See par. (C) above regarding location.) The resistor is installed in a suitable space by drilling and tapping the lantern housing for machine screws.

(2) The resistor comes equipped with mounting brackets or lugs. Connect the resistor into the circuit between the flasher and the lamp as shown. Temporarily connect a jumper across the flasher contacts as shown to provide a steady light while adjusting the resistor to the proper voltage. This voltage is obtained by adjusting the resistor until the reading of a test voltmeter corresponds to the predetermined and assigned voltage. The resistor may then be fastened in place.

(3) When applying the resistor to a type W lantern, it may be necessary to install the resistor elsewhere in the circuit. Any location is satisfactory as

long as the resistor is not exposed to the weather, and is connected into the circuit between the flasher and the lamp.

(4) At all lanterns where such resistors are installed, servicing personnel should make it a routine servicing step to check the lamp voltage reading at each visit to ascertain that the resistor is not burned out and is adjusted to supply the assigned voltage. Over-voltage will decrease the lamp life and increase servicing, frequency of probable outages and candlepower; under-voltage will decrease the candlepower to less than that assigned.

E. The 10-ohm—10-watt adjustable resistor referred to above has proven satisfactory through considerable field usage. The adjustable resistor may be protected from rust by coating the coil with a protective paint *after* the correct setting of the contactor has been made.

21-12 INSTALLATION, LIGHTED BUOYS

21-12-1 General—

A. The installation of electric equipment on buoys is similar in most respects to the installation on minor lights. Lanterns, lampchangers, and flashers are interchangeable, the majority of lanterns used being 150- and 200-mm. size although a few 300- and 375-mm. lanterns may be found in use.

21-12-5 Procedure—

A. *Batteries.*—Place the low discharge DHB-5-1 batteries in the racks or frames in their proper positions according to the wiring diagram, and secure them in the buoy pockets. Interconnect the batteries as previously described and connect the two-conductor flexible lead from the rack terminals to the wires leading into the battery pocket through the interior connection (or steel elbow used in new buoys). (See sec. 21-4-30.)

B. *Wiring leads.*—From the buoy pocket a No. 12 double-conductor rubber-covered flexible cable leads out of the tank pocket through a hollow interior fitting (connection), through a watertight connector in the buoy head, and to the lantern, either through a junction box in the buoy daymark, or in the case of small buoys, direct. New electric buoys received from the manufacturer will come fully wired ready to receive batteries and lanterns.

New buoys have a seamless steel elbow welded directly to the side of the battery pocket between the flange and buoy head. The elbow leads over to the tower leg and is fitted with a watertight stuffing box. The wire is lead through this elbow and is connected directly to the battery leads.

C. *Watertightness.*—Carefully examine all joints and watertight connections. It is particularly important that battery pocket covers be tight. Check the rubber tube on the vents frequently as it has a tendency to dry out.

D. Mount the lantern in the same manner as described for acetylene buoys (see Chapter 20).

E. To convert acetylene buoys to electric, install a steel elbow as described in paragraph (B) above.

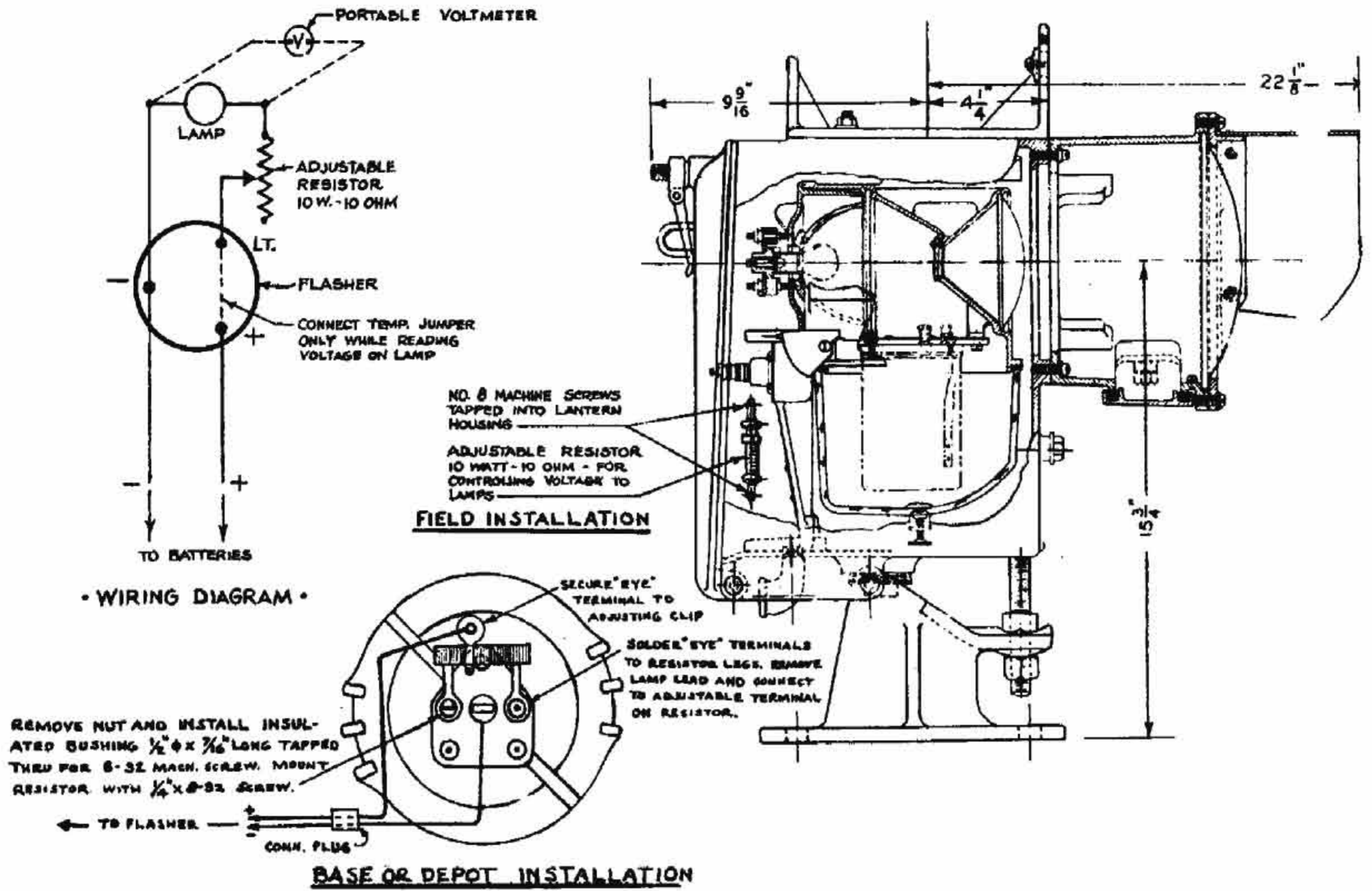


FIGURE 21-77A.—Installation of adjustable resistor for operating range lanterns at reduced voltage.

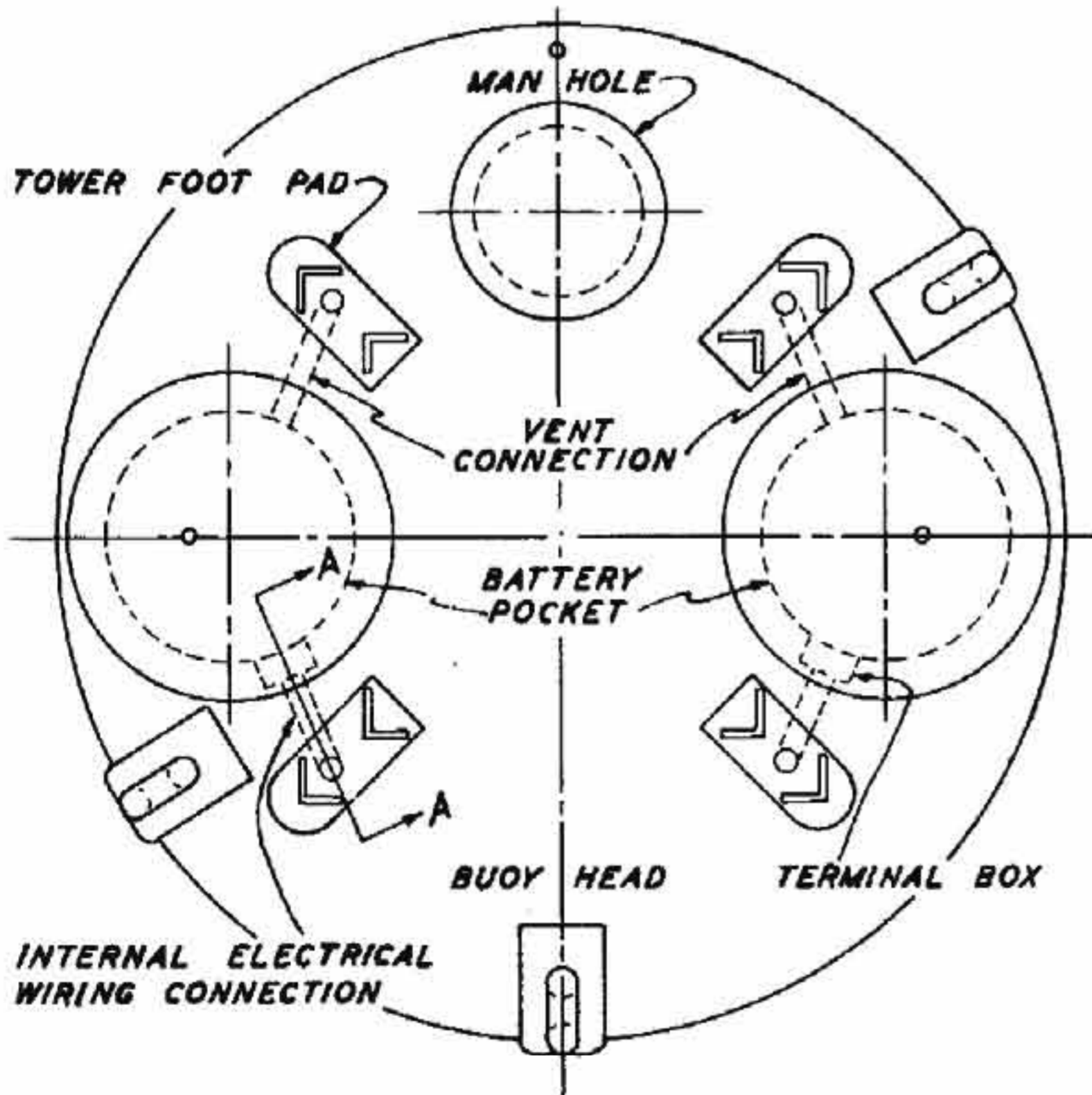


FIGURE 21-78.—Buoy head plan. (Recently constructed buoys have a slightly different arrangement for leading the connecting wire from the battery pocket to the tower leg. See text.)

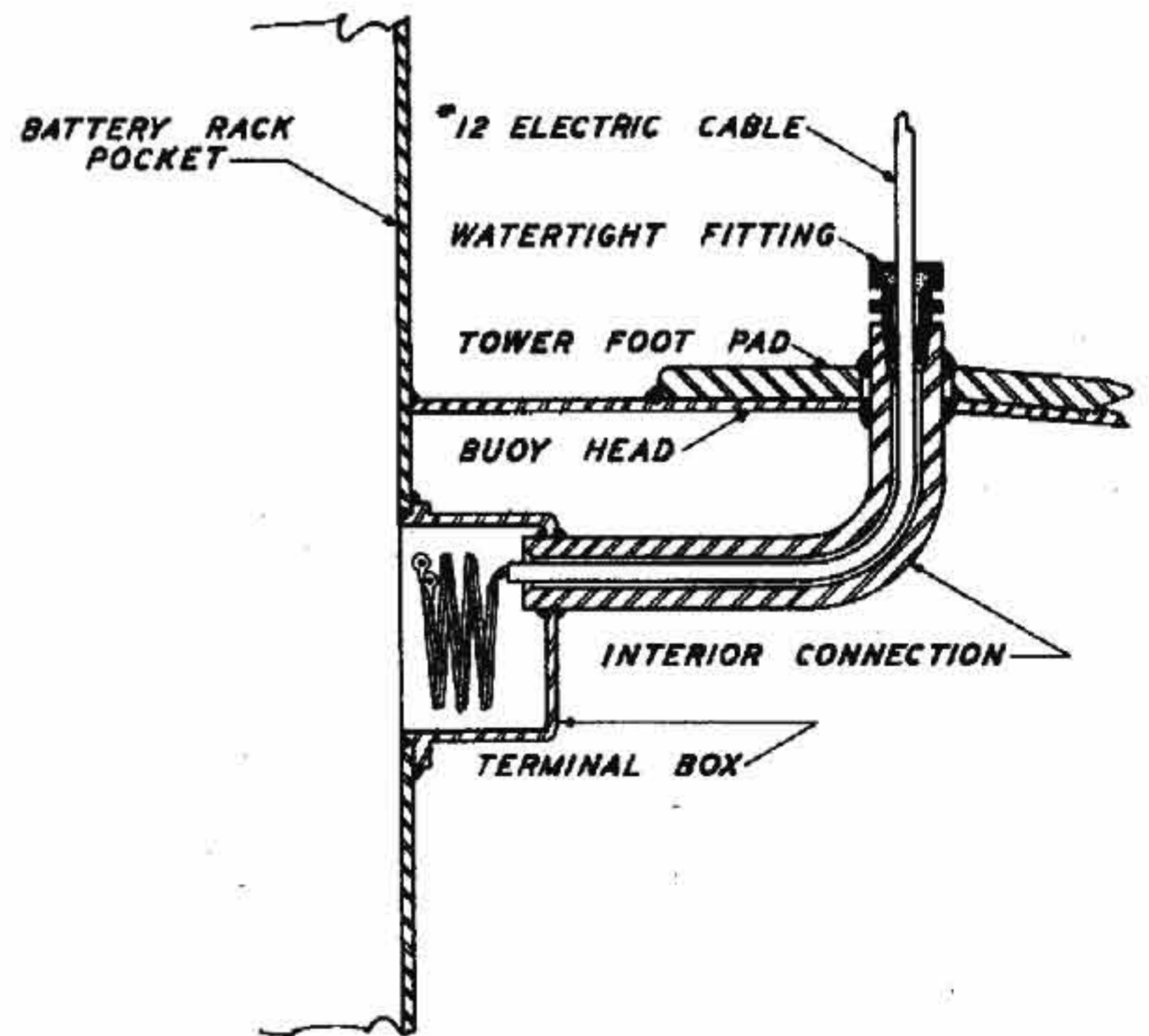


FIGURE 21-79.—Interior electric connection (sec. AA of fig. 21-78). (Recently constructed buoys have a slightly different arrangement. See text.)

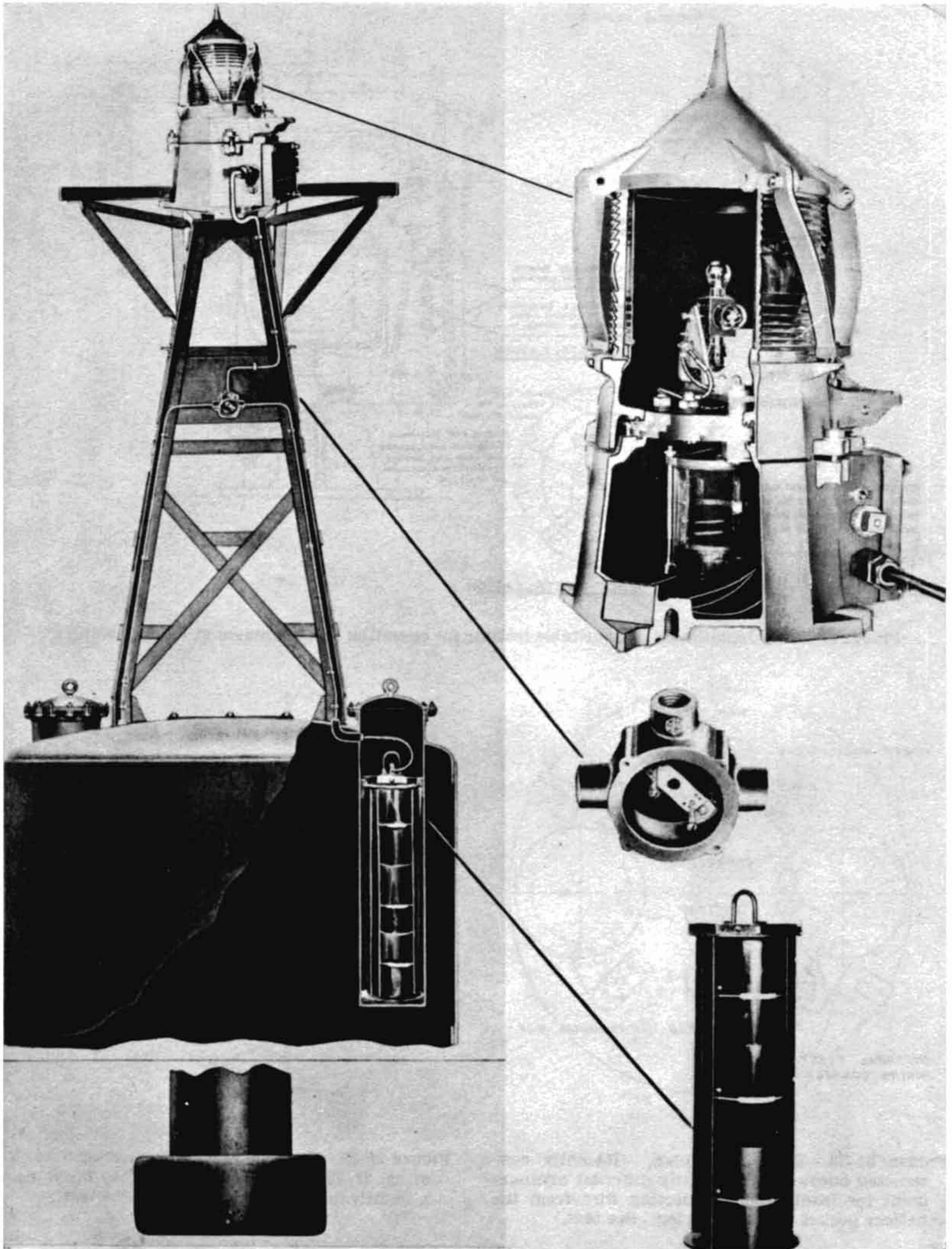


FIGURE 21-80.—Typical electric buoy wiring circuit. (Recently constructed buoys have a slightly different arrangement. See text.)

21-13 SERVICING MINOR LIGHTS

21-13-1 General—

A. The servicing of minor lights may involve the exchange of batteries, lamps, occasional "trouble shooting," replacement of flasher and lampchanger mechanism, and replacement of broken lenses, shades, and gaskets.

21-13-5 Batteries—

A. *Low-discharge lead cells.*—When changing lead cells, and before disconnecting, open the main switch if any. Put an identifying mark on each cell in the bank to avoid a mix-up with the recharged batteries. Remove only one bank at a time and take care not to lose track of the connecting leads, tops, and the *relative position of each cell as to polarity*. When connecting, make sure that the terminals are clean and the fittings are made tight, and cover them with a light coat of vaseline. Check the over-all voltage; if lower than required, it may be that one or more cells have been connected up in reverse polarity. If all the cells are in proper position and low voltage is still indicated, check each cell for voltage and specific gravity. Record the serial numbers of the batteries before or at the time of installation. For further information on lead cells see sections 21-4-10 and 21-4-30.

B. *Primary cells.*—Renew the elements of primary cells in accordance with the instructions given under paragraph 21-4-15 (A). If the cells are permitted to stand with open circuit a peak voltage will build up of up to 38 percent in excess of the normal voltage of 0.66 volt per cell. This may be higher than the rating of the lamp and may thus cause failure. To avoid this, after the cell bank has been connected, short circuit each cell for two minutes, then place the light in operation. This procedure will cut down *excess peak voltage*. The number of cells normally used for flashing lights without a sunrelay is as follows:

- 3.5-lamp voltage, 5 cells.
- 6.2-lamp voltage, 9 cells.
- 12.0-lamp voltage, 18 cells.

Caution.—Be careful in handling the caustic solution. Dry or in solution, it will burn or injure the skin. In case of accident, wash the affected part thoroughly in water and apply the antidotes prescribed on the label of each soda can until a physician can be obtained.

C. *Air cells.*—When installing air cells, follow the instructions contained in section 21-4-20 and bear in mind the following:

(1) Do not fill the battery with water until it is installed in place. If the battery should be carried any distance after filling, thoroughly wipe out the filler cap before placing the battery in service.

(2) Keep the vent hole in the filler cap open and free from salts at all times. Low temperatures do no harm on open circuit and have no serious effect at light drains and short duration closures. For higher continuous drains, the battery should be used at normal room temperature.

(3) The battery should be inspected every two months in hot, dry locations and every three months elsewhere to keep the water level up to the indicator wire visible through the filler hole.

D. *Battery inspection.*—Every power installation should be checked as follows:

- (1) Inspect and check voltage of each cell.
- (2) Connect power system, close lighting circuit and with light operating, make the following checks:
 - (a) Again, check the voltage of each cell.
 - (b) Check each bank of cells in series. This voltage should equal sum of normal voltage of cells in bank.
 - (c) Voltage of all banks in parallel should be equal to the voltage of the individual banks of the circuit.
 - (d) *Voltage at the light* should be 12 to 13 volts for a 12-volt lamp or 6.0 to 7.0 volts for 6-volt lamp.
 - (e) *Add or remove an equal number of cells from each bank* to give voltage at the light within the limits stated above.
 - (f) Grease all battery terminals to reduce corrosion.

(3) *Battery replacements* in power systems which have failed should be governed by the following:

(a) Replace all cells when the computed service period will expire within a short time or when more than 50 percent of the cells in the system are defective and/or show individual voltages below lowest allowed limit.

(b) Replace only defective and/or below normal voltage cells when the computed service period will not expire within a short time, and less than 50 percent of the cells in the system are defective and/or show individual voltages below normal.

E. *Dead battery procedure:*

- (1) Check the voltage of each individual cell.
- (2) If the cell voltage of a low discharge battery is below the usable limit (approximately 1.90 volts), the specific gravity reading should be obtained in order to determine if the complete battery is exhausted and must be replaced. An emergency battery of correct voltage should be installed if a regular replacement is not available. This may consist of a 6- or 12-volt "hot shot," starting battery, or similar source of current.

(a) If only one or two cells are "down" they should be replaced. Replacement must be attempted with caution, however, as one or two low cells is an unusual occurrence and may be an indication that the battery has been damaged. If low discharge cells are involved, note specially whether the defective cell has leaked. Notice whether an odor of sulfuric acid or chlorine is present. If so, investigate for evidence of electrolyte which must be removed and the area neutralized with soda.

(b) A voltage test is not a conclusive method for determining the condition of a low discharge (or any lead-acid) battery. Specific gravity of the electrolyte should be checked if practicable.

F. *Service routine.*—Provision is usually made at depots or servicing bases for a definite service routine, wherein the installation is visited at prescribed intervals. At each cell, the following routine with reference to batteries is suggested.

(1) Check specific gravity and record readings at each cell.

(2) Check and record voltage at each cell.

(3) Check and record total voltage of battery circuit.

(4) Check all battery connections.

(5) Clean terminals of any corrosion and apply coating of vaseline.

G. The results of specific gravity readings taken at the time of a routine service check may be used as a means of determining the approximate replacement date of the bank.

21-13-10 Lamps—

A. *Replacing lamps.*—At the time of battery servicing of minor lights, the lamps should be inspected. Where lampchangers are installed, one or more lamps may be found burned out, and replacements of the same voltage, ampere rating, and size should be made. It is also advisable to replace the lamp found in service, thus providing four unused lamps available to insure maximum reliability.

B. Types FU-1297 and SK-5529 lampchangers manufactured during recent years (since 1948) have lamp carriage blocks with numbered (1 to 4) lamp sockets. Always start operation with the No. 1 lamp in the operating position. Then, when servicing the light several months later, note the lamp socket number in the burning position. Remove all lamps in sockets with lower numbers as well as the one found burning. For example, if upon servicing the light it is found that No. 3 lamp is in the burning position, replace the lamps in sockets 1, 2 and 3. Before closing the lantern, place No. 1 lamp in burning position.

C. Where no lampchangers are installed, always replace the lamp found burning in addition to any burned out lamp, to insure maximum reliability.

21-13-15 Lanterns—

A. At the time of every inspection of an unattended light, the lantern, lens, and reflector if any, should be cleaned.

B. The following is a list of electric lanterns normally used on minor lights (the 150 and 200 mm. are also used on buoys, showing lamp data, consumption per day (based on a 0.4-3.6 characteristic, one-tenth luminous time ratio), approximate candlepower.

Lantern size	Bulb	Fila-ment	Volts	Am-peres	Con-sumption in am-pere hours	Beam candle power
90	S-8	C-8	6.2	0.46	1.236	20
150	S-8	C-8	6.2	.70	1.932	40
150	S-8	C-8	6.2	.92	2.605	75
150	S-8	C-8	6.2	1.4	4.132	110
200	S-8	C-8	6.2	.92	2.605	90
200	S-8	C-8	6.2	1.4	4.132	140
200	S-8	C-8	6.2	1.84	5.608	190
200	S-11	C-8	6.2	2.8	9.004	270
200	S-8	C-8	12	.55	1.491	90
200	S-8	C-8	12	.77	2.143	140
200	S-8	C-8	12	1.15	3.339	220
200	S-8	C-8	12	1.35	3.985	300
200	S-11	C-8	12	2.03	6.284	440
200	S-11	C-8	12	3.05	9.955	700
300	S-8	C-8	12	1.15	3.339	350
300	S-8	C-8	12	1.35	3.985	450
300	S-11	C-8	12	2.03	6.284	650
300	S-11	C-8	12	3.05	9.955	1100
				<i>Watts</i>		
300	A-19	C-5	32	36	2.64	400
300	A-21	C-5	32	60	4.32	2000
300	A-21	C-5	32	100	7.44	3700
300	P-25	C-5a	32	250	18.72	7500
375	A-21	C-5	32	60	4.32	3000
375	A-21	C-5	32	100	7.44	5000
375	P-25	C-5a	32	250	18.72	10000

An approximation of daily current consumption can be had for other luminous time ratios, such as: One-fifth, one-fourth, one-third, and one-half, by multiplying the above figures by 2, 2.5, 3.3, and 5, respectively.

21-13-20 Service Tools—

A. The following is a list of tools and minor spare equipment used in field servicing of electric apparatus.

Adjustable crescent wrenches, 12-inch, 8-inch and 6-inch.	Screws and nuts, various sizes, including 8-32 x 1/2-inch and 10-32 x 1-inch.
Battery lugs and jumpers.	Set of spin-tight socket wrenches.
Blow torch, alcohol, small.	Set of box wrenches.
Buoy vent.	Set of open-end wrenches.
Cleaning cloths and oil can.	Shunts, assorted.
Emery cloth, medium grade.	Solder, wire (not acid core).
File, half round, smooth 8-inch.	Soldering posts.
File, magneto.	Special filling syringe for low-discharge batteries.
Hydrometer.	Standard wire, No. 12.
Lamps, assorted.	Stillson wrench, 6-inch.
Matches.	Stop watch.
Metal tool box and lock.	Sunrelay cover.
Pliers, side cutting, 6-inch.	Sunrelay key.
Screwdrivers, 6-inch and 10-inch.	Tape, friction and rubber.
	Vaseline.
	Voltmeter, 0-50 D. C.

21-13-25 Service Testing—

A. The service testing of battery operated minor lights is a relatively simple procedure involving the use of a test lamp or voltmeter at certain important test points of the installation.

B. *Possible faults.*—If the light is flashing on other than its advertised characteristic, the fault is probably in the flasher mechanism. If the light is extinguished, the fault may lie in the light sensitive control, the lampchanger or lamp, or the batteries may be dead or shorted out through faulty wiring.

C. *Check battery voltage.*—Upon arriving at the scene of a battery-operated light which has been reported extinguished, the first general step is to check the battery voltage at the bank. (In the case of a buoy, rather than to open the battery pockets unnecessarily, check the voltage at the lantern terminals. *Do not work in a buoy pocket until it has had time to air out thoroughly. Exercise particular care in making and breaking connections. A spark may cause an explosion.*)

(1) If incorrect voltage is found at the bank of batteries (or lantern terminals), check the intercell jumpers for correct lead from the series-connected cells. Replace as necessary and be sure to maintain correct polarity.

(2) If correct voltage is found at the bank, check through such switches and fuses as may be installed. If the voltage is correct, proceed to the lantern.

D. *Examine all lamps.*—Seldom will all four lamps be found to be burned out at one time. In such a case the lampchanger will operate continuously after the last lamp has burned out. Replace the lamps and check the lampchanger for operation.

E. *For a W. & T. lantern with flasher and lampchanger but without sun and protective relays* (fig. 21-81).—proceed as follows:

Step 1: Assuming a check at the battery bank has shown the correct voltage, place a voltmeter across terminal box connections 1 and 4 in the lantern. This checks the battery voltage and wiring from the battery bank to the terminal box. If the voltage is incorrect, replace the wires or check terminal connections and intercell wiring.

Step 2: Check from the POS terminal on the flasher to ground (the mounting bar of the flasher is grounded). If the voltage is correct and the flasher is not running, replace the flasher.

Step 3: Check from LT terminal on the lampchanger to ground. This checks the flasher contacts and the entire LT circuit to the lampchanger. If correct voltage (during flash interval only) is found here, but not light, a defective lampchanger is indicated. Replace it.

F. *For a C. G. standard or Service-type lantern* the procedure is simplified by the absence of a terminal box. If there is no sunrelay or protective relay installed, there are only two important points where current failure would indicate the necessity for battery or mechanism replacement. These are shown on figures 21-82.

Step 1: Assuming that a check of the battery bank has shown the correct voltage, a test for voltage from the positive terminal of the flasher to ground will check the wiring to this point (step 1). If the voltage is correct and flasher is not running, replace the flasher.

Step 2: A test for voltage at the point outlined in step 2, figures 21-82, from ground to the lampchanger light terminal, will check through the flasher contacts and wiring. Correct voltage here during the flash interval will indicate a faulty lampchanger.

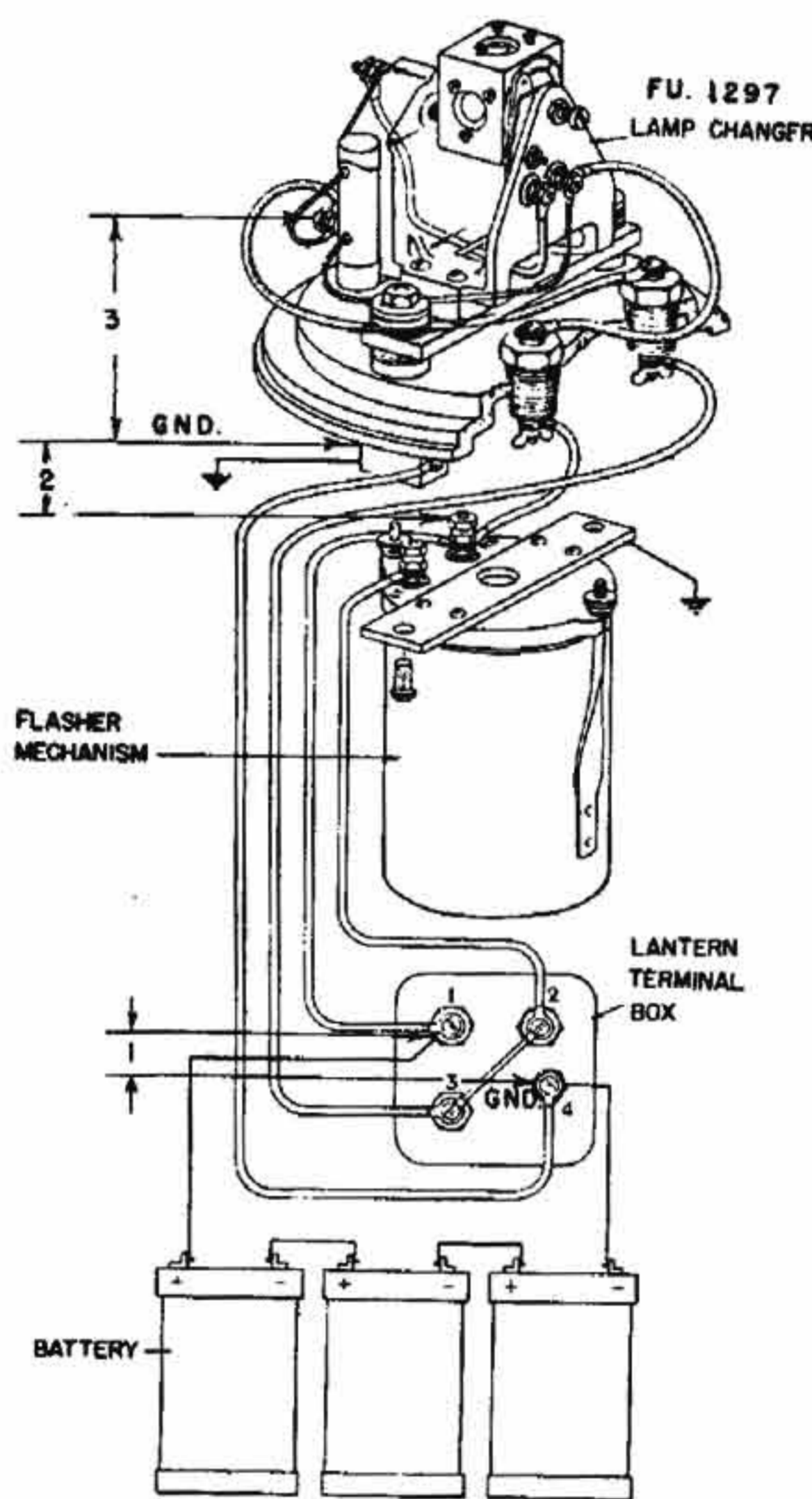


FIGURE 21-81.—Faultfinding diagram for W. & T. flasher-lampchanger circuit.

G. *For a lantern with flasher, lampchanger, sun and protective relays* (Fig. 21-83), proceed as follows:

(1) Place jumper across terminals 2 and 3. If the light operates, and the outage has been observed at night, this indicates a faulty sunrelay. Adjust (see sec. 21-9-5), or replace it, or if necessary, leave the jumper in place. If the light does not operate, proceed to step 1 as outlined in subparagraph (2) below:

(2) *Step 1:* Terminal 1 to terminal 4 (GND). This checks the battery voltage in the terminal box. If no voltage is shown, check the battery wiring leading to the terminal box.

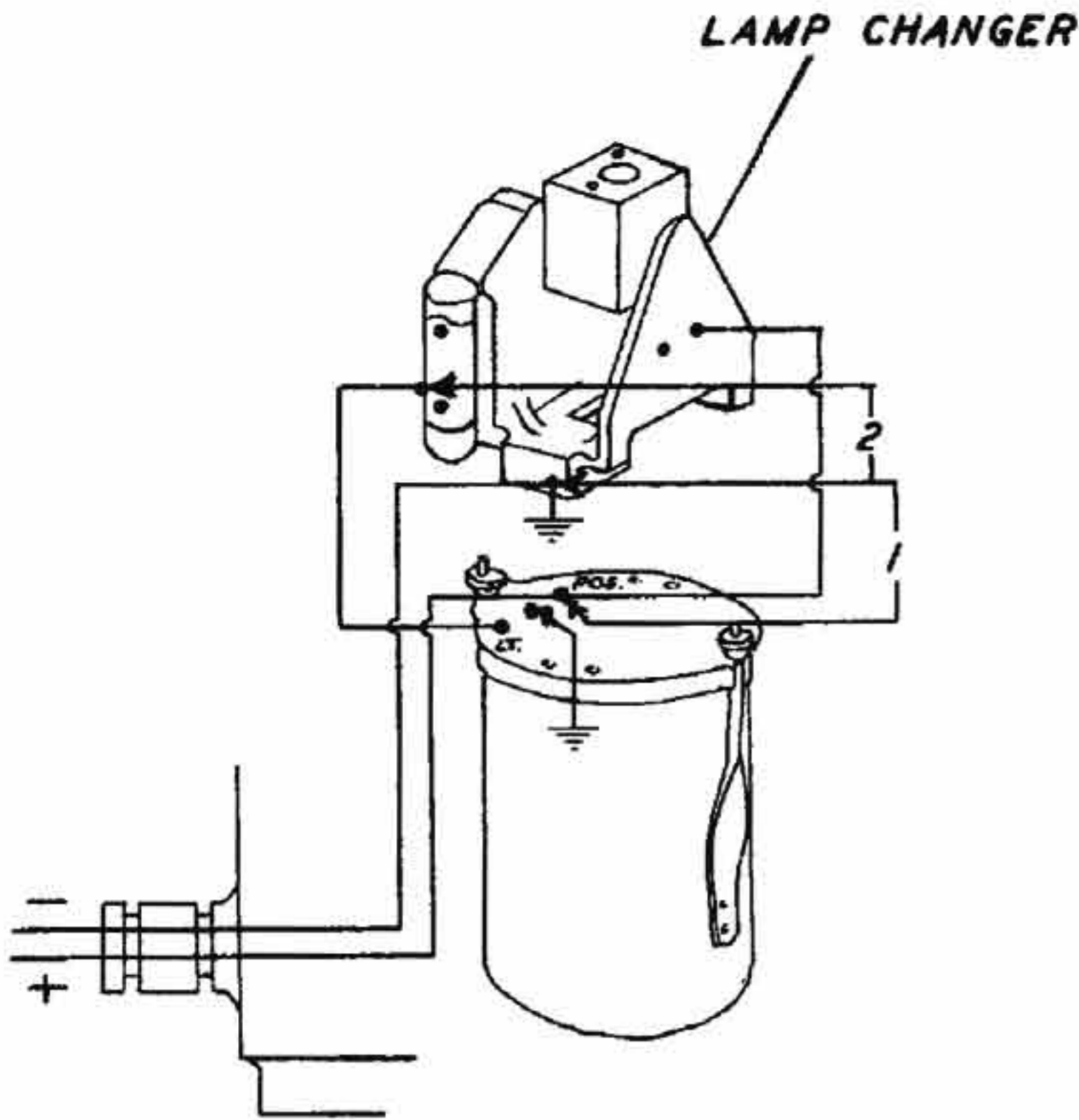


FIGURE 21-82.—Faultfinding diagram for C. G. standard and service-type lanterns.

Step 2: Ground to positive flasher terminal. With a correct reading at step 1, and if flasher is not running, check the voltage between the positive flasher terminal and ground. If voltage is correct, replace the flasher. If no voltage, examine the wire leading from terminal box post No. 1 to POS on flasher mechanism. Also examine the internal ground connections for good continuity.

Step 3: With the flasher running, but still no light, check between terminals 2 and 4 in the terminal box. This should show intermittent voltage, i. e., each time the cam makes the contacts close. If there is no voltage here, the light contacts are faulty. Replace the flasher if a spare is available, otherwise, make emergency repairs to the light contacts.

Step 4: With correct voltage at step 3, and with a jumper across terminals 2 and 3, the protective relay should be heard to operate. If not, check the wiring between terminal 3 and the protective relay, then from the protective relay to ground by placing a voltmeter across the relay coil terminals. If intermittent voltage is shown, the protective relay coil is defective and should be replaced.

Step 5: With the protective relay operating and still no light, check between the lampchanger light terminal and ground. If no voltage is obtained here, examine the protective relay contacts and wiring. If intermittent voltage is obtained, the lampchanger is defective and should be replaced.

(3) Remove the jumper between terminals 2 and 3 in the terminal box. Assuming that the sunrelay has been covered for at least one-half hour, the light should continue to operate with the jumper removed. If the light does not operate with the jumper removed, readjust the sunrelay. If the sunrelay has been installed for a considerable time, replacement is recommended. If no replacement is

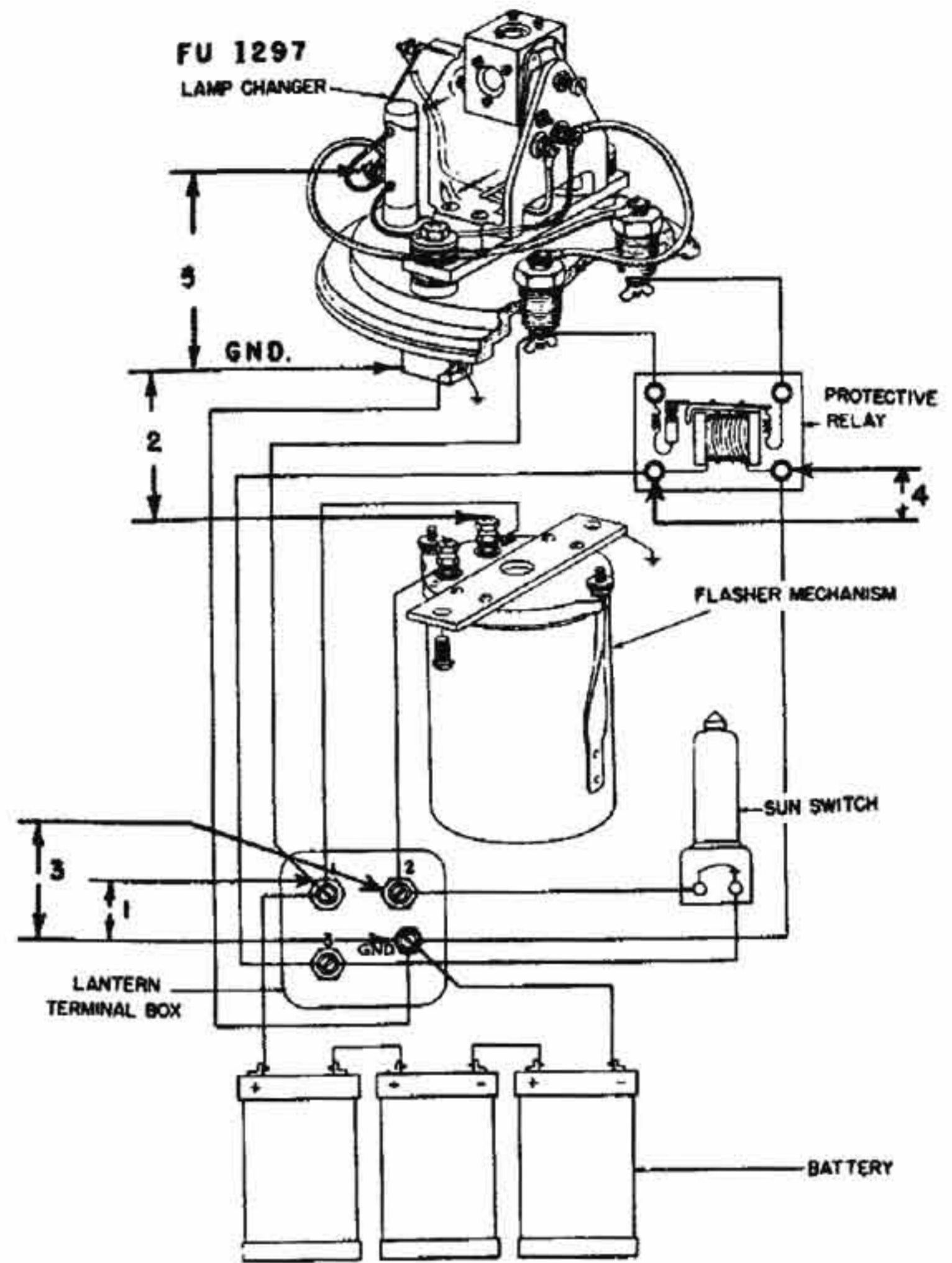


FIGURE 21-83.—Fault finding diagram for W. & T. flasher, lampchanger, protective relay and sun-relay circuit.

available, replace the jumper on terminals 2 and 3 as a temporary measure.

H. Test procedures previously outlined apply equally as well to the types SA and FA-147 range lanterns.

21-13-30 Temporary Service Repairs—

A. When no replacement parts are available, certain temporary measures may be used to return the light to operation.

(1) If a *lampchanger* is found defective, a flashing light may be obtained by disconnecting both wires from the terminals located on the face of the lampchanger coil (mechanism) case and securing the ends together. *Do not place a jumper across these terminals.* The lampchanger will then serve as a single lamp stand and should be replaced as soon as possible. A new lamp of proper voltage and amperage should be installed so as to assure as long service as possible under single lamp operation.

(2) *Sunrelays*, once properly adjusted, seldom give trouble. In the event this does occur (either the light fails to come on or go out), and no spare is available, remove the sunrelay and fasten the wire terminals together, or in the case of W. & T. lanterns, place a jumper across terminals 2 and 3. Return the sunrelay for repairs.

(3) If a *protective relay* fails to operate, and the flasher is running, indications show that the relay coil is open. In this event, a flashing light can be maintained by removing the light leads running to and from the protective relay and attaching the ends together. This bypasses the relay. However, this places the lamp current through the flasher contacts which are designed to handle up to two amperes only; therefore, the protective relay should be replaced as soon as possible.

21-14 SERVICING LIGHTED BUOYS

21-14-1 General

A. The servicing of lighted buoys is similar in most respects to the procedures described under Part 21-13. The 150- and 200-mm. lanterns are interchangeable between minor lights and buoys and are serviced and tested in the same manner.

21-15 MAJOR LIGHTS

21-15-1 Definition and Constituent Parts—

A. An electrically operated major light is exhibited from a fixed structure ashore or on a marine site where a light of high candlepower and reliability is required. These lights are usually located at manned stations and are powered from generating plants or commercial electric lines.

B. The constituent parts of major electric lights are:

<i>Essential</i>	<i>Optional</i>
Lantern.	Lampchanger or standby light source.
Lens.	Time clock or light sensitive control.
Light source.	Alarm circuits.
Wiring.	Standby power supply.
Switching.	
Power supply.	

21-15-10 Electrification of Large Optics—

A. *Lamp supports.*—In the electrification of large optics at attended stations, the lamp, carefully centered in the lens, is mounted on an adjustable pedestal or suspended in an inverted position. The vertical adjustment is necessary to compensate for moderate differences in the light center length of individual lamps. These pedestals must be fabricated for each individual case. See figures 21-88 and 21-89 for typical examples.

21-15-11 LAMP CARD

A. *Lamp card.*—There shall be posted in the lantern house in a conspicuous location a card listing the lamp characteristics of the main light. The

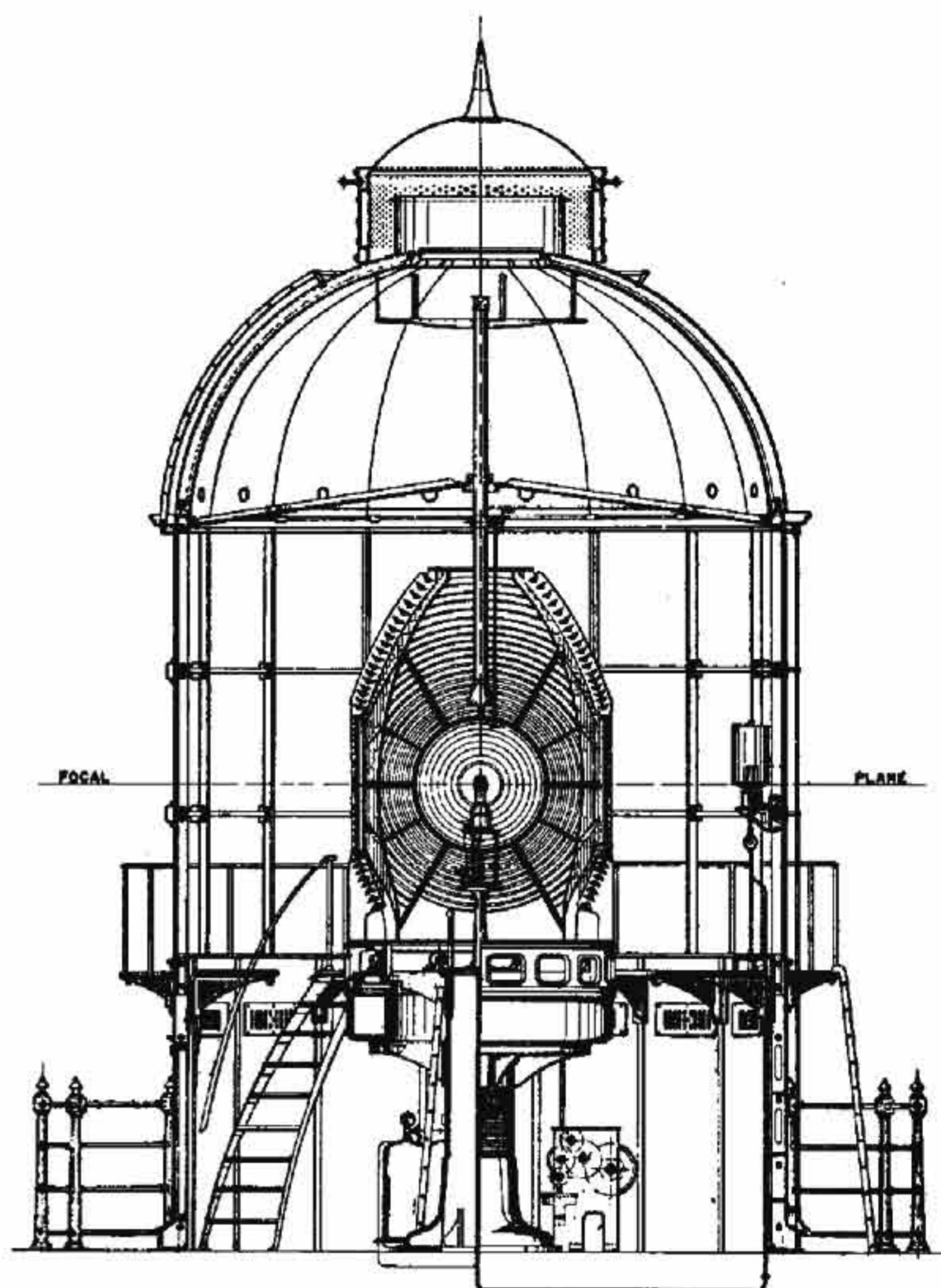


FIGURE 21-84.—Major lens and lantern.

card shall list lamp voltage, wattage, bulb shape and finish, filament type and dimensions, base type and burning position, and life of lamp in hours.

21-15-15 Lampchangers and Standby Light Source—

A. *Lampchangers.*—An approved lampchanger shall be made a part of the electric equipment in all major unattended lenses. It is approved practice to install lampchangers in all lenses where clearance permits. Lampchangers containing the large size lamps will be found designed to take two lamps. The operation of some lampchangers is such that the burning lamp is held in place by a holding coil in series with the filament. When the filament

burns out, the holding coil is de-energized, permitting the carriage to change position by spring arrangement bringing the spare lamp into position. Others, upon opening of the filament circuit, release a spring-operated mechanism which serves to bring the spare lamp into position. Several spare lamps are found in lampchangers of smaller size. In changing lamps in a large two-lamp type lamp-changer, be very careful to leave the "operating" lamp in burning position, and not the "spare." Should the "spare" be left in burning position, upon burning out, the other lamp would not come into position. Lampchangers rotate only in one direction, from operating lamp to spare, therefore, *always position lampchangers correctly.*

B. Standby light source.—Except when standby or duplicate power supply is installed, a standby light source shall always be in readiness for immediate insertion in the optic at attended light stations. When electrifying, the standby light source may consist of:

- (1) Retention of one set of original light source apparatus (I. O. V. or oil wick lamp).
- (2) Aladdin lamp.
- (3) Small lens lantern with complete light source, battery, etc.
- (4) Acetylene standby arranged to move into position automatically or manually.

C. When stand-by electric power is provided, a lampchanger shall be installed in the lens if clearance permits. When the stand-by light is an I. O. V. apparatus, it should be placed in operation as often as necessary to assure readiness in case of emergency.

21-15-20 Focusing—

A. It is extremely important that lamp filaments be properly focused; that is, the center of the filament in line with the horizontal and vertical center of the lens belt or bull's eyes. If the light source is too low, the beam will shoot up; if too high, the beam will shoot down. There are instances where a light source is deliberately de-centered so that the beam will be shown at a predetermined angle. In such instances, the officer-in-charge of the light will be informed of the specified focal height of the light source.

B. Large lamps.—In particular reference to range lanterns or revolving lights which still use large lamps with C-13 or C-13B filaments (screw type sockets), it will be found occasionally that upon screwing the lamp firmly in the socket, the filament will not be in the proper position; that is, flat side parallel with the reflector or bull's-eye. This can be corrected by springing up the center contact in the bottom of the lamp socket. Always be sure the power is off before doing this. Positioning of other filaments can be accomplished in the same manner where screw base sockets are used.

C. Check filament.—Filaments in frosted lamps are not ordinarily visible. However, when it is desired to check the type of filaments in a given lamp, proceed as follows:

- (1) Select a piece of cardboard larger in size than the entire bulb.
- (2) Pierce a small hole in the center of the cardboard. (One-eighth inch for large lamps and proportionately smaller for smaller lamps.)
- (3) Place the cardboard so the hole is close to, and in line with, another bright light.
- (4) Place the frosted lamp in front of the cardboard and in line with the light beam emitting from the hole in the cardboard. When properly adjusted, the outline of the filament will be clearly visible.

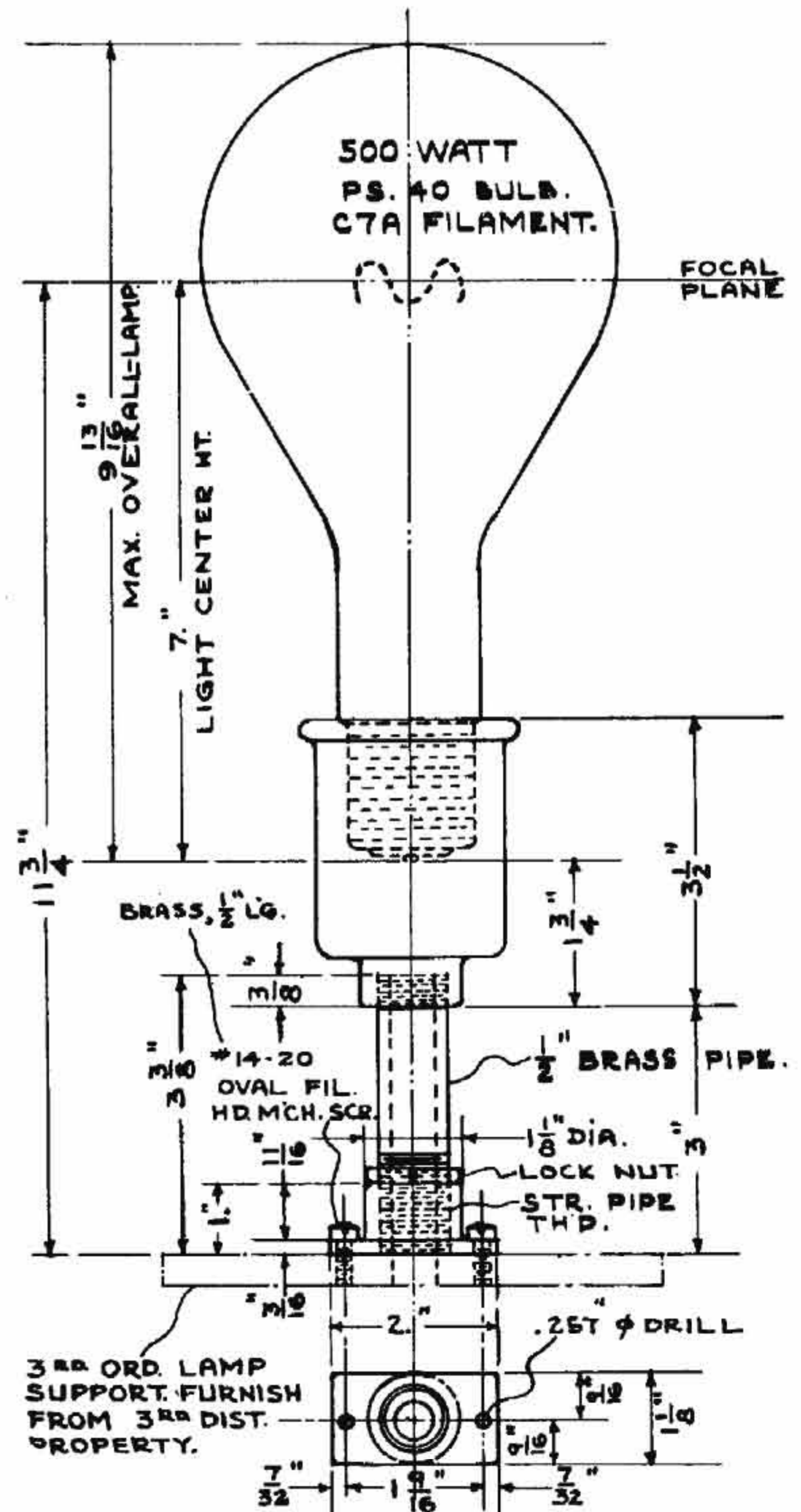
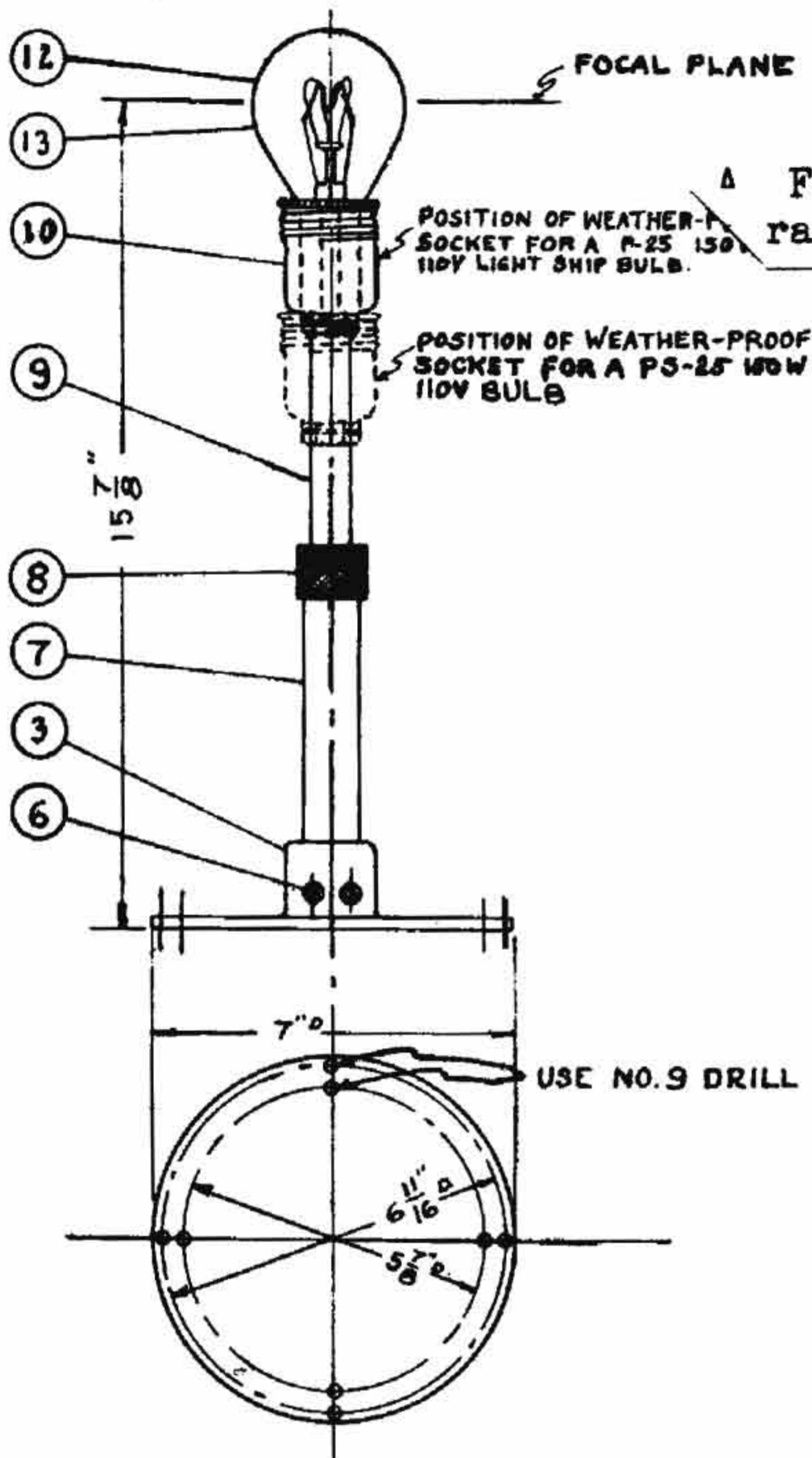


FIGURE 21-88.—Electric lamp stand.



LIST OF PARTS	
Part No.	Name
3	Adjustable lamp stand base.
6	Adjustable lamp stand insulated bushing.
7	Adjustable lamp stand support.
8	Adjustable lamp stand clamp nut.
9	Adjustable lamp stand extension.
10	Weather-proof socket.
12	P-25 150-w. 110-v. light ship bulb.
13	PS-25 150 w. 110 v. bulb.

FIGURE 21-89.—Adjustable lamp stand for 375-mm. lantern.

21-15-25 Alarm Devices—

A For information relative to alarm devices see para 29-3-30A Chapter 29 of this manual

indicate:

- (1) Extinguishment of main light, or of one filament if a two-filament source is used (revolving beacon or two filaments in same globe).
- (2) Failure of regular power supply.
- (3) Failure of revolving apparatus.

B The actual means of accomplishing the alarm is left to the ingenuity of the engineer where standard devices are not supplied as a part of the apparatus. Marginal current relays in lamp circuits, photoelectric devices, voltage relays, etc., are a few of the possible devices for accomplishing the purpose. If a spotlight is used as an indicator, its axis must be such that it will not give a misleading indication to the mariner.

21-15-30 Flashing Equipment—

A. The flashing characteristic of major lights is obtained in several ways, depending on the optical apparatus.

B. *Fixed lenses.*—In the fixed (drum) lenses it may be obtained by three different methods: by using a fixed light source and revolving an occulting shade around the source; by interrupting the current to the electric source by means of a flasher; or by revolving prismatic flash panels around the outside of the lens. If flashing is accomplished by the second method, many types of flashers are available. For many years sign flashers employing gear reductions and mechanical breakers have been used with success. Mercury tube breakers are preferable. Mercury breakers driven by heavy duty flasher mechanisms are available. If due consideration is given to current requirements there is no restriction as to type of flasher, provided reliability is stressed. The use of a reactor has proved advantageous when flashing large electric lamps to limit the instantaneous surge of current. Two-step flashers have been used, and in a few instances the filament is not completely extinguished.

C. The *revolving lens* is composed of flash panels assembled to produce predetermined sequences of flashes dependent upon the angular arrangement of the panels and the speed of revolution. (See figs. 21-90 and 21-91.) The revolving mechanism is called the lens carriage. It may be supported on wheels or may be carried on a float plunger supported by a film of mercury. The mechanism is guided by central bearings. Newer and smaller revolving lens mechanisms are guided and supported by conventional thrust and guide ball or roller bearings, or by combinations of bearings. Many of the chariots are provided with means for wedging or chocking against movement, or to remove the load from the bearings. (See Chapter 29 for more details on this subject.)

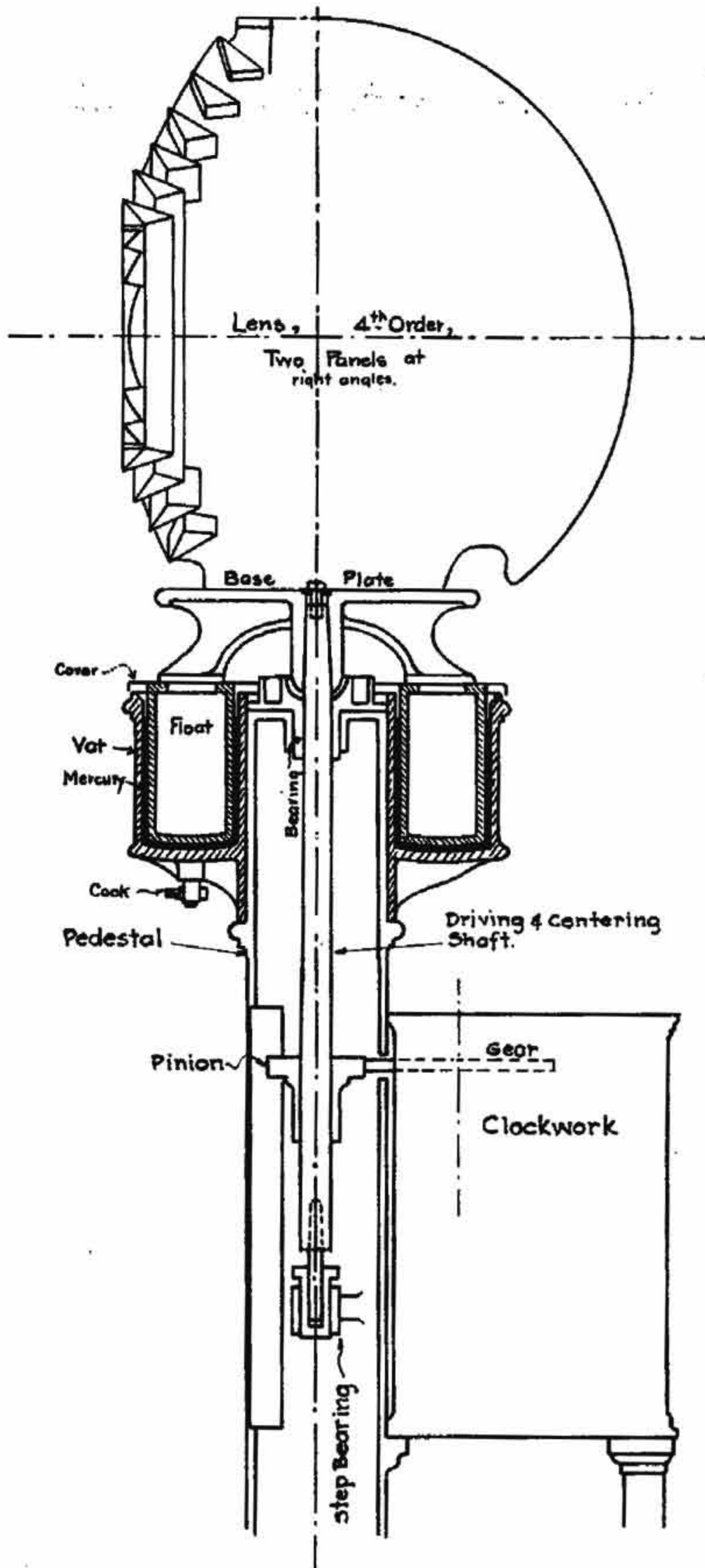


FIGURE 21-90.—Fourth order mercury float-type lens and pedestal.

(1) Drive is accomplished by gear reductions connected to the chariot through a pinion meshing to the periphery of the chariot, or to the central shaft in the case of the smaller lens support.

(2) The earlier source of drive was a weight lowered through a shaft in the tower. Speed control was accomplished by means of a revolving vane friction governor geared to the weight drum by a clock train placed in a glazed enclosure.

(3) Subsequent to electrification, many drives have been electrified by practical adaptation of conventional gear motors or geared reductions. Constant speed AC or DC motors (in many instances in duplicate) are normally used, although speed controls of various types have been applied. In view of trends which are discussed in Chapter 23, changes in lens drive shall hereafter be accomplished only after submission of work authorization requests which carefully describe the conditions of the optic as well as that of the chariot. Maintenance of the lens drive machinery is conventional for the types of apparatus involved.

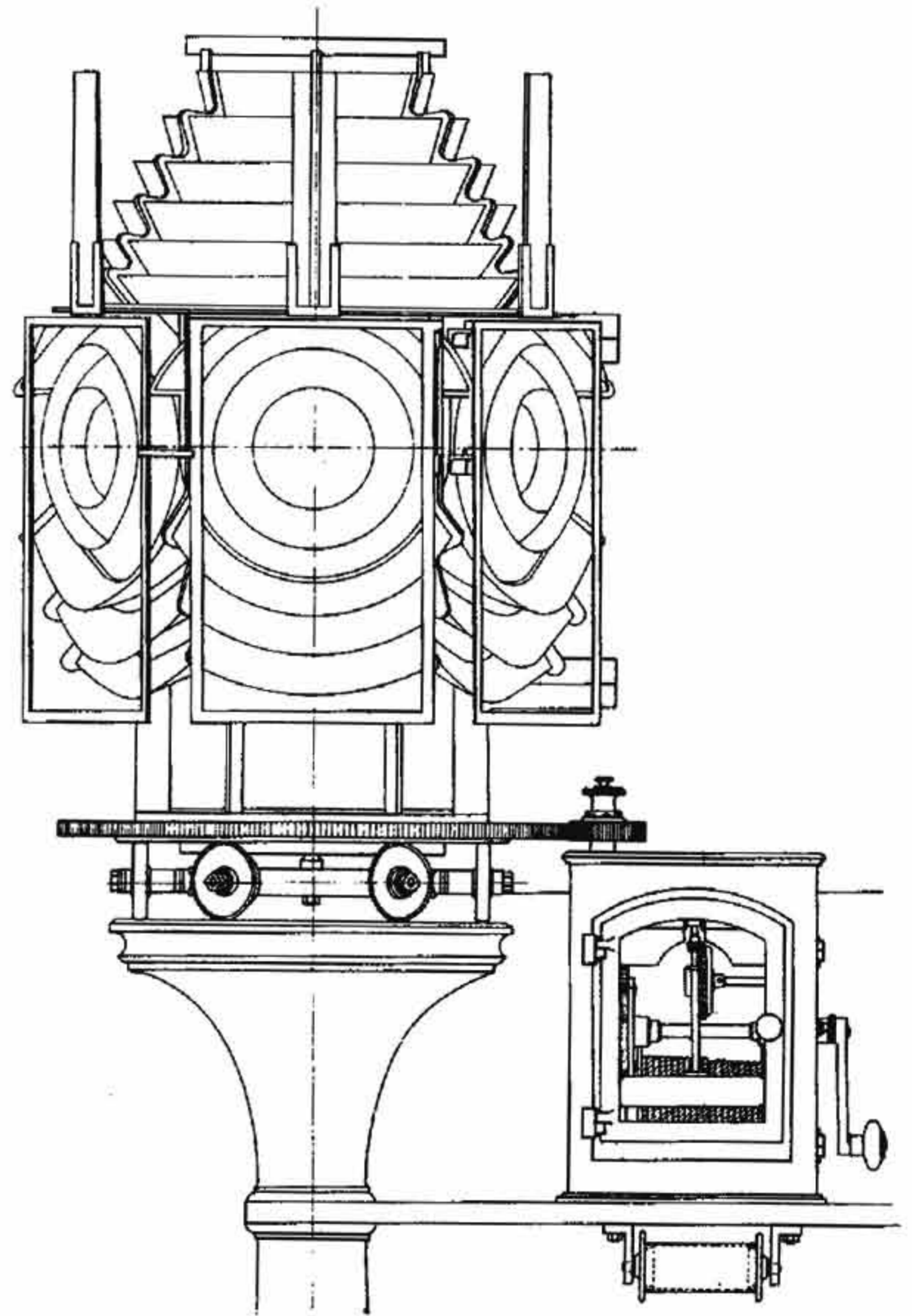


FIGURE 21-91.—Lens and chariot assembly.

21-15-35 Airways-type Revolving Beacon—

A. *Adaptation of standard units.*—In order to avail itself of standard commercial apparatus, the Service has made use of the CAA approved 36-inch airways beacon (figs. 21-92 and 21-93). This is used as manufactured for normal aeronautical use and also as modified to special double-drum, double-ended units. The special modifications provide single, double, and triple flashes. Short-long combinations are also available. The candlepower depends on the light source and spread roundels which are used. The units may be revolved at 1, 2, 3, 4½, 6, or 12 revolutions per minute.

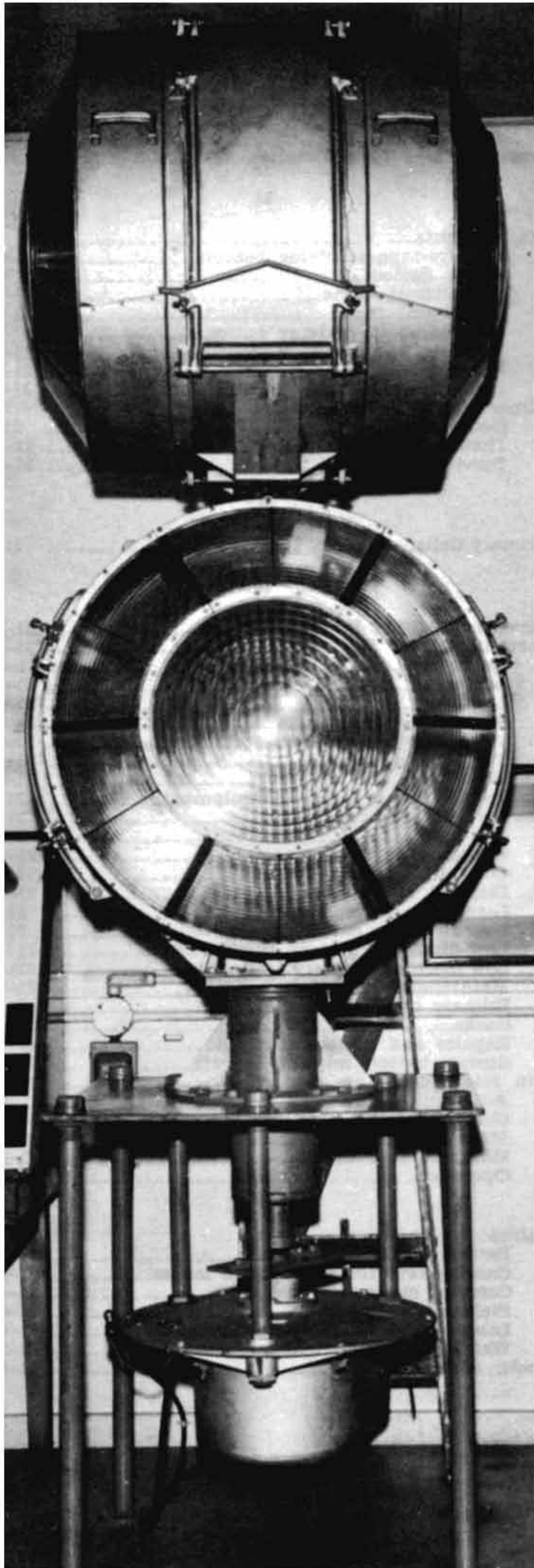


FIGURE 21-92.—36-inch double-drum revolving beacon.

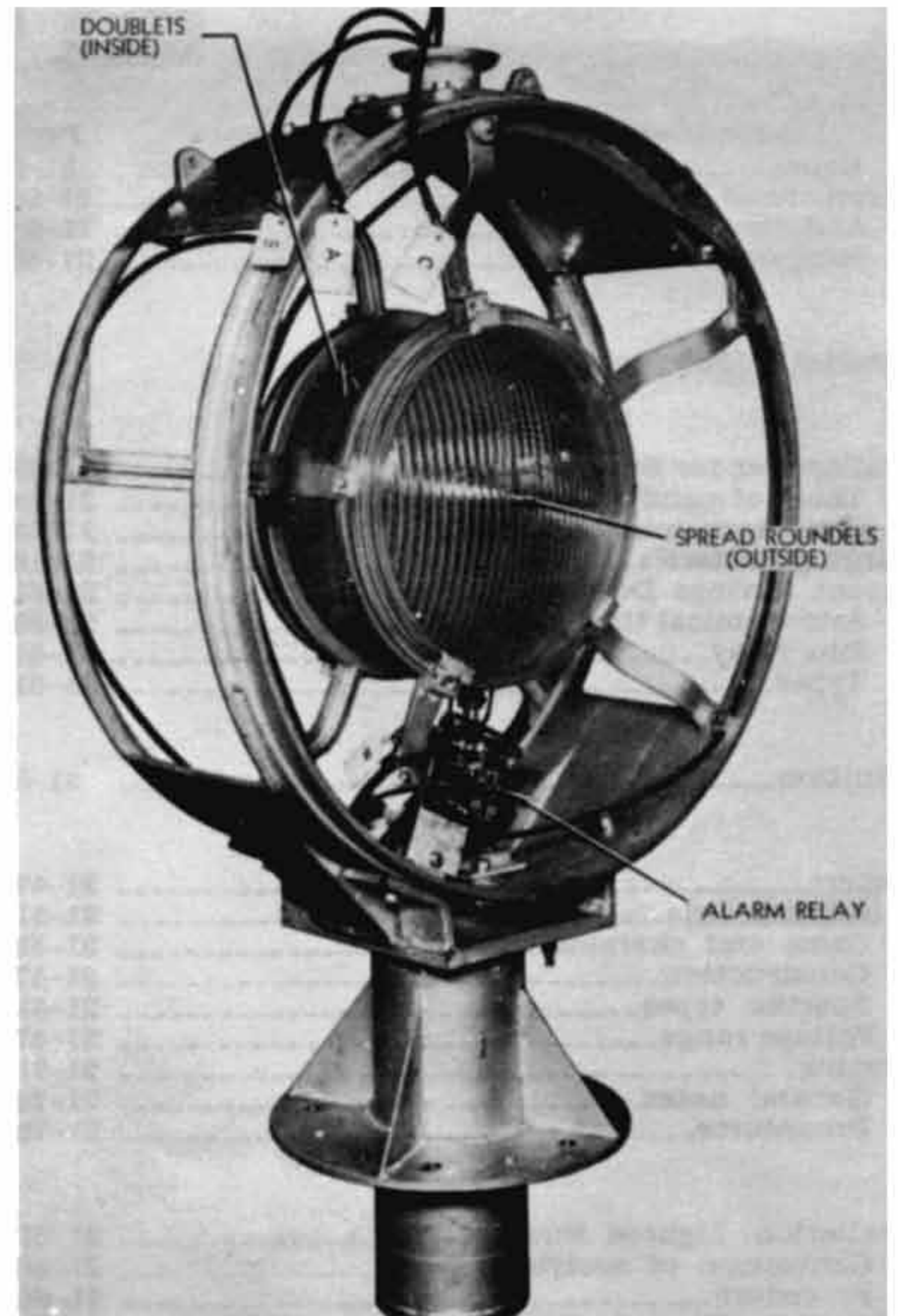


FIGURE 21-93.—36 inch revolving beacon assembly.

B. Candlepower.—Using 1000-watt C13 filament lamps (2 required) the candlepower and corresponding beam spread (to 15 percent of maximum candlepower) are as follows:

Beam spread	Candlepower
6°	1,100,000
18°	240,000
36°	140,000

The candlepower in red is about 22 percent and in green about 20 percent of the candlepowers given above. If one end of the drum is blanked off and a spherical mirror installed, the candlepower from the opposite end is increased by approximately 60 percent.

(1) *Dual utility for marine and aviation service.*—The candlepowers given in the table are the horizontal values as published for the mariner. In recognition of the dual utility of the landfall light for both the mariner and the aviator, the units, at 1¼° above the horizon, give a candlepower of approximately 25 percent higher than the values given in the table.

C. Availability.—The double drum unit is available from several manufacturers. It is weather-proof and uses parts which have been standardized and service-tested for several years on the civil airways of the United States.

D. Drive may be either direct or alternating current, and units are furnished with lampchangers and alarm units.

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