



# Delco-Remy

*U. S. Government Vehicle  
Electrical Equipment*

# HANDBOOK

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**Delco-Remy**  
**U. S. GOVERNMENT VEHICLE**  
**ELECTRICAL EQUIPMENT**  
**HANDBOOK**

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# General Instructions

## ECHELONS OF SERVICE:—

A considerable variety of electrical equipment is being used by the various branches of the armed forces. The maintenance procedures naturally vary to some extent on this equipment, due not only to the variation in equipment, but also due to the many types of service under which the equipment operates.

For this reason, the chapters in this pamphlet on the different items of electrical equipment do not break the service procedures down into echelons of service. Rather, maintenance is considered on a mileage or time basis, with the selection of the echelon of service to perform any particular operation being left up to the using arm.

Certain general rules should, however, be observed in the allocating of any service operation to a particular echelon of service. First and most important, no service operation normally beyond the training, available time or testing equipment of an echelon should be attempted by that echelon. For example, readjustment of generator regulators by first and second echelons, in general, should be discouraged.

FIRST and SECOND ECHELONS should, as a rule, function as follows in the servicing of electrical equipment:

- (1) Lubricate the generator, cranking motor, distributor, every 30 days.
- (2) Check the electrical equipment periodically.
- (3) Quick check the equipment as outlined in the chapters on the units involved when defective operation is noted so that the defective unit can be located.
- (4) Make unit replacements on the periodic maintenance schedule and when defective units are located.

Following is method of making periodic checks as called for in paragraph (2), above.

### a. BATTERY

**1. Weekly.** Test specific gravity. Replace battery if below 1.225. Add water as necessary. Test by hand, hold-down clamps, and cable connections for tightness. Tighten if necessary. Visually inspect terminals, connections, battery top for cleanliness. Clean if necessary. Any apparent defects such as loose cell covers, cracked or bulged case or cover, loose terminals, etc., requires battery replacement. Be sure vent plugs are tight.

**2. Six months.** High-discharge test battery, battery cables and connections. Install new battery if necessary. Replace cables, or clean connections and tighten cables as necessary.

### b. GENERATOR REGULATOR

- 1. Thirty days.** Check by hand the tightness of

connections and regulator mounting. Tighten if necessary. Connect meters and check the electrical settings (relay closing voltage, current regulator setting and voltage regulator setting). If the settings are not in line with specifications, the regulator should be replaced. If, however, no replacement regulator is available, either one of two actions may be taken by the mechanic:

a. He may refer the trouble to the next higher echelon for diagnosis and correction.

b. He may adjust the electrical settings himself. **BUT THIS LATTER COURSE IS DANGEROUS TO THE EQUIPMENT IF THE MECHANIC IS NOT ABSOLUTELY SURE THAT HE CAN CORRECTLY MAKE THE REQUIRED SETTINGS! WRONG ADJUSTMENTS BY MECHANICS WHO "THOUGHT" THEY KNEW HOW, HAVE DESTROYED MANY REGULATORS AND GENERATORS. NO MECHANIC SHOULD BE ALLOWED TO ADJUST REGULATORS UNLESS HE HAS BEEN TRAINED TO DO SO.**

### c. GENERATOR

**1. Thirty days.** Check visually and by hand, wiring, connections, pulley, mounting, belt, belt tension. Make necessary corrections.

**2. Six months.** Remove coverband and inspect commutator and brushes. Replace worn brushes. Clean commutator if it is only slightly dirty, gummed, or rough with number 00 sandpaper. **Do not use emery cloth.** Check generator output with meter. Replace generator if defective operation or defects are noted.

**3. Yearly—fall.** Replace generator with new, rebuilt unit.

### d. CRANKING MOTOR

**1. Thirty days.** Check visually and by hand, connections, cable mounting, operation of drive mechanism. Check operation of unit. Make necessary corrections.

**2. Six months.** Remove coverband and inspect commutator and brushes. Replace worn brushes. Clean commutator if it is only slightly dirty, burned, gummed, or rough with number 00 sandpaper. **Do not use emery cloth.** Replace cranking motor if defective operation or defects are noted.

**3. Yearly—fall.** Replace cranking motor with new, rebuilt unit.

### e. IGNITION DISTRIBUTOR

**1. Thirty days.** Remove cap and check cap, rotor, points, wiring, connections. Check centrifugal and vacuum advances by rotating cam and distributor (or breaker plate) by hand and then releasing. Clean,

replace, adjust contact points as necessary. Time. Replace distributor if defective operation or defects are noted.

2. **Six months.** Replace distributor with new, rebuilt unit. Time.

f. **IGNITION COIL AND CONDENSER**

1. **Thirty days.** Check mounting, connections, wiring, condition of case, coil head, etc. Replace if unit looks defective.

2. **Yearly—fall.** Check coil and condenser on tester.

THE HIGHER ECHELONS OF SERVICE are, of course, equipped and trained to perform major overhauls of the electrical equipment, to conduct electrical

tests of units, and make adjustments on generator output regulators and other units, and such procedures should be entrusted to them insofar as it is possible to do so.

**HANDLING OF DETACHED UNITS**

When the generator, cranking motor, distributor, regulator, battery, etc. are removed from a vehicle, some attention must be given to the proper handling of the units, if damage by careless handling is to be avoided. If coverbands have been removed, they should be reinstalled, to prevent dirt and moisture from getting into the units. So far as possible, detached units should be stored in a dry, clean place. In transporting units, some provision should be made to crate or box them, so they will not roll around on the truck, with a resulting battering or breaking of terminals, coverbands, distributor and coil caps, drive shafts, etc.



*This Handbook*

has been prepared by the

**SERVICE DEPARTMENT**

of the

**Delco-Remy Division**

in the hope that it will help—

★ *Keep 'em Rolling!*

★ *Keep 'em Sailing!*

★ *Keep 'em Flying!*



# The Storage Battery

The lead-acid storage battery is an electrochemical device for converting chemical energy into electrical energy and for converting electrical energy into chemical energy. A six-volt battery consists of three cells of two volts each, connected in series. Each cell is composed of an acid-proof compartment into which is assembled an **Element**, emersed in electrolyte (sulphuric acid and water) and protected by a hard rubber cover sealed in place with asphaltic acid-proof sealing compound.

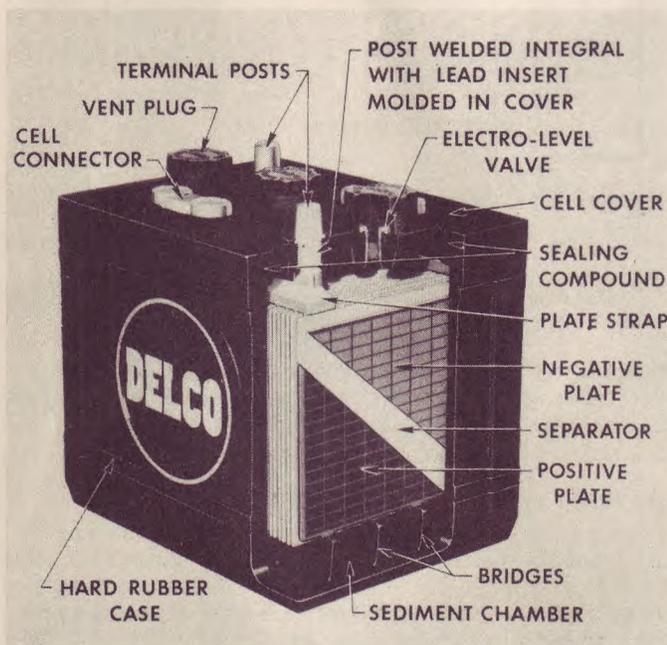


FIGURE 1-1  
Construction of a typical lead-acid storage battery

The **Element** is made up of two **Groups** of plates, **positive** and **negative**, nested together, each positive plate having a negative plate on each side of it, and all plates insulated from each other by **Separators**.

A **Group** is made by properly spacing and welding (or "lead burning") plates to a lead-antimony alloy plate strap which has a round post designed to protrude through a hole in the cell cover for a battery terminal or connector strap.

**Plates** (positive or negative) are made by applying special lead oxide pastes, which become the active material after charging, to rectangular lattice-like lead-antimony grids. The horizontal and vertical bars of the grid hold the active material of the plates into place and in addition, the grid serves to distribute the current evenly over the plate.

**Separators** may be composed of rubber, glass mat, or Port Orford cedar. Port Orford cedar has been successfully used on many batteries. The separator is smooth on one side and grooved on the other. The grooved side, placed against the positive plate, permits free circulation of the electrolyte about the positive plate where the greater part of the electrochemical activity takes place and the grooves permit normal shedding of the positives to take place. The material which sheds drops down into the sediment chambers at the bottom of the cells. On some applications where exceptional vibration or high temperatures are present, it may be desirable to use glass retainer mats in conjunction with the Port Orford cedar separators. The glass retainer mats are assembled on both sides of the positive plates and aid in holding in place the active materials of the plates. In addition, the glass retainer mats help protect the Port Orford cedar separators from abrasion and high temperatures.

A vent and filler plug screws into a threaded hole in each cell cover. (Figure 1-2.) The plug has a vent hole to permit the gas which forms in the cell to escape and one or two perforated baffle plates to break up the acid spray which accompanies the gassing, and permit it to return to the electrolyte. The baffles also prevent sloppage.

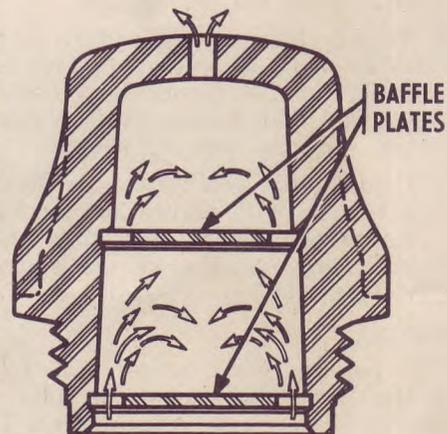


FIGURE 1-2  
Vent plug showing baffle plates

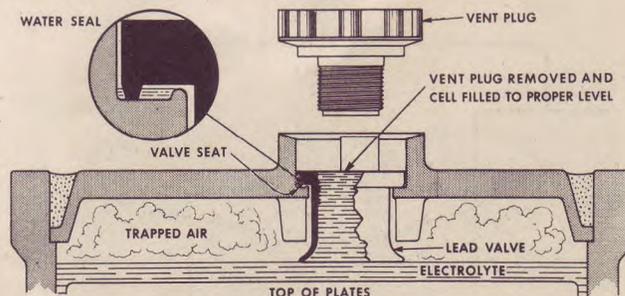


FIGURE 1-3

The **Electro-level** is a device assembled in some Delco batteries which automatically eliminates over-filling of the battery when water is added. It consists of a hollow

# BATTERY RATINGS—OPERATION—GRAVITY

lead valve with an overhanging lip which seats and seals on a valve seat in the cell cover as shown in Figure 1-3 when the vent plug is removed. This traps air as shown and prevents the addition of too much water. When the plug is replaced, it is screwed into the valve, raising it, permitting the air and gas formed in the cell to escape. An efficient baffle arrangement is provided by the valve, valve seat and vent plug. Care must be used in replacing the plug so that it is tight. Otherwise it may work loose. The valve will then drop down and cause a siphoning action which will suck the acid from the battery and spray it on the battery top and battery holder.

## BATTERY RATINGS

The amount of energy that a fully charged storage battery can deliver is dependent upon the total area and volume of active plate material and the quantity of electrolyte. There are three commonly recognized ratings for automobile batteries.

1. Twenty Hour Rate, which is based on (a) a starting temperature of 80° F.; (b) a constant current output for 20 hours; and (c) a final limiting voltage of 1.75 volts per cell. For example, assume that a battery delivers 4.3 amperes for 20 hours; this battery would be rated at 86 ampere hour capacity (20x4.3). The Twenty Hour Rate is the one commonly used in advertising battery capacity.
2. Twenty Minute Rate, which is the discharge rate in amperes at which a battery may be discharged for 20 minutes before the voltage drops to 1.6 volts per cell. This rating gives an indication of the battery's normal starting ability.
3. Cold Rating, which indicates the number of minutes a battery will deliver 300 amperes at 0° F. before its voltage drops to 1.0 volts per cell. This rating gives an indication of the battery's cold weather starting ability.

## OPERATION

The positive plate active material is lead-peroxide ( $PbO_2$ ), chocolate brown in color, and the negative plate active material is spongy lead ( $Pb$ ), grey in color. The electrolyte consists of 39.2% sulphuric acid and 60.8% water (1.300 gravity) when the battery is in a charged condition. (These percentages are by weight.)

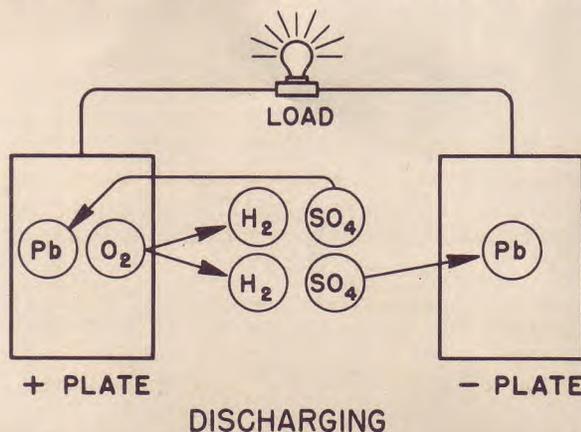


FIGURE 1-4

Chemical activities in battery—battery discharging

When connected into an electrical circuit the battery delivers current. This current is derived from chemical reactions between the sulphuric acid ( $H_2SO_4$ ) and active materials of the plates, during which lead sulphate ( $PbSO_4$ ) is formed at both plates, and the acid is replaced by water ( $H_2O$ ) in the electrolyte. The battery is "discharged" when there is not enough sulphuric acid left in the electrolyte for effective chemical action and the active materials in the plates have been mostly converted into lead sulphate. See Figure 1-4. When current is forced back into the battery to re-

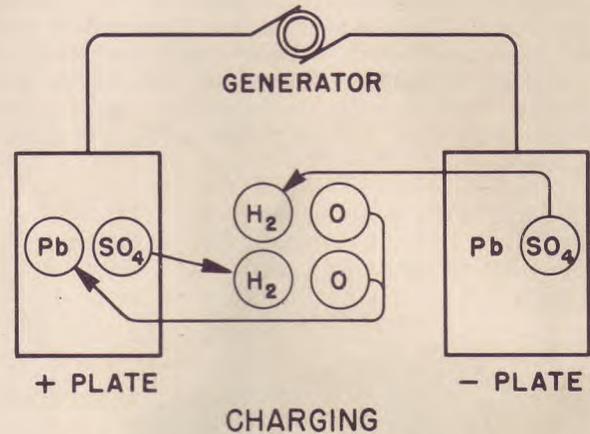


FIGURE 1-5

Chemical activities in battery—battery being charged

charge it, the chemical actions are reversed so the positive plate again becomes lead peroxide, the negative plate spongy lead, and the sulphuric acid reappears in the electrolyte, replacing water. See Figure 1-5.

## BATTERY SPECIFIC GRAVITY

To determine how much additional current is still available from the battery, it is necessary to determine the percentage of acid in the electrolyte, as this percentage varies with the state of battery charge. Since the specific gravity of sulphuric acid is 1.835 and water is 1.000, the percentage of acid may be determined by checking the electrolyte specific gravity with a hydrometer. (Figure 1-6.) It is not necessary to actually determine the percentage of acid, since the following specific gravities at 60° F. can be taken as a measure of the state of charge of the battery:

- 1.275 - 1.300 = fully charged battery
- 1.245 - 1.270 = three-fourths charged
- 1.215 - 1.240 = one-half charged
- 1.180 - 1.210 = one-fourth charged
- 1.150 - 1.175 = barely operative
- 1.120 - 1.145 = completely discharged

Since specific gravity varies not only with the percentage of acid, but also with temperature (increasing temperature lowers gravity, while decreasing temperature raises gravity) it is necessary to correct for temperature to determine accurately the condition of charge of the battery. While other standards are in use (70° F. and 80° F.), Delco batteries should be corrected to the 60° F. standard. For every ten degrees electrolyte temperature above 60° F. add four points to the gravity

# BATTERY CHARACTERISTICS—SELF-DISCHARGE

reading. For every ten degrees below 60°F. subtract four points from the gravity reading. Examples:

- 1.250 at 100°F. Add 16 points. Corrected reading is 1.266.
- 1.230 at 0°F. Subtract 24 points. Corrected reading is 1.206.

It is not necessary to make temperature corrections if only an approximate idea of the condition of charge is desired or if the temperature is not too far away from the 60°F. standard.

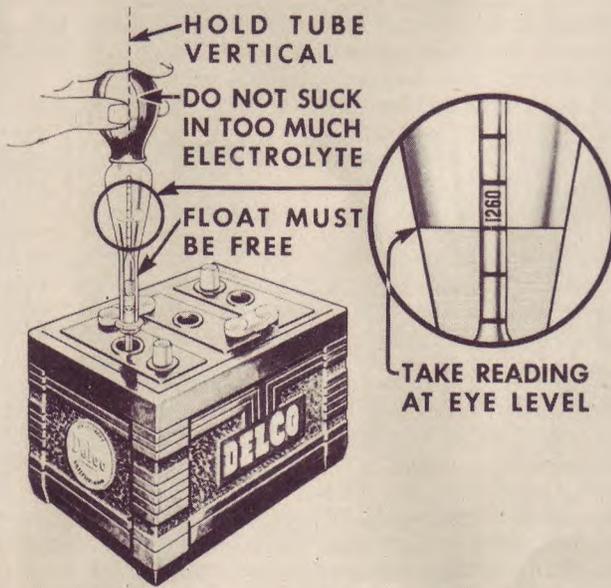


FIGURE 1-6  
Taking hydrometer reading

The above gravity readings are for relatively new batteries. Older batteries, because of acid loss due to gassing and shedding of sulphated material from the plates, will have a lower top gravity, so that a battery with an original top gravity of 1.295, for example, may drop to 1.250 - 1.275 top gravity after 18 to 24 months in service.

## TORRID CLIMATE BATTERY GRAVITY

Batteries operating in hot or torrid climates should have a weaker electrolyte than for temperate climates. Instead of 1.300 gravity the electrolyte should be adjusted to around 1.230 (corresponding to 31.0% sulphuric acid) for a fully charged battery. This will prolong the life of the negative plates and the separators as well as reduce the amount of self-discharge. On discharge the gravity could go as low as 1.075 (11.0% sulphuric acid) before the battery ceases to function effectively. Where freezing conditions do not prevail, there is no danger with gravities from 1.230 to 1.075.

## BATTERY CHARACTERISTICS

The terminal voltage of a battery may vary considerably according to whether it is being charged or discharged, what the charge or discharge rate is, and

temperature and gravity. These may be summed up as follows:

1. Terminal voltage (battery being **charged**) increases with:
  - a. Increasing charging rate.
  - b. Increasing specific gravity.
  - c. Decreasing temperature.
2. Terminal voltage (battery being **discharged**) decreases with:
  - a. Increasing discharge rate.
  - b. Decreasing specific gravity.
  - c. Decreasing temperature.

Inasmuch as the battery terminal voltage plays an important part in generator output regulation and determines the efficiency of operation of all the electrical units in the system, it is desirable to keep in mind the above battery characteristics in any study of the electrical system.

## SELF-DISCHARGE

The chemical action in the battery continues even when the battery is not in operation and causes the battery to "self-discharge." Self-discharge varies according to battery gravity and temperature. See Figure 1-7. Older batteries, and batteries into which impurities have been introduced by using impure water, will self-discharge more rapidly.

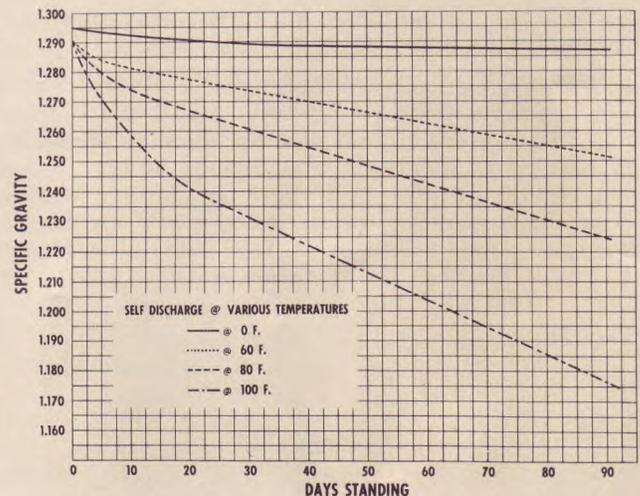


FIGURE 1-7  
Chart showing self-discharge

## FREEZING POINT

Care must be taken to keep the battery specific gravity high enough to avoid freezing. The higher the gravity, the lower the temperature required to freeze the electrolyte:

Gravity	Freezing Temperature	Gravity	Freezing Temperature
1.100	18°F	1.220	-31°F
1.160	1	1.260	-75
1.200	-17	1.300	-95

Consequently, a battery should never be left out in cold weather after it has become discharged as, for example, in attempting to start an engine.

# CARE OF BATTERY IN STORAGE—ON VEHICLE

## CARE OF BATTERIES IN STORAGE

Since batteries are a perishable item, they must receive care in storage to avoid being damaged. To keep stored batteries in a satisfactory state of charge, they should be recharged or "boosted" every 30 days if possible, at a rate of one ampere per positive plate per cell. A 17 plate battery, for example, should be charged at a rate of 8 amperes. This is important because the lead sulphate which forms in the plates due to self-discharge is especially hard to break down and a sulphated battery which has been allowed to stand for a period of time may be ruined. While the battery should be protected from freezing, it is also important not to store it in too warm a place, since this increases the rate of self-discharge.

Batteries should not be stacked one on top of another without some provision for supporting the weight of the upper batteries. Otherwise, the weight, acting through the terminal posts, may collapse the plate assemblies of the lower batteries.

## MAINTENANCE OF BATTERY ON VEHICLE

**Week**—The battery gravity should be checked at least once a week with a hydrometer, and some record of the battery condition kept. This provides a running record of battery performance, useful in detecting and correcting troubles which might otherwise cause damage to the battery or other electrical equipment. Various conditions which may be found and their corrections are discussed below.

Be sure the plugs are replaced tightly, otherwise they may work loose. On the type battery with the Electro-level, this is especially important, since a loose plug may allow the Electro-level valve to pump up and down, siphoning the electrolyte from the battery. Where the vehicle operates under dusty conditions, make sure that the hole in the vent plug is not stopped up as this could create a pressure in the battery which might damage it.

**1. Overcharging**, indicated by an excessive use of water, may cause the electrolyte level to drop below the plates unless water is added frequently. Plates exposed to the air dry out, sulphate, and lose their ability to take a charge. The remainder of the plate area, in concentrated acid solution, may fail rapidly not only because of the strong acid, but also because it is worked doubly hard. Separators exposed to the air dry out, crack, and eventually permit a short circuit to develop between plates. The remainder of the separator area which is emersed in the electrolyte may become charred due to its being subjected to the concentrated acid. Even though water is added frequently so the above conditions are avoided, battery overcharge will still damage the battery, since it causes the active material in the plates to loosen and shed. Excessive temperatures may develop which tend to cause buckling and consequent short circuiting of the plates, and charring of the separators. Therefore, in addition to adding water, the generator and regulator must be checked and adjusted so battery overcharge is eliminated.

**2. Undercharging**, indicated by consistently low gravity readings, will result in sulphation of the plates,

eventually to a point where they will be rendered useless so that the battery may be ruined. This condition results from (a) too low a generator output, (b) a low regulator voltage setting, (c) poor connections or defective wiring in the generator-to-battery circuit, (d) permitting the battery to remain idle without periodic "boosting" charges so that it self-discharges, or (e) excessive load demands on the battery. These conditions must all be checked for and the proper corrections made where necessary.

**3. Cell readings more than 25 specific gravity points** apart indicates (a) partial short in low cell, (b) loss of acid from leak or spraying in low cell, or (c) excessive water evaporation in high cells. With this condition, the battery should be removed, fully charged and subjected to a high discharge test. If cell voltages are within 0.2 volt and the gravity readings are still more than 25 points apart, readjust the acid. If the cell voltages are more than 0.2 volt apart, the battery must be replaced or rebuilt.

**4. Cracked case** results from (a) the battery being too loose in its holder, (b) hold-down clamps being drawn down too tightly, (c) battery being frozen, or (d) damage by flying stones.

**5. Bulged case** results from (a) excessively high temperatures due to overcharge and climatic conditions or (b) hold-down clamps being drawn down too tightly.

**30 Days or 1,000 Miles**—Check battery terminal connections and cables. Clean battery top. It is essential that the top of the battery be kept clean.

**6 Months or 6,000 Miles**—Since the hydrometer check of the battery gravity discloses **only** the chemical condition of the battery, it is desirable to subject the battery to a high discharge test periodically to determine its ability to deliver current under load. The battery gravity must be above 1.225 for this test since a battery with a lower gravity reading will not test satisfactorily under high discharge. A high discharge tester may be used when available. Or a low reading voltmeter may be used to check each cell while the cranking motor is cranking the engine with the ignition switch off or the high tension lead removed. **Caution:** Do not operate cranking motor for more than 30 seconds at any one time. If the voltage of any cell falls below 1.5 volts at 80°F., or if there is a difference of more than 0.2 volt between cells, battery trouble is indicated. At temperatures below 80°F., the cell voltages will normally drop to lower values, due to the low efficiency of the battery, as well as the greater current draw resulting from higher required cranking torques, until at sub-freezing temperatures, the voltage will approach the 300 ampere at 0°F. rating of the battery. (See Cold Rating, above.)

Defective battery connections or cables may be found by using a low reading voltmeter and with the cranking motor cranking the engine, checking (a) between the grounded battery terminal and the vehicle frame, (b) between the ungrounded battery terminal and the cranking motor terminal stud and (c) between the cranking motor housing and the vehicle frame. If the

# CHARGING BATTERIES

voltmeter reads more than 0.2 volt on any of these tests, there is excessive resistance in the circuit under test. The cable should be removed, the terminal and cable clamp cleaned and the cable replaced. New cable should be used if the old is frayed, corroded badly or has broken strands. Covering the terminal and cable clamp with a coating of petroleum jelly will retard corrosion.

## CLEANING BATTERY HOLDER

If the battery holder has become corroded, it may be cleaned after the battery has been removed with a wire brush and an ammonia or bicarbonate of soda solution. Painting the holder with acid-proof paint will protect it.

## PUTTING BATTERY BACK IN VEHICLE

Care must be exercised to make sure the battery is put back into the vehicle correctly with respect to polarity. The positive terminal of the battery is larger than the negative terminal to reduce the possibility of error. As an added check, the lights may be turned on after the battery has been connected. If the dash ammeter indicates **charge**, the battery has been put in backwards. If the ammeter indicates **discharge**, the battery has been connected correctly with respect to polarity.

## CHARGING OF BATTERIES ON LINE

When a battery requires charging on the line, it should be supplied with a charging rate of one ampere per positive plate per cell. For example, a 15 plate per cell battery should be charged at a 7.0 ampere rate, and the charge should be continued for 2 hours after the gravity and terminal voltage shows no further rise. Never permit the electrolyte temperature to rise above 110°F.

## CHARGED DRY BATTERIES

Some batteries for government applications are shipped without electrolyte, with dried "formed" (or charged) plates and dry separators. There is a tag on such batteries giving the details of the procedure for putting these batteries into service. Until such time as the batteries are made "wet" by adding electrolyte, it is absolutely necessary that the sealing devices (either a soft rubber disc under the vent plug or a sealing plug in the vent opening) be left in place. The battery must not be unsealed until just before the electrolyte is added and the battery is put into use.

The strength of the electrolyte to be added varies according to the climate in which the battery is to be used. For temperate climates the electrolyte should be 1.280 specific gravity. For tropical or torrid climates (where freezing temperatures never occur) the electrolyte should be only 1.210 specific gravity. 1.280 gravity electrolyte is made by mixing one part by volume of sulphuric acid with 2.75 parts by volume of distilled water. 1.210 gravity electrolyte is made by mixing one part by volume of sulphuric acid with 4.2 parts by volume of distilled water. Distilled water, while not absolutely essential, should be used where possible, since undistilled or impure water introduces impurities which increase self-discharge rate and shorten battery life.

Prepare battery for service as follows:

1. Remove the vent plugs and destroy the sealing devices. If the battery has the Electro-Level, lift the lead valve and turn clockwise until valve rests on shoulder in the cover. Fill each cell with electrolyte  $\frac{1}{4}$  to  $\frac{3}{8}$  inch above the separators.
2. Wait 5 minutes and then fill each cell again with electrolyte to same height above separators.
3. Allow battery to stand for 2 hours.
4. Fill each cell again, if necessary, to bring electrolyte level up  $\frac{1}{4}$  to  $\frac{3}{8}$  inch above separators.
5. The battery is now ready for service. If charging facilities are available, a charge at approximately 6 amperes until the specific gravity and counter-voltage become constant (about 16 hours) will improve the initial capacity.

## PREPARING ELECTROLYTE

**CAUTION:** Use the following precautions when preparing electrolyte.

- a. Use glass, china, earthenware, rubber or lead vessels only. Never use a metallic vessel other than lead.
- b. Carefully and slowly pour the acid into the water. **Never pour water into the acid**, as this will cause an explosion which will throw the acid considerable distances, so that any one standing near might be seriously injured. **BE CAREFUL!**
- c. Stir thoroughly with a wooden paddle and allow it to cool before taking hydrometer reading.
- d. Cool to a temperature below 90°F. (but not below 60°F.) before using.

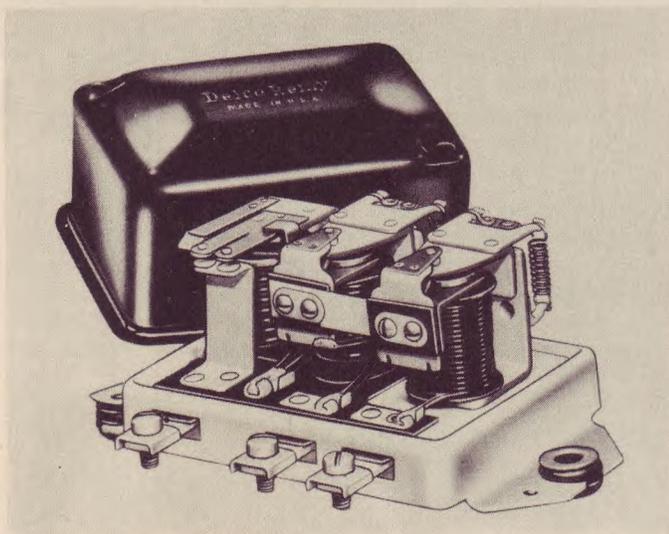
## BATTERIES

Model	Normal Chg. Rate	20 Hr. Rate	20 Min. Dischg. Rate	No. of Min. 300 Amps. at 0°F.	5 Sec. Voltage 300 Amps. at 0°F.	OVER-ALL DIMENSIONS		
						Length	Width	Height
15AA-3	7.0	100	120	3.6	4.2	9"	7"	8-5/8"
15X-3	7.0	100	120	3.6	4.2	9"	7"	8-5/8"
17K-3	8.0	115	137	4.3	4.4	10-3/8"	7"	8-11/16"
19C-1	10.4	155	175	6.5	4.7	13-1/16"	7"	9-5/32"
19Q-3	9.0	125	145	5.0	4.5	10-3/8"	7"	8-11/16"
12025A-1	12.0	180	210	8.5	*	20-3/8"	10-15/16"	9-11/16"

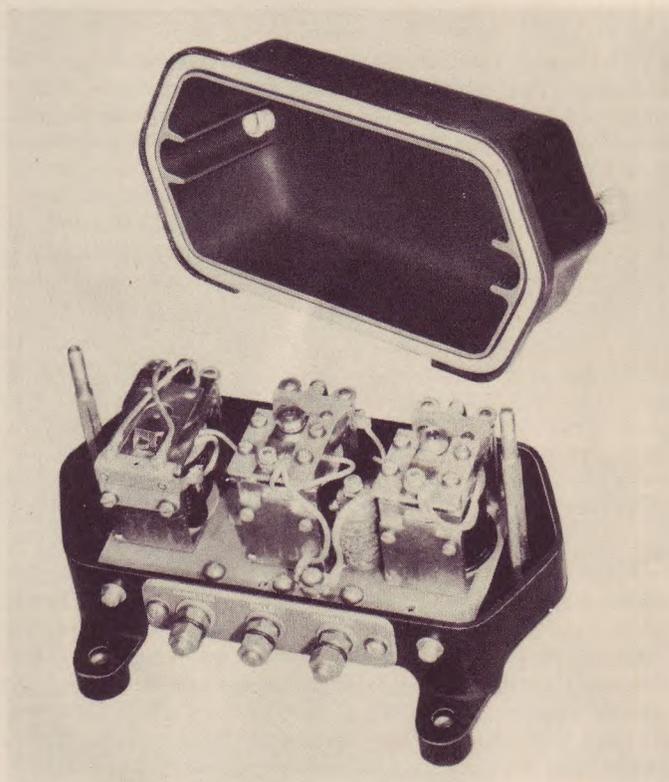
\*4 Hr. Rate—138

# Regulators and Step-Voltage Controls

Most late generator output control devices may be divided into two classifications, step-voltage controls, and current and voltage regulators. Current and voltage regulators may be divided into two types, the standard-duty type shown in Figure 2-1, which is set on closed circuit, and the heavy-duty type shown in Figure 2-2, in which the voltage regulator unit is set on open circuit.



**FIGURE 2-1**  
Current and voltage regulator. (Type set on closed circuit.)



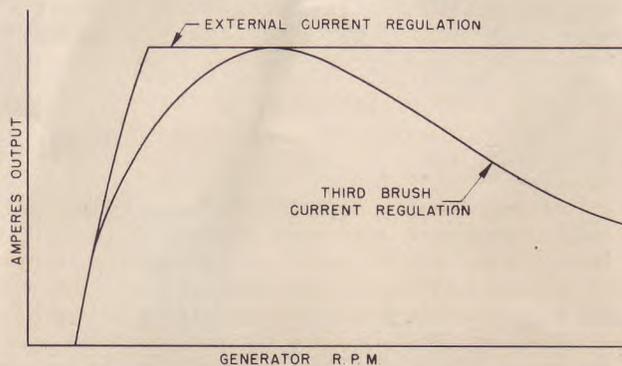
**FIGURE 2-2**  
Current and voltage regulator. (Type set on open circuit.)

## NEED FOR REGULATORS

Years ago only a small output generator was required because the electrical demands of the vehicle were small and the third brush generator met all requirements. The third brush generator limits its maximum output by utilizing a phenomenon known as "armature reaction" and the maximum output is easily adjusted by adjusting the third brush.

However, as more electrical equipment came into use on the vehicle, generator output had to be increased. This sometimes tended to produce battery overcharge and high voltage in the electrical system, particularly during long trips. The step-voltage control was introduced to combat this tendency. Then, due to the fact that the third brush generator has a relatively late cut-in and slow build-up, as well as the characteristic of tapering off in output at higher speeds, a straight shunt generator was adopted and is now in general use. The shunt generator cuts in and reaches its maximum (as determined by the setting of the current regulator) at lower speeds and does not taper off at higher speeds. (Figure 2-3.)

Three separate magnetic switches must be used with the shunt generator in order to provide complete control at all times. These are (1) the cut-out relay, (2) the voltage regulator, and (3) the current regulator.



**FIGURE 2-3**  
Third brush and shunt generator output curves

# THEORY OF REGULATION

**The Cut-Out Relay** closes the circuit between the generator and the battery when the generator voltage has built up to a value sufficient to force a charge into the battery. The cut-out relay opens the circuit when the generator slows or stops and current begins to flow back from the battery into the generator.

**The Voltage Regulator** prevents the line voltage from exceeding a predetermined value and thus protects the battery and other electrical units in the system from high voltage. As will be remembered from the chapter on batteries, one characteristic of batteries is that as either the specific gravity or the charging rate increases, other conditions being the same, the battery terminal voltage increases. If the terminal voltage is held constant as the battery comes up to charge (specific gravity increases) the charging rate will be reduced. The voltage regulator performs this job of holding the voltage constant and it consequently protects the electrical system from high voltage and the battery from overcharge.

**The Current Regulator** limits the generator output to a safe value. It is, in effect, a current limiting device which operates when the generator output has increased to its safe maximum and prevents the generator from exceeding this value.

## THEORY OF REGULATION

The discussion which follows is based on the type regulator illustrated in Figure 2-1. The heavy-duty regulator, Figure 2-2, is discussed in the latter part of the chapter, and the differences between the two types explained. Both operate on the same principles.

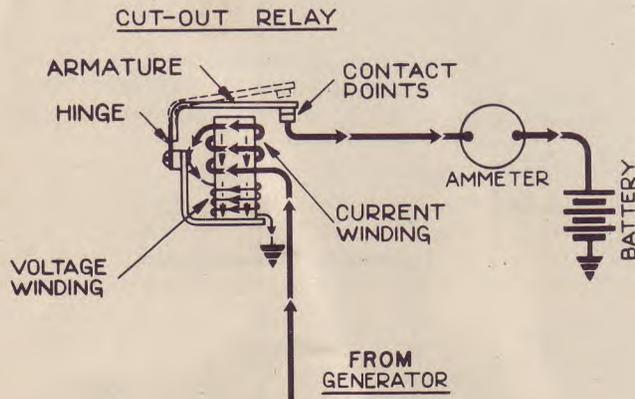


FIGURE 2-4  
Cut-out relay wiring circuit

**The Cut-Out Relay** (Figure 2-4) has two windings assembled on a core, a current winding of a few turns of heavy wire which carries full generator output, and a voltage winding of many turns of very fine wire which is connected across the generator so that full generator voltage is impressed upon it at all times. Above the winding core is a flat armature which carries a contact point. When the generator is not operating, the armature is held away from the windings by spring tension. When the generator begins to operate,

voltage builds up which forces current through the relay windings. This creates a magnetic field in the winding core. When the voltage reaches the value for which the relay is set, the magnetism is strong enough to overcome the armature spring tension and the armature is pulled toward the core. The contact point on the armature makes contact with the stationary point, closing the circuit between the generator and battery. Current flows to the battery, passing through the current winding of the relay in the right direction to add to the magnetism of the voltage winding in holding the points closed.

When the generator slows sufficiently or stops, current begins to flow from the battery to the generator. This reverses the direction of the current flow in the relay current winding and consequently its magnetic field is reversed. The magnetic field of the voltage winding is always in the same direction. Therefore, the magnetic fields of the two windings now buck each other and the resultant magnetic field is no longer strong enough to hold the points closed, the armature spring tension pulls the armature away from the winding core and the points separate, breaking the circuit between the battery and generator.

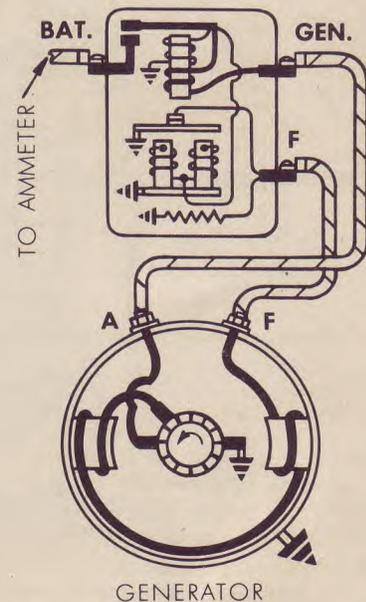
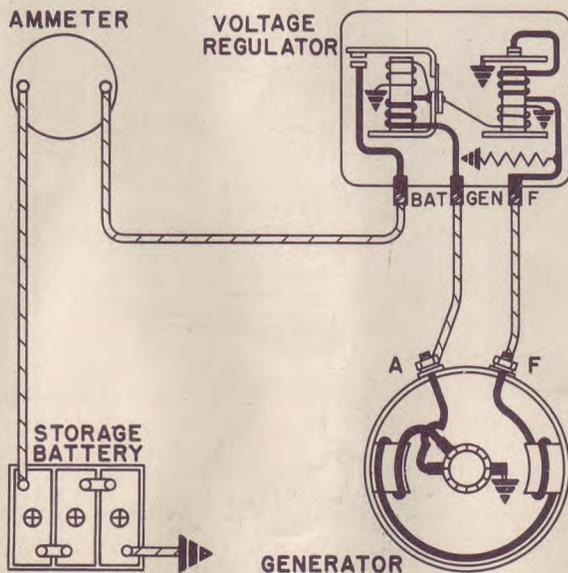


FIGURE 2-5  
Wiring circuit of step-voltage control

**The Step-Voltage Control** (Figure 2-5) contains a cut-out relay and the step-voltage control unit. The step-voltage control unit is a magnetic switch which operates much like the cut-out relay. It has two windings which are connected across the generator so that generator voltage is impressed on them. Above the windings there is a flat steel armature with a contact point on it. This point is held against a stationary contact point by the tension of a spiral spring hooked to the armature. In this position the generator field circuit is connected directly to ground, so that the generator can produce

## THEORY OF REGULATION

full output. Full generator output to the battery causes the battery to increase in charge, and this causes an increase in battery and line voltage. This in turn increases the magnetic pull of the step-voltage control windings. When the voltage reaches the value for which the step-voltage control is set, the magnetic field is strong enough to overcome the spiral spring tension holding the points closed. The armature is pulled down toward the winding core, the points open. This inserts resistance into the generator field circuit, so that generator output is reduced. The points remain open, and generator output remains at a low value so long as conditions of operation remain unchanged. But as soon as the battery becomes partly discharged or an electrical load is added to the line so that the line voltage is reduced, the magnetic strength is reduced so much that the armature is pulled away from the winding core by the spiral spring tension, the points close, the generator field becomes directly grounded, and the generator output increases to full value as determined by generator speed and line voltage. There are, in effect, two generators, a full output generator when the battery and line voltage are low, and a low output generator when the battery is in a full state of charge and there is little or no connected electrical load.



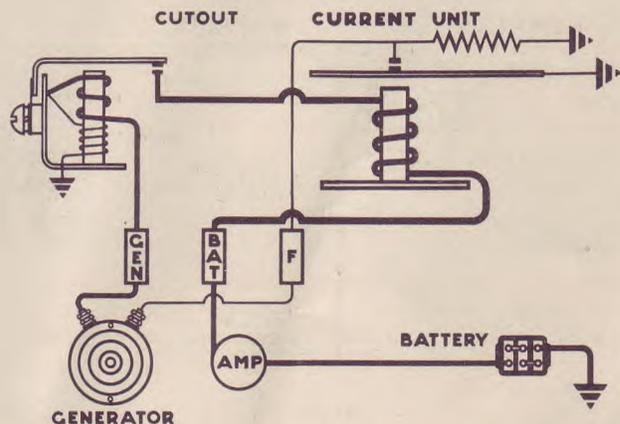
**FIGURE 2-6**  
Voltage regulator wiring circuit

**The Voltage Regulator** (Figure 2-6) is also a magnetic switch with two windings, a voltage winding of many turns of very fine wire which is connected across the circuit so that line voltage is impressed on it at all times and a current winding of a few turns of heavy wire which carries the generator field current directly to ground when the regulator contact points are closed. Above the core upon which these windings are assembled is a pair of points, normally held closed by spring tension. The lower point is mounted on a flat armature held in position by the spring tension. As the battery approaches a charged condition, the battery terminal and line voltage increase and they will continue to increase so long as the charging rate is not reduced.

However, when the voltage reaches the value for which the voltage regulator is set, the magnetism of the voltage winding, plus the magnetism of the current winding, have increased to a value sufficient to overcome the armature spring tension. The armature is pulled toward the core and the points separate.

When the points separate, the field current has to go to ground through a resistance. In other words a resistance has been inserted into the generator field circuit and this means the generator field current and consequently the generator voltage and therefore the generator output are reduced. But as soon as the field current stops flowing through the current winding in the regulator, the magnetism of this winding collapses. In addition, the reduced generator voltage results in a weakening of the magnetism of the regulator voltage winding. The result is that the total magnetism is no longer sufficient to hold the armature down and the points open. They therefore close and directly ground the generator field once more. Magnetism is again produced in the regulator current winding, the magnetism of the voltage winding increases due to increasing line voltage until the points once more open. This complete cycle takes place 50 to 200 times a second, and the generator voltage is held at the correct value to prevent high voltage in the system and battery overcharge.

As the battery specific gravity continues to increase, the voltage regulator, by maintaining a constant voltage, continues to further reduce the generator output. When the battery has reached a fully charged condition, the regulator will have reduced the charging rate to a few amperes, depending upon battery temperature.



**FIGURE 2-7**  
Current regulator wiring circuit

**The Current Regulator** (Figure 2-7) is constructed in much the same manner as the voltage regulator, with the exception that the current regulator has but one winding which is composed of a few turns of heavy wire through which the total generator output flows at all times. When, due to generator speed, condition of the battery and load demands, the generator output increases to the value for which the current regulator

# STEP-VOLTAGE CONTROL MAINTENANCE

is set, the magnetism of the current winding is sufficient to separate the points. This inserts resistance into the generator field circuit and the generator output is reduced. This reduces the magnetic strength of the current regulator winding and the points close to directly ground the field and permit increased generator output once again. This complete cycle takes place 50 to 200 times a second and limits the generator output to the value for which the regulator is set.

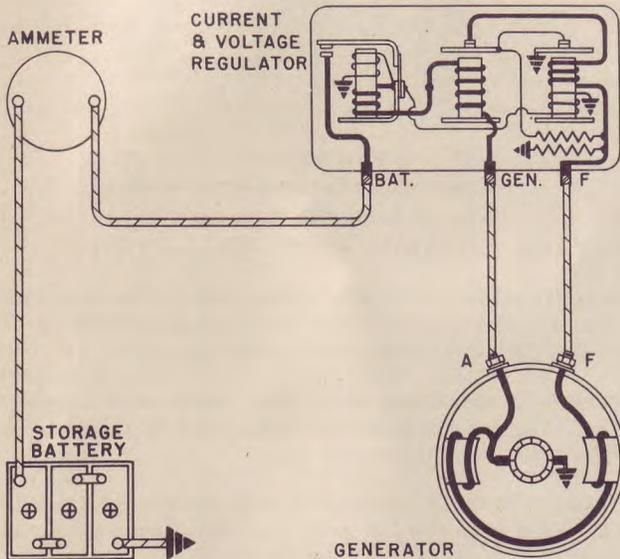


FIGURE 2-8

Current and voltage regulator wiring circuit. (Standard type.)

When the current and voltage regulator (Figure 2-8) are used together to control the generator output, either the current regulator or the voltage regulator operates at any one time, both never operate at the same time. If the electrical load requirements are large and the battery is low, the current regulator will operate to prevent the generator output from exceeding its safe maximum; the voltage is not sufficient to cause the voltage regulator to operate. However, if the electrical load is reduced, or the battery specific gravity increases sufficiently, the line voltage will increase to a value sufficient to cause the voltage regulator to operate.

When this happens, the generator output begins to taper off and it falls below the value required to operate the current regulator. The current regulator, therefore, stops operating; all regulation is dependent upon the voltage regulator.

Two resistances are in use on many current and voltage regulators. They are connected in parallel into the generator field circuit when the current regulator points open to give a lower value of resistance. When the voltage regulator points open, only one resistance is inserted into the generator field; this provides a higher value of resistance. The reason for this is that the voltage regulator must employ a higher value resistance than the current regulator; it requires more resistance in the generator field to reduce the output of the generator to a low value than to merely prevent the output from increasing beyond the safe maximum of the generator.

## STEP-VOLTAGE CONTROL MAINTENANCE

### 30 DAYS OR 1,000 MILES

The cut-out relay and step-voltage control settings should be checked as explained below. Check the step-voltage mounting and lead connections to make sure they are tight. The cover must be assembled tightly and the rubber gasket must be in place between the cover and the step-voltage control base.

To check the closing voltage of the cut-out relay, connect a voltmeter between the GEN terminal and the

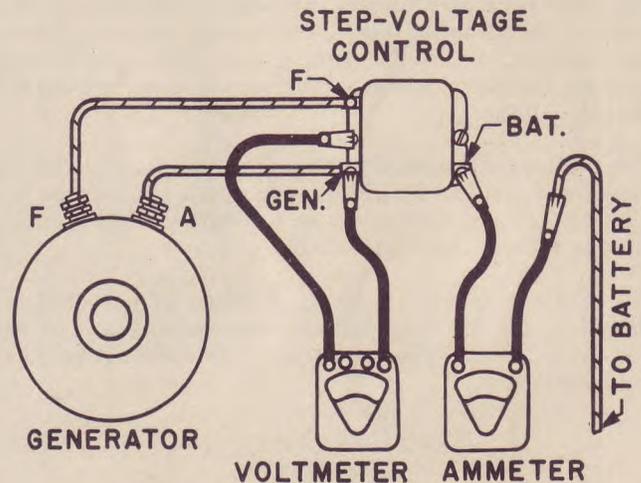


FIGURE 2-9

Meter connections to check closing voltage of cut-out relay

voltage control base as shown in Figure 2-9. Slowly increase generator speed and note the voltage at which the relay points close.

To check the operating voltages of the step-voltage control, connect voltmeter and variable resistance as shown in Figure 2-10, gradually increase engine speed

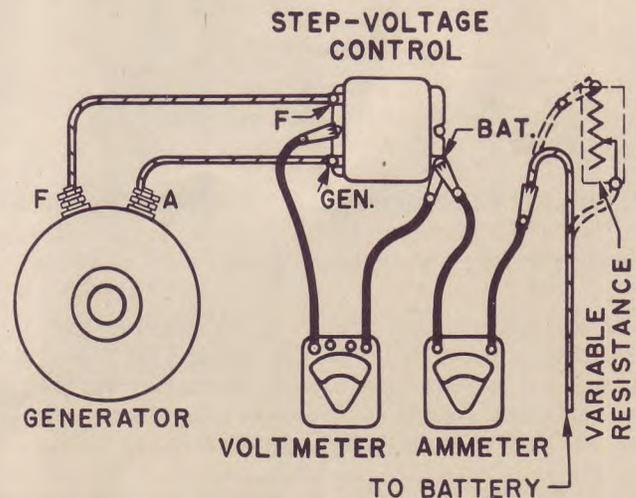


FIGURE 2-10

Meter and resistance connections to check operating voltages of step-voltage control. Ammeter for checking generator output.

## STEP-VOLTAGE CONTROL MAINTENANCE

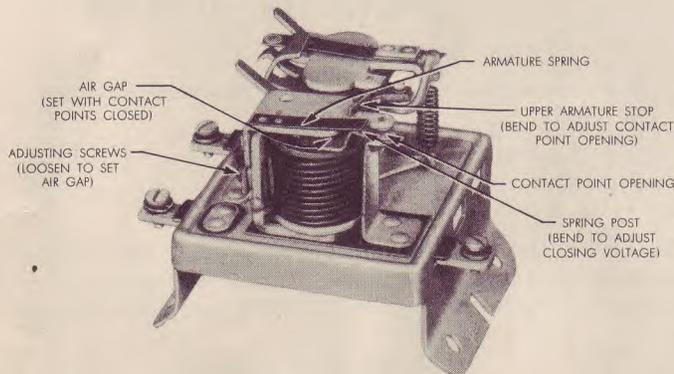
and note the voltage at which the voltage control points open. Decrease speed and note voltage at which the points close. **VOLTAGE CONTROL MUST BE AT OPERATING TEMPERATURE AND COVER MUST BE IN PLACE.** If the battery is in a low state of charge, the voltage will not increase sufficiently to cause the unit to operate. To obtain sufficient voltage under this condition, with the generator operating at medium speed, cut in resistance until the voltage control points open. Then cut out resistance until they close.

### VOLTAGE CONTROL ADJUSTMENT (On Vehicle)

**The Cut-Out Relay Closing Voltage** is adjusted (Figure 2-11) by bending up on the flat spring post to increase the tension of the flat spring and raise the closing voltage. Bending down on the spring post lowers the closing voltage.

**The Voltage Control Opening Voltage** is adjusted by bending the spiral spring hanger down to increase the opening voltage setting or up to decrease the opening voltage setting. See Figure 2-12.

**The Voltage Control Closing Voltage** is adjusted by changing the Air Gap, which requires removal of the unit from the vehicle for a complete readjustment, as outlined below.



**FIGURE 2-11**  
Adjustments of cut-out relay

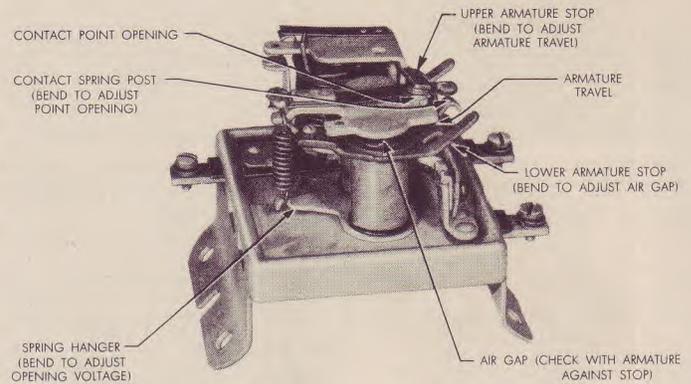
### VOLTAGE CONTROL ADJUSTMENT (On bench)

#### CUT-OUT RELAY: (Figure 2-11)

**Air Gap** between the center of the winding core and armature is measured with the points held closed and is adjusted by loosening the two screws at the back of the relay and raising or lowering the armature as required. Tighten screws after adjustment.

**Point Opening** is adjusted by bending the upper armature stop.

**Closing Voltage** is adjusted as already outlined above.



**FIGURE 2-12**  
Adjustments of step-voltage control

### VOLTAGE CONTROL UNIT: (Figure 2-12)

**Spring Tension** of the flat spring should be measured at the contact points with the armature up, and is adjusted by bending slightly the flat spring.

**Air Gap** is measured with the armature held down against the lower armature stop and is adjusted by bending the lower armature stop.

**Armature Travel** is measured with the armature in the up position between the armature and the lower armature stop and is adjusted by bending the upper armature stop.

**Point Opening** is measured with the armature held down against the lower armature stop, and is adjusted by bending the contact spring post.

**Opening Voltage** is adjusted as detailed above.

**Closing Voltage** is adjusted by adjusting the air gap. To raise the closing voltage, increase the air gap. To lower the closing voltage, decrease the air gap. Only a slight air gap adjustment will be required as a rule. After this adjustment, it may be necessary to slightly readjust the contact point opening to bring it back into the specified limits.

## REGULATOR MAINTENANCE

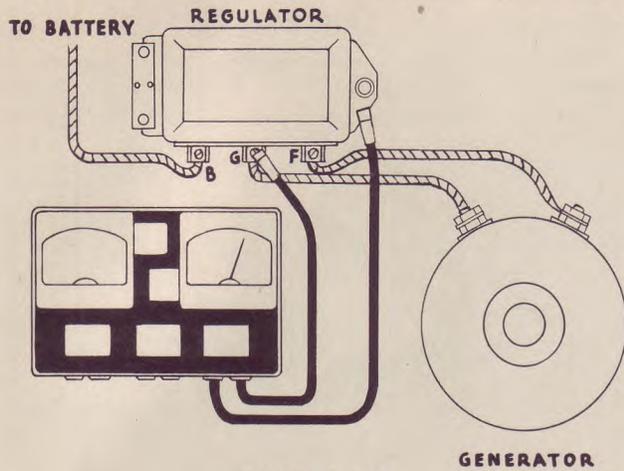
(Type illustrated in Figure 2-1)

### 30 DAYS OR 1,000 MILES

The cut-out relay, current regulator and voltage regulator settings should be checked as explained below. Check the regulator mounting and the lead connections to be sure they are tight. The cover must be assembled tightly and the rubber gasket between the cover and regulator base must be in place.

**To Check the Closing Voltage of the Cut-Out Relay**, connect a voltmeter between the GEN terminal and the regulator base as shown in Figure 2-13. Slowly increase the generator speed and note the voltage at which the relay contact points close.

# REGULATOR MAINTENANCE



**FIGURE 2-13**  
Cut-out relay closing voltage check

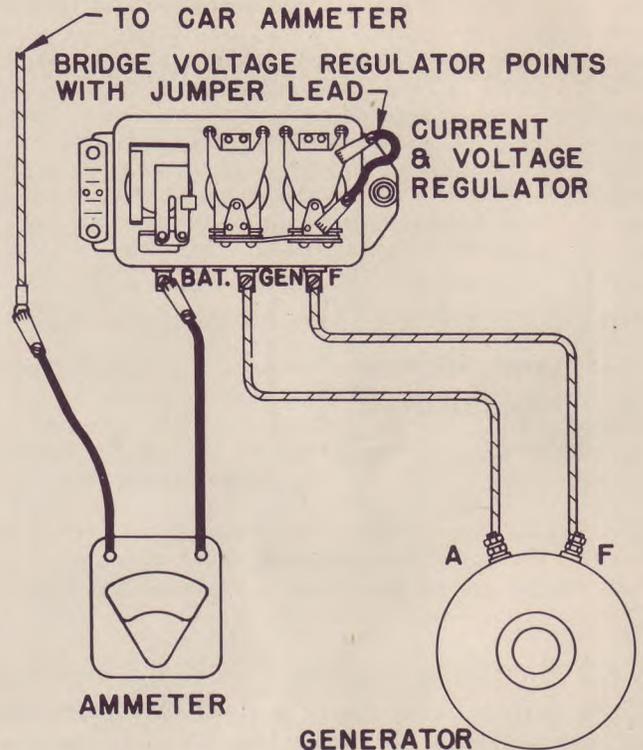
**To Check the Current Regulator Setting,** the voltage regulator must be prevented from operating. Three methods of preventing voltage regulator operation are available, and they are discussed below. All use an ammeter connected into the charging circuit at the regulator BAT terminal to measure the current setting.

**(1) Battery Discharge Method.** By this method, the battery is partly discharged by cranking the engine for 30 seconds with the ignition turned off so the engine will not start. **NEVER USE THE CRANKING MOTOR FOR MORE THAN 30 SECONDS AT A TIME WITHOUT PAUSING TO ALLOW THE CRANKING MOTOR TO COOL OFF.** Excessive cranking will damage the cranking motor. Immediately after the cranking cycle, start the engine, turn on lights, radio and other accessories (the horns may be blown if necessary) so that the generator output will increase to its maximum as determined by the current regulator setting without causing the voltage regulator to operate.

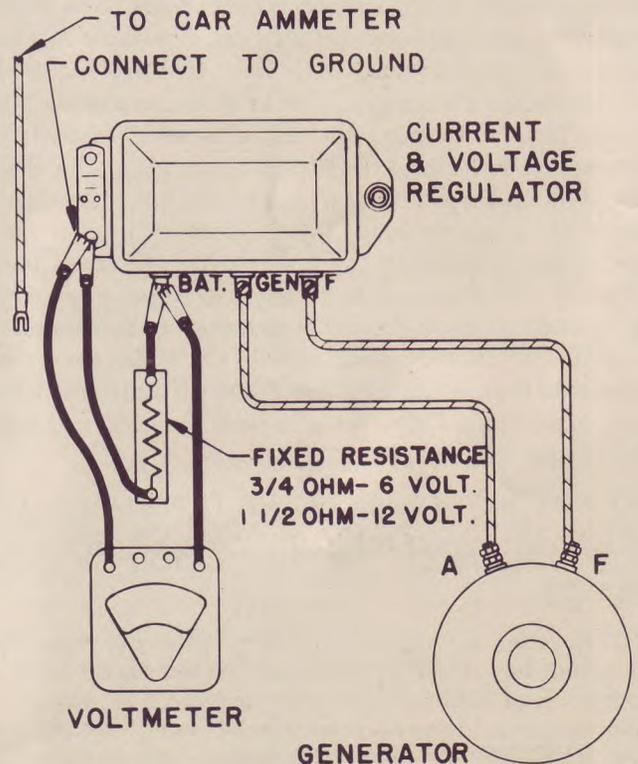
**(2) Load Method.** If a load approximating the current regulator setting is placed across the battery during the time that the current regulator setting test is made, the voltage will not increase sufficiently to cause the voltage regulator to operate. This load may be provided by a carbon pile or by a bank of lights.

**(3) Jumper Lead Method.** If the regulator cover is removed and a jumper lead placed across the voltage regulator contact points (Figure 2-14), the voltage regulator cannot operate. Consequently, the generator output will increase to its maximum as determined by the current regulator setting. Lights and accessories should be turned on to prevent high voltage during the test. Since this procedure requires removal of the regulator cover, it may not be used by the lower echelons of service, because they are not normally permitted to remove the regulator cover. One of the other two methods of checking the current regulator setting must therefore be used by the first and second echelons.

**To Check the Voltage Regulator Setting,** either of two methods may be used, the fixed resistance, or the variable resistance method. With the fixed resistance method,



**FIGURE 2-14**  
Current regulator check



**FIGURE 2-15**  
Voltage regulator check—fixed resistance method

od, disconnect the lead from the BAT terminal of the regulator and connect a  $\frac{3}{4}$  ohm fixed resistance ( $1\frac{1}{2}$  ohm for 12-volt) and a voltmeter from this terminal

## REGULATOR ADJUSTMENT ON VEHICLE

### VARIABLE RESISTANCE METHOD

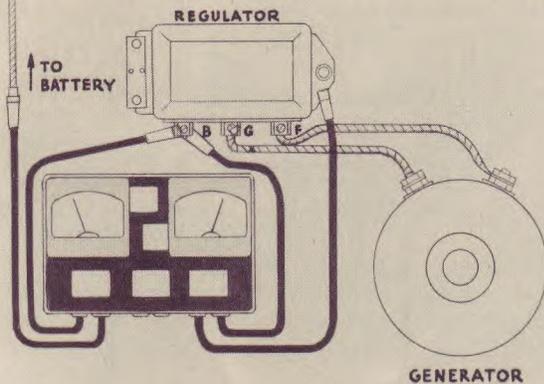


FIGURE 2-16

Voltage regulator check—variable resistance method

to the regulator base as shown in Figure 2-15. The resistance must be capable of carrying 10 amperes continuously and must not change in value as its temperature changes. Note voltage setting with the regulator at **operating temperature** with the generator running at medium speed. The regulator cover must be in place. With the variable resistance method, a variable  $\frac{1}{4}$  ohm resistance, an ammeter and a voltmeter are required; a combination instrument such as shown in Figure 2-16 is satisfactory. Connect the ammeter and variable resistance in series into the charging circuit at the BAT terminal and connect the voltmeter from the BAT terminal to the regulator base. Operate the generator at medium speed with the regulator at **operating temperature** and the cover in place. If less than 8 amperes is obtained, turn on the lights to increase the generator output. Cut in resistance slowly until the generator output is reduced to between 8 and 10 amperes. Then slow generator to idle, bring it back to speed and note the voltage setting.

**DO NOT RUN OR TEST THE GENERATOR ON OPEN CIRCUIT. TO DO SO WILL CAUSE SERIOUS DAMAGE TO THE REGULATOR OR GENERATOR.**

**NOTE:** After any check or adjustment of the regulator or generator, **ALWAYS** connect momentarily with a jumper lead between the GEN and BAT terminals of the regulator, after the regulator has been reconnected and **BEFORE** the engine is started. The momentary surge of current to the generator will correctly polarize it with respect to the battery it is to charge. This applies to generators used with the type regulator illustrated in Figure 2-1. For information on polarizing generators used with the type regulator illustrated in Figure 2-2, see pages 18 and 19.

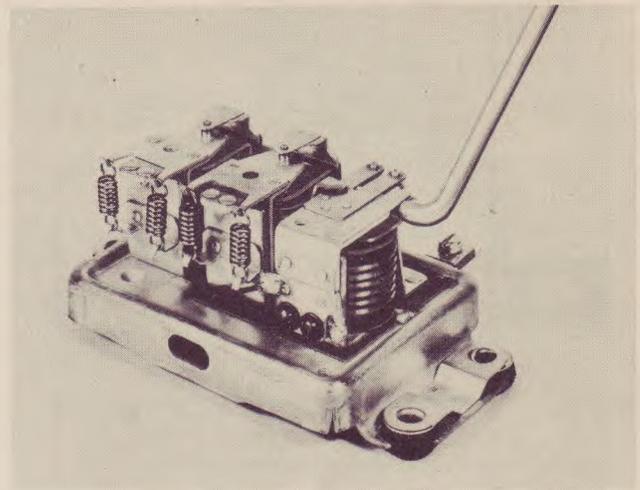


FIGURE 2-17

Cut-out relay closing voltage adjustment

### REGULATOR ADJUSTMENT (on vehicle)

**The Cut-Out Relay Closing Voltage** is adjusted (Figure 2-17) by bending up on the flat spring post to increase the tension of the flat spring and raise the closing voltage. Bending down on the spring post lowers the closing voltage.

**The Current Regulator Setting** is adjusted (Figure 2-18) by bending the lower spring hanger of **ONE** spring down to increase the current setting or up to lower the setting. Confine adjustment to one spring only.

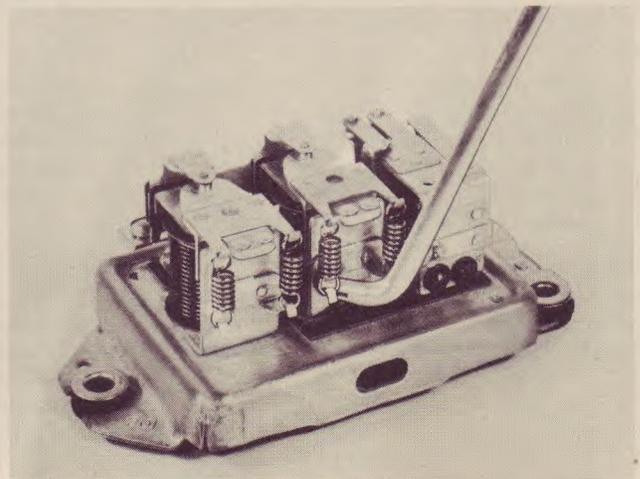


FIGURE 2-18

Current regulator adjustment

**The Voltage Regulator Setting** is adjusted exactly the same as the current regulator setting. After each change of voltage, replace regulator cover, reduce generator speed until relay points open, then bring generator

## REGULATOR ADJUSTMENT ON BENCH

back to speed and note voltage setting. In addition, if the voltage is being checked by the variable resistance method, the variable resistance must be readjusted so the 8 to 10 ampere output is maintained.

### REGULATOR ADJUSTMENT (on bench)

If a complete adjustment of the regulator is required, remove it from the vehicle and make the following mechanical checks and adjustments:

#### CUT-OUT RELAY:

**Air Gap** between the center of the winding core and the armature should be measured with the contact points held closed (Figure 2-19). If both sets of points do not close at the same instant, bend the spring fingers until they do. Adjust by loosening the two adjusting screws and raising or lowering the armature as required.

**Point Opening** is adjusted by bending the upper armature stop. (Figure 2-20).

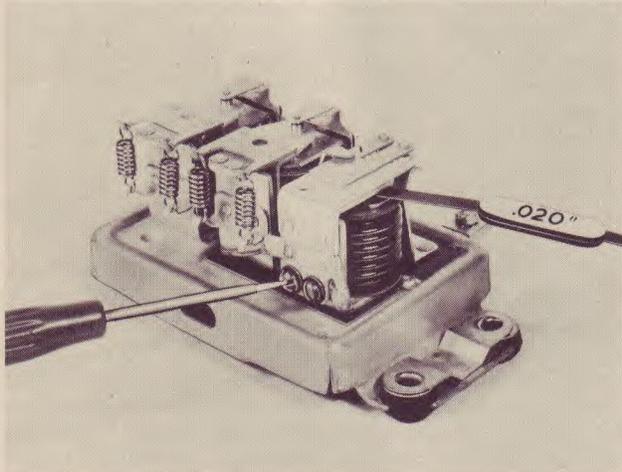


FIGURE 2-19  
Cut-out relay air gap adjustment

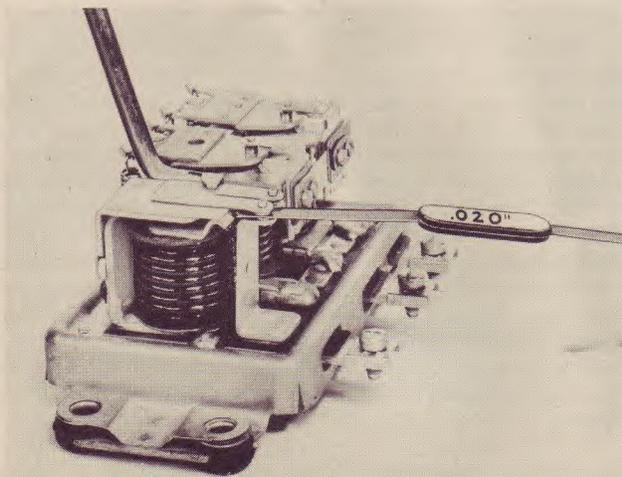


FIGURE 2-20  
Cut-out relay point opening adjustment

#### VOLTAGE REGULATOR: (Figure 2-21)

**Air Gap** should be measured between the center of the core and the armature with the points just touching. Push armature all the way down by hand, allow to come back until points just touch, then measure air gap. Adjust by loosening the two upper contact mounting screws and moving the contact mounting bracket up or down as required. Be sure points are lined up and screws are tightened after adjustment.

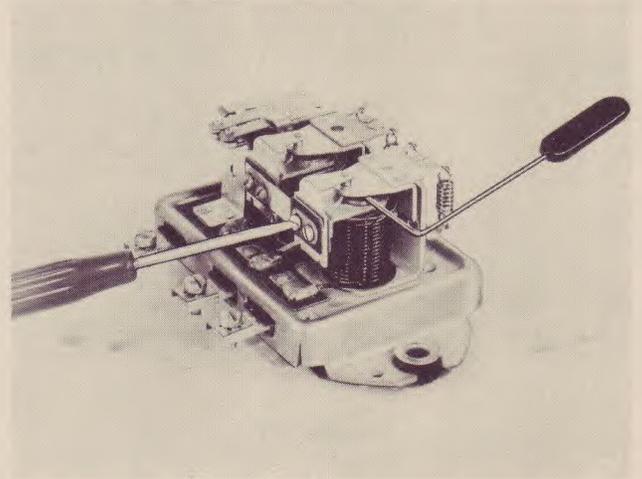


FIGURE 2-21  
Regulator air gap adjustment

#### CURRENT REGULATOR:

**Air Gap** is checked and adjusted in exactly the same manner as for the voltage regulator.

After the above point opening and air gaps have been checked and adjusted, reconnect the regulator to the proper type generator and battery and using the meter connections, previously outlined, check the electrical settings of the cut-out relay, current regulator and voltage regulator. Adjust as necessary.

### REGULATOR REPAIR (on bench)

#### CLEANING REGULATOR POINTS

One of the most important operations in regulator service is the cleaning of contact points. This operation must be performed correctly to assure normal operation of the regulator and generator. The points must be cleaned one at a time with a spoon or riffle file (obtainable through United Motors Service) which will clean out the slight cavity or pit formed in the flat point during normal operation. When the flat point is on the upper contact bracket, it will be necessary to remove the upper contact bracket to clean the points. IN ANY EVENT, IT WILL BE NECESSARY TO LOOSEN THE UPPER CONTACT BRACKET BEFORE ATTEMPTING TO CLEAN THE POINTS. EMERY CLOTH OR SANDPAPER should never be used to clean the points, since particles of sand or

## QUICK CHECKS

emery may embed in the points and prevent normal operation. Do not use a flat file, since it will not clean out the cavity in the flat point.

### ASSEMBLING THE UPPER CONTACT SUPPORTS

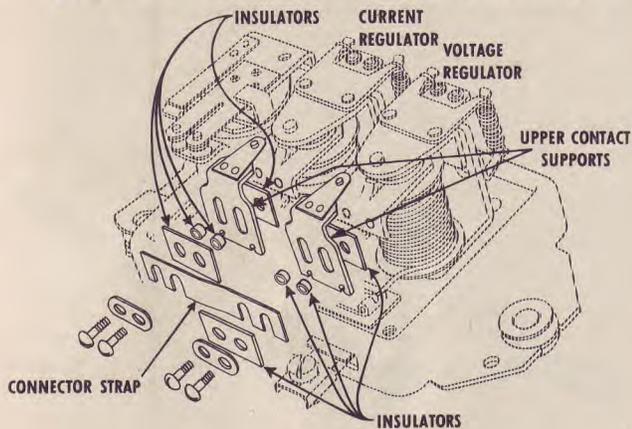


FIGURE 2-22

After the points have been cleaned, the contact brackets may be reassembled as shown in Figure 2-22. Note that the connector strap is connected to the voltage regulator upper contact bracket, while it is insulated from the current regulator upper contact bracket. This diagram may also be followed if new upper contact brackets are being installed. The AIR GAPS must be reset after assembly.

### REPLACING ARMATURES

The regulator armatures may be replaced by drilling out the two rivets which mount the armature hinge spring on the regulator frame. Support the frame to avoid bending it, center punch the rivet heads and use a 3/32 drill. Assemble the new armature with the screws, lockwashers and nuts supplied with the service armature. Assemble screws down so they will not ground against the regulator cover.

### REPLACING REGULATOR SPIRAL SPRINGS

When regulator spring replacement is required, or when the regulator is completely out of adjustment care must be used so that, after adjustment is completed, each spiral spring will carry one-half of the total required spring tension. On the CURRENT REGULATOR, install one spring and adjust it to one-half the total current setting. Install the second spring and complete adjustment on this spring. On the VOLTAGE REGULATOR, install one spring, connect a voltmeter from the GEN terminal to the regulator base. Open the voltage regulator points by hand and slowly increase generator speed until 3 volts are obtained (6 volts on 12-volt system). This establishes approximate

generator speed at which adjustment of the first spring should be completed. Now release the points and adjust the spring to one-half the total voltage setting. Install the second spring, connect meters and resistance as previously described and complete adjustment on this spring, following the procedure already outlined.

### QUICK CHECKS TO LOCATE SOURCE OF TROUBLE IN GENERATOR-REGULATOR SYSTEM ON VEHICLE

The following quick checks will determine whether or not the units are operating normally and if they are not, they will help locate the source of trouble so that the proper corrective measures may be taken.

**(1) A Fully Charged Battery and a High Charging Rate.** Connect test ammeter into the circuit at the BAT terminal of the regulator and disconnect the lead from the "F" terminal of the regulator to determine whether it is the regulator or some other unit in the electrical system which is causing the condition. This takes the regulator completely out of the generator field circuit and the output should normally drop off. If the output does not drop off with the generator operating at medium speed and the "F" terminal lead disconnected, the generator field is grounded, either in the wiring harness or in the generator itself.

If the output does drop off as the "F" terminal lead is disconnected, check the regulator for a high voltage setting. Remember, however, that where temperatures are high, the charging rate may also be high, even though the battery is charged and the voltage regulator setting is satisfactory for normal climatic conditions. (See page 5 in the chapter on batteries.) Therefore, in hot climates, it may be necessary to reduce the voltage regulator setting to as low as 6.9 volts (13.7 on 12-volt system) in extreme cases. The cut-out relay must likewise be reduced to 6.2 to 6.6 volts (12.3 on 12-volt system) so that it still operates at a lower voltage than the regulator.

**(2) With a Low Battery and a Low or No Charging Rate,** check the circuit for loose connections or defective leads, since these produce high resistance which causes the voltage regulator to operate as though the battery were fully charged even though the battery is in a discharged condition. Next, momentarily ground the "F" terminal of the regulator with the generator operating at a medium speed. If the output increases, check the regulator for oxidized or dirty contact points, or a low voltage setting. If the output remains low, check the generator as the source of trouble. If no output at all is obtained, make sure the cut-out relay is closing, since it could be that it is not closing due to a high closing voltage setting or an open voltage winding.

**Burned Resistance Units, Regulator Winding or Fused Contacts** result from open circuit operation or high resistance in the charging circuit. With any of these conditions, check the vehicle wiring carefully.

# HEAVY-DUTY REGULATOR—MAINTENANCE

## HEAVY-DUTY REGULATOR

(Type illustrated in Figure 2-2)

The heavy-duty regulator operates on the same principles as the standard type outlined earlier in the chapter. However, there is some difference in their construction, due to the part of the generator field circuit into which the regulator inserts the resistance and to the additional windings employed in the heavy-duty regulator. As will be remembered (Figure 2-7) the standard type regulator grounds the generator field circuit in the regulator, either through the regulator points or through a resistance. On the heavy-duty type (Figure 2-23), the generator field is connected to ground in the generator and the generator field circuit is connected to the insulated side of the system within the regulator, either through the regulator points or through a resistance.

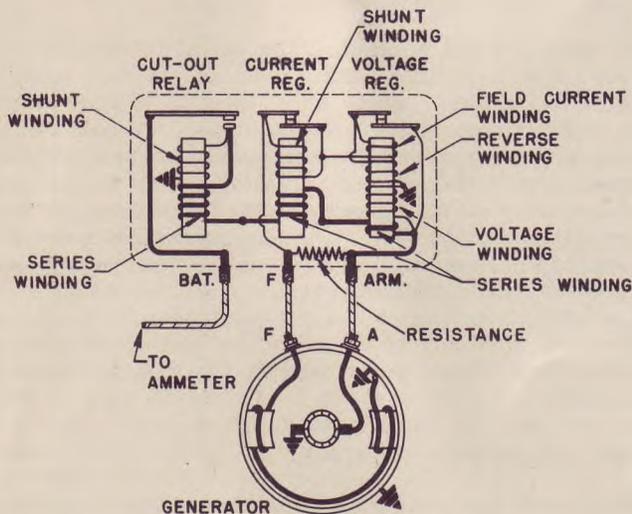


FIGURE 2-23

Wiring diagram of heavy-duty regulator

**The Cut-Out Relay** has two windings which perform the same function as in the standard regulator.

**The Current Regulator** has one additional winding which is connected across the current regulator contact points. This inserts the winding, which is of comparatively high resistance, into the generator field circuit in parallel with the resistance unit when the current regulator contact points open.

**The Voltage Regulator** has two additional windings, a heavy series winding of a turn or two which carries full generator output and a "reverse" winding of many turns of very fine wire. There are also the generator field current winding and the main voltage winding as found in the other type regulator. The heavy series winding of a turn or two of wire has no effect on the operation of the regulator, it is merely an additional safeguard against overload. The "reverse" winding is wound and connected so that, when the voltage regulator contact points are closed, it aids the main voltage winding which tends to open the voltage regulator

points. When the points do open, due to the voltage attaining the value for which the regulator is set, the action of the three windings is as follows:

Field Current Winding magnetic field is reduced because it becomes connected in series with the "reverse" winding.

"Reverse" Winding magnetic field reverses because the induction of the generator field, which attempts to maintain the flow of field current, starts to force current through the reverse winding in a direction opposite to the direction it flows when the voltage regulator points are closed.

Main Voltage Winding maintains its magnetic field in the same direction although the magnetic field becomes somewhat weakened due to the lowered line voltage resulting from the insertion of the resistance unit into the generator field circuit.

The result is that the total magnetic field of the voltage regulator is reduced to a value which permits the spring tension to close the points again, reconnecting the generator field directly to the insulated side of the system. The added windings merely speed up the operation of the points so that a more constant voltage is maintained in the system.

## REGULATOR MAINTENANCE

(Type illustrated in Figure 2-2)

### 30 DAYS OR 1,000 MILES

The cut-out relay, current regulator and voltage regulator settings should be checked as explained below. Check the regulator mounting and lead connections to be sure they are tight.

To check the closing voltage of the cut-out relay, connect a voltmeter between the ARMATURE terminal of the regulator and the ground screw (Figure 2-24). Gradually increase generator speed and note closing voltage of relay. On the type application where the cut-out relay points are closed on idle, momentarily ground the regulator FIELD terminal. This kills off

## RELAY CLOSING VOLTAGE CHECK

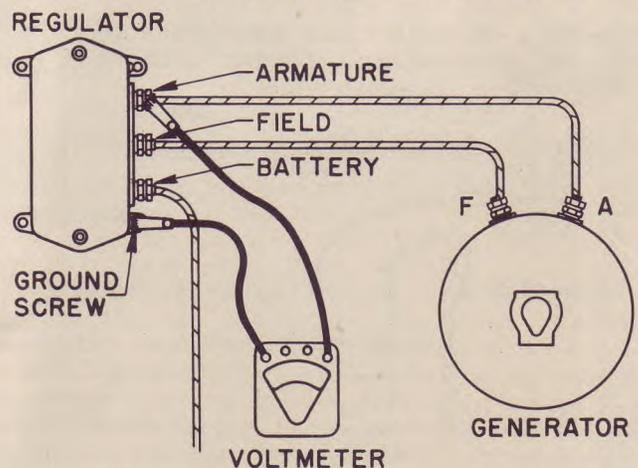


FIGURE 2-24

## REGULATOR MAINTENANCE

the generator so the relay points will open. As the generator builds up, the voltage required to close the relay points can then be noted.

### VOLTAGE REGULATOR CHECK

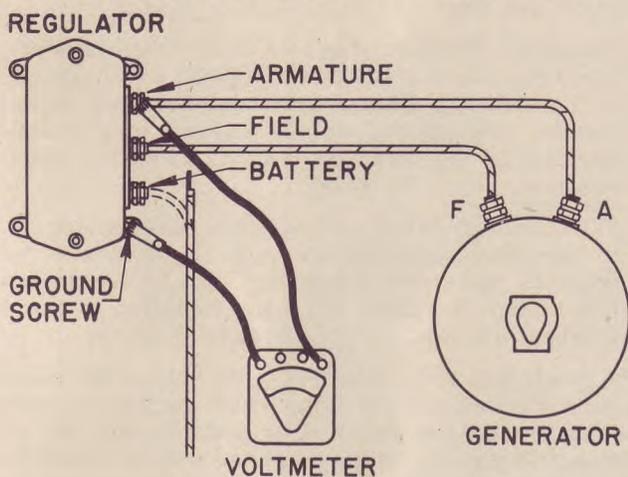


FIGURE 2-25

To check the voltage regulator setting, leave the voltmeter connected from the ARMATURE terminal to the ground screw as above, and disconnect the lead from the BATTERY terminal of the regulator and operate on open circuit. (Figure 2-25). With the generator operating at medium speed, note the voltage setting. **The regulator must be at operating temperature.** The regulator may be checked at the end of a run, or the engine should be operated for 45 minutes to insure that the regulator is hot.

To check the current regulator setting, the voltage regulator must be prevented from operating. Three methods of preventing voltage regulator operation are available, and they are discussed in the following paragraphs. All make use of an ammeter connected into the charging circuit at the regulator BATTERY terminal to measure the current setting.

### CURRENT REGULATOR CHECK

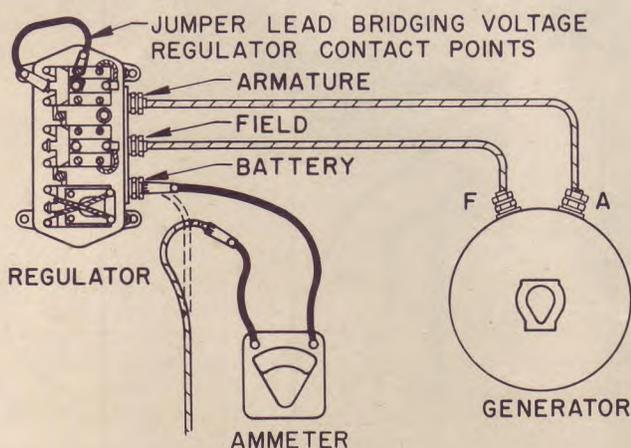


FIGURE 2-26

(1) **Battery Discharge Method.** By this method, the battery is partly discharged by cranking the engine for 30 seconds with the ignition turned off so the engine will not start. **NEVER USE THE CRANKING MOTOR FOR MORE THAN 30 SECONDS AT A TIME WITHOUT PAUSING TO ALLOW THE CRANKING MOTOR TO COOL OFF.** Excessive cranking will damage the cranking motor. Immediately after the cranking cycle, start the engine, turn on lights, radio and other accessories (the horns may be blown if necessary) so that the generator output will increase to its maximum as determined by the current regulator setting without causing the voltage regulator to operate.

(2) **Load Method.** If a load approximating the current regulator setting is placed across the battery during the time that the current regulator setting test is made, the voltage will not increase sufficiently to cause the voltage regulator to operate. This load may be provided by a carbon pile or a bank of lights.

(3) **Jumper Lead Method.** If the regulator cover is removed and a jumper lead placed across the voltage regulator contact points as shown in Figure 2-26, the voltage regulator cannot operate. Consequently, the generator output will increase to its maximum as determined by the current regulator setting. Lights and accessories should be turned on during the test to prevent high voltage. Since this procedure requires removal of the regulator cover, it may not be used by the lower echelons of service, because they are not normally permitted to remove the regulator cover. One of the other two methods of checking the current regulator setting must therefore be used by the first and second echelons.

### POLARIZING GENERATOR

NOTE: After any check or adjustment of the regulator or generator, the generator must be correctly polarized as follows:

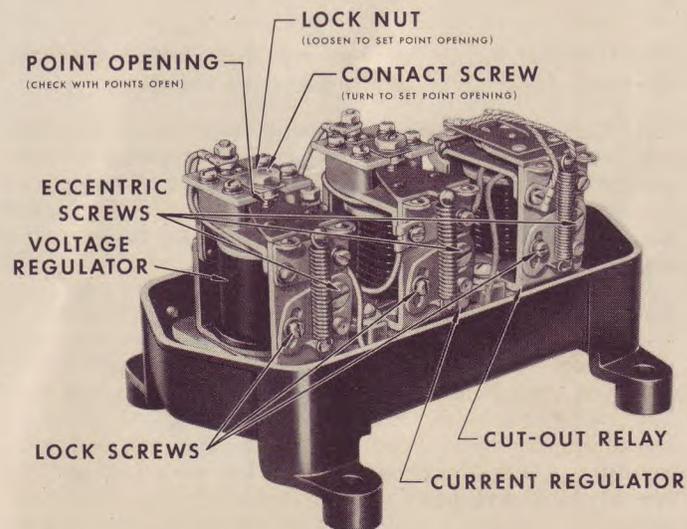


FIGURE 2-27

Relay and regulator adjustments

## REGULATOR ADJUSTMENT

1. Remove "F" terminal lead from the generator.
2. Connect momentarily with a jumper lead from the generator "F" terminal to the insulated terminal of the battery. This allows a flash of current to flow through the generator field windings which correctly polarizes the generator with respect to the battery. (On insulated system, momentarily connect generator "F" terminal in turn to each battery terminal. Current will flow through the generator field windings from only one battery terminal.)
3. This procedure must be followed BEFORE the engine is started. Failure to observe this will cause damage to the generator and relay.

Formerly it was stated that the correct procedure for polarizing generators was to connect across the ARMATURE and BATTERY terminals of the regulator with a jumper lead. THIS METHOD MUST NOT BE USED on the heavy-duty regulator illustrated in Figure 2-2, or on four unit regulator (Figure 2-30), since it may cause the generator or regulator to burn up. Use the method outlined above to polarize the generator correctly.

### REGULATOR ADJUSTMENT (on vehicle)

**The Cut-Out Relay Closing Voltage** is adjusted (Figure 2-27) by loosening the locking screw and turning the eccentric to adjust the tension of the spiral spring. Increasing the tension increases the closing voltage, decreasing the spring tension lowers the closing voltage.

**The Voltage Regulator Setting** is adjusted (Figure 2-27) by loosening the locking screw and turning the eccentric to adjust the tension of the spiral spring. Increasing the tension increases the voltage setting, decreasing the tension lowers the setting. After tightening the lock screw, check the setting by cycling the generator, that is, reduce the generator speed until the relay points open, then bring the generator back to speed. (Or momentarily ground the regulator FIELD terminal.) This reduces the residual magnetism in the regulator winding cores which would otherwise produce an error in the setting.

Regulator voltage must always be set ABOVE the cut-out relay closing voltage; otherwise the cut-out relay might never close since the regulator would hold the voltage below the value required to operate the cut-out relay.

**The Current Regulator Setting** is adjusted by loosening the locking screw and turning the eccentric in the same manner as on the voltage regulator.

### REGULATOR ADJUSTMENT (on bench)

If a complete adjustment of the regulator is required, remove it from the vehicle, and make the following mechanical checks and adjustments:

#### CUT-OUT RELAY:

**Air Gap** between the armature and the core—not between the brass pin in the armature and the core—

is measured with the points held closed. (Figure 2-28.) Adjust by loosening the two screws holding the lower contact bracket, and raise or lower the contact bracket as required. Be sure the points are lined up and tighten the screws well after adjustment.

**Point Opening** is adjusted by bending the upper armature stop. If the points do not close at the same instant, the spring fingers should be bent slightly so they do meet simultaneously.

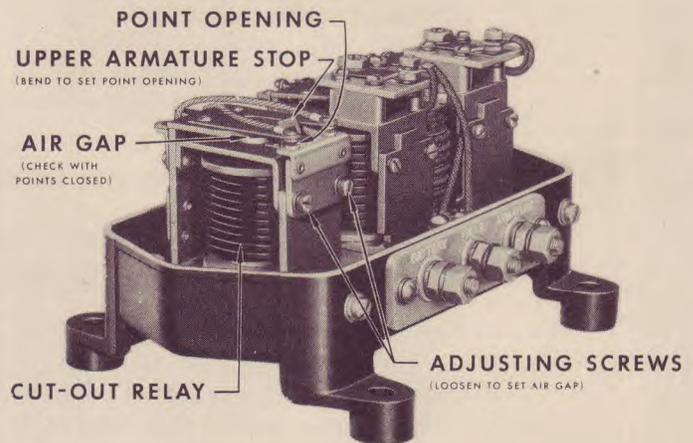


FIGURE 2-28  
Relay adjustments

#### VOLTAGE REGULATOR:

**Point Opening** is checked with the armature held down against the core. To adjust, loosen the lock nut and turn the contact screw. (Figure 2-27.) The spring holding the contact screw should rise slightly above the fiber insulator when the points come together. This provides a wiping action which improves their operation.

#### CURRENT REGULATOR:

**Point Opening** is checked and adjusted exactly as for the voltage regulator.

After the above point openings and air gap have been checked and adjusted reconnect the regulator to the proper type generator and battery, and using the meter connections previously outlined, check the electrical settings of the cut-out relay, the voltage and the current regulator. Adjust as necessary.

**NOTE: THE REGULATOR MUST BE IN THE OPERATING POSITION (Horizontal or Vertical) WHEN THE ELECTRICAL SETTINGS ARE CHECKED OR ADJUSTED.**

### REGULATOR REPAIR (on bench)

#### CLEANING REGULATOR POINTS

In order to clean the regulator contacts correctly, it will be necessary to remove the contact screw. The lower point may then be cleaned with a spoon or riffler file which will clean out the slight cavity formed in normal operation. The contact on the screw may also be cleaned with the riffler file. Some operators remove

## QUICK CHECKS

both the contact screw and the armature so the points may be dressed on a grinding wheel. Care must be taken if this method is used to avoid removing too much material and to make sure the contact surfaces are smooth after the cleaning operation is completed. In reassembling the armature, make sure the armature is held down tightly against the regulator frame while the armature assembling screws are tightened. Reset the air gaps.

### QUICK CHECKS TO LOCATE SOURCE OF TROUBLE IN GENERATOR-REGULATOR SYSTEM ON VEHICLE

The following checks will determine the location of trouble if trouble is experienced so the proper corrective measures can be taken.

(1) **Fully Charged Battery and a High Charging Rate** will result from

- a. High voltage regulator setting.
- b. Poor ground connection between regulator and generator.
- c. Defective regulator winding.
- d. Direct short between generator charging circuit and generator field circuit which prevents resistance from being inserted into generator field circuit in a normal manner.

To locate trouble, remove regulator cover and open voltage regulator contacts. If the output drops off, the trouble is due to a, b, or c, above. Check ground connections. Check regulator voltage setting. If the output does not drop off, the condition is probably due to d. above. Disconnect the lead from the "FIELD" terminal of the regulator. If the output drops off, the short is in the regulator. If it does not drop off, the short is in the generator.

**IMPORTANT:** Delco-Remy voltage regulators are originally adjusted on the assumption that the vehicle will be equipped with its full complement of electrical accessories such as heater, radio, etc. When the vehicle is not so equipped, it is advisable to readjust the voltage regulator setting to a somewhat lower value, to reduce the possibility of battery overcharge. In order to take care of variable loads in the vehicle electrical system and minimize the danger of rundown batteries, the voltage regulator is normally set on the high side of the specifications. If, for instance, the specifications of a particular regulator call for a 14.5 to 15.0 volt setting, the setting is adjusted to 15.0 volts, and this figure is stamped on the regulator name plate.

It is possible, however, with this maximum voltage setting, to obtain some overcharging of the battery, if temperatures are high, and if the vehicle does not use a normal complement of electrical accessories. This is particularly true on the Half-Track Scout vehicles using the Delco-Remy 5639 Regulator and 985 Generator which are designed to produce 55 amperes and carry the electrical load of a two-way radio system as well as other electrical accessories.

On earlier Half-Track Scout vehicles, a large cylindrical radio interference filter was used in the generator charging circuit, and the additional re-

sistance thus introduced required that the voltage regulator be set at 15.5 volts when the vehicle used radio equipment and at 15.0 volts when radio equipment was not installed on the vehicle. If battery overcharge was experienced with the 15.0-volt setting, due to high temperature or low electrical load, it was permissible to reduce the voltage to as low as 14.5 volts. On later Half-Track vehicles, a small suppression type filter is being used, which has lower resistance and consequently the maximum voltage setting with this equipment must be not more than 15.0 volts. If battery overcharge is experienced with this setting, it may be reduced to as low as 14.1 volts.

On any vehicle where the voltage setting is reduced to prevent battery overcharge, it will be necessary to reduce the cut-out relay closing voltage setting also, so it is still below the voltage regulator setting.

When the vehicle does not have its full complement of electrical accessories or where battery overcharging is experienced, reduce the voltage settings as below. The cut-out relay setting must also be reduced, so it is still well below the voltage regulator setting.

Original specified setting (stamped on name plate)	Reduce voltage not lower than *	Cut-out relay voltage reduced to
7.5	7.1	6.5
15.0	14.1	13.0
15.5	14.5	13.5
30.0	28.2	26.0

\* At operating temperature

This reduction of the voltage setting will compensate for the fact that the vehicle is not carrying its full complement of electrical equipment and will thereby prevent battery overcharge. These reductions in voltage setting should not be made in localities where cold weather is experienced, since this would produce undercharged batteries. Or, if the reductions are made during hot weather, they should be again increased as cold weather sets in.

(2) **With a Low Battery and a Low or No Charging Rate**, check the circuit for loose connections and defective leads, since these produce high resistance which causes the voltage regulator to operate as though the battery were fully charged, even though the battery is in a discharged condition. Next, bridge the regulator "ARMATURE" and "FIELD" terminals momentarily with a jumper lead with the generator operating at medium speed. If the output increases substantially, check the regulator for a low setting or oxidized points. If the output does not increase, check the generator as the source of trouble. If no output at all is being obtained, the cut-out relay may not be closing due to a high setting or an open winding. Also, the cut-out relay will not close if the generator is inoperative.

(3) **Excessive Arcing or Sluggish Action of the Regulator Contact Points** may result from any of the conditions listed below:

- a. Resistance unit open
- b. Defective regulator windings
- c. Contact points pitted or oxidized
- d. Shorted generator field
- e. Regulator contact points out of alignment

# FOUR UNIT REGULATOR

- f. Poor ground connections between regulator and generator
- g. Excessive resistance in charging circuit due to defective leads or bad connections.

**CAUTION:** NEVER UNDER ANY CONDITION CLOSE THE RELAY CONTACT POINTS MANUALLY WHILE THE BATTERY IS CONNECTED. THE LOW RESISTANCE OF THE GENERATOR AND REGULATOR WILL ALLOW SUFFICIENT CURRENT TO FLOW TO CAUSE SERIOUS DAMAGE TO THE EQUIPMENT.

## HEAVY-DUTY FOUR UNIT REGULATOR

The four unit regulator (Figure 2-30) is similar to the three unit regulator, except that it has a field relay which works in conjunction with the voltage regulator, inserting and removing the resistance in the generator field circuit. When the voltage regulator operates, it closes its points, thus connecting the field relay winding across the line so that it becomes energized. The field relay consequently opens its points, causing resistance to be inserted into the generator field circuit. The generator output and voltage drop, the voltage regulator points open, permitting the field relay points to close so that the generator output and voltage can increase. This cycle takes place and is repeated very rapidly, regulating for a constant voltage. The current regulator and cut-out relay operate in the manner detailed for the three unit regulator. The four units should be checked as follows:

### ELECTRICAL SETTINGS (Four unit regulator)

The regulator must be at operating temperature (135°-145°F.) and in actual operating position when the electrical settings are checked.

## RELAY CLOSING VOLTAGE CHECK

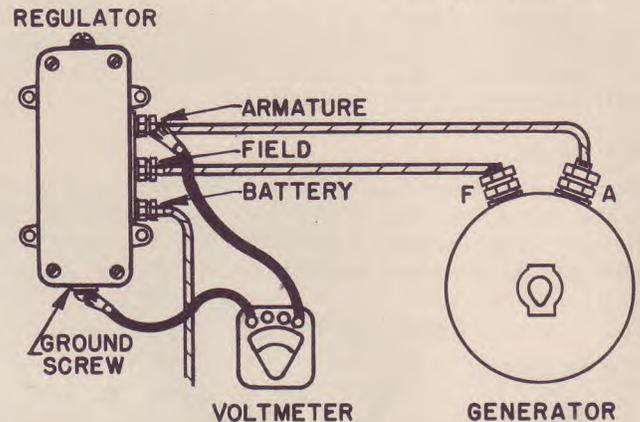


FIGURE 2-29

Meter connections to check closing voltage of cut-out relay

### Cut-Out Relay

Connect a voltmeter from the regulator ARMATURE terminal to the ground screw or ground return terminal of regulator as shown in Figure 2-29. Gradually increase generator speed and note closing voltage of the cut-out relay. If the voltage does not increase to a value sufficient to cause the cut-out relay to operate, it is possible that the voltage regulator is set too low. To eliminate the voltage regulator from the system, place a jumper lead across the field relay points as shown in Figure 2-33. This prevents voltage regulator action so that the voltage can increase to a value sufficient to cause the cut-out relay to operate. Adjust the cut-out relay by loosening the lock screw and turning the eccentric to increase or lower the spiral spring tension (Figure 2-30). Increasing the tension increases

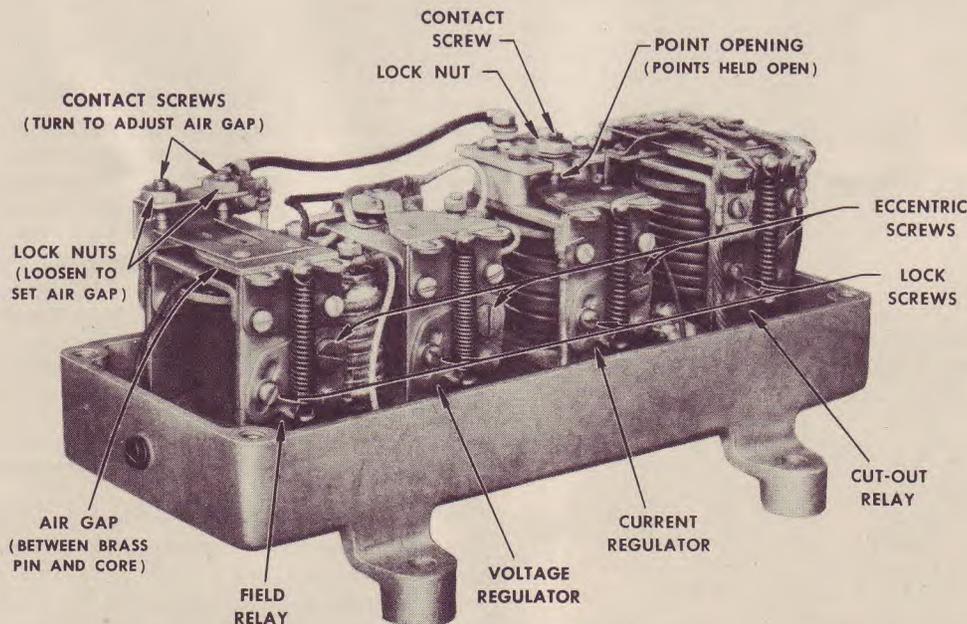


FIGURE 2-30

Adjustments of electrical settings of four units in four-unit regulator. Mechanical adjustments of field relay and current regulator

# FOUR UNIT REGULATOR

the closing voltage. Tighten lock screw and remove jumper lead from field relay points after adjustment is completed. Note: NEVER CLOSE CUT-OUT RELAY POINTS BY HAND WITH BATTERY CONNECTED. THIS WILL DESTROY THE REGULATOR AND GENERATOR.

### Field Relay

Connect a jumper lead across the voltage regulator points, disconnect lead from the regulator BATTERY terminal, and connect voltmeter from the regulator ARMATURE terminal to the ground screw or ground

### Voltage Regulator

With voltmeter connected as in previous tests and lead disconnected from regulator BATTERY terminal (Figure 2-32), operate generator at a speed approximately 25 per cent above speed at which maximum output is normally attained, and note voltage setting. Adjust by means of the lock screw and eccentric. After tightening lock screw at the end of adjustment, check setting by stopping generator and then bringing it back to speed. NEVER SET VOLTAGE REGULATOR BELOW CUT-OUT RELAY SETTING SINCE THIS WOULD PREVENT THE VOLTAGE

### FIELD RELAY CHECK

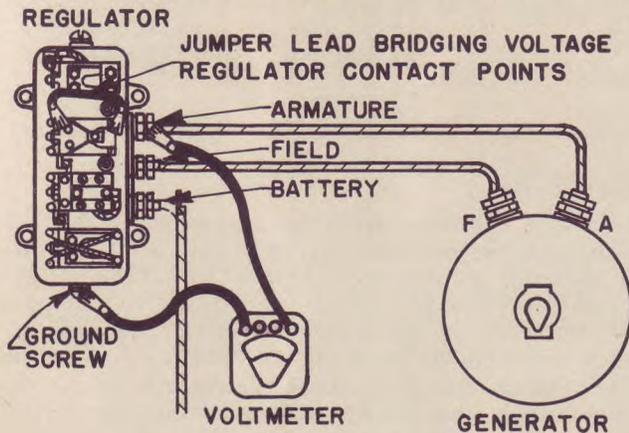


FIGURE 2-31

Meter connections to check field relay voltage setting

return terminal of the regulator as shown in Figure 2-31. Operate generator at a speed approximately 25 per cent above speed at which maximum output is normally attained, and note field relay operating voltage. Adjust by loosening the lock screw and turning the eccentric (Figure 2-30). After each change of adjustment, check setting by stopping generator and then bringing it back to speed. Tighten lock screw and remove jumper after adjustment is completed.

### VOLTAGE REGULATOR CHECK

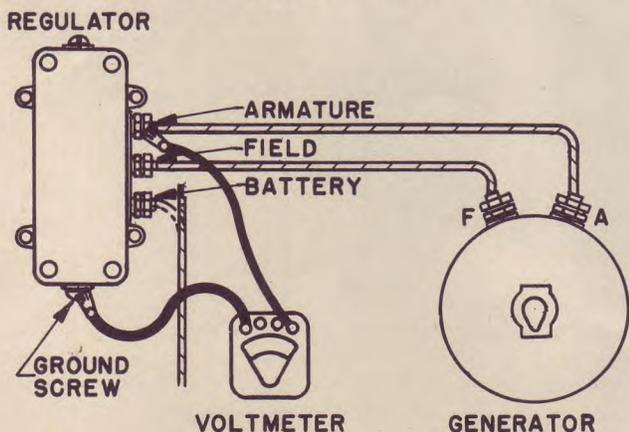


FIGURE 2-32

Meter connections to check voltage regulator setting

### CURRENT REGULATOR CHECK

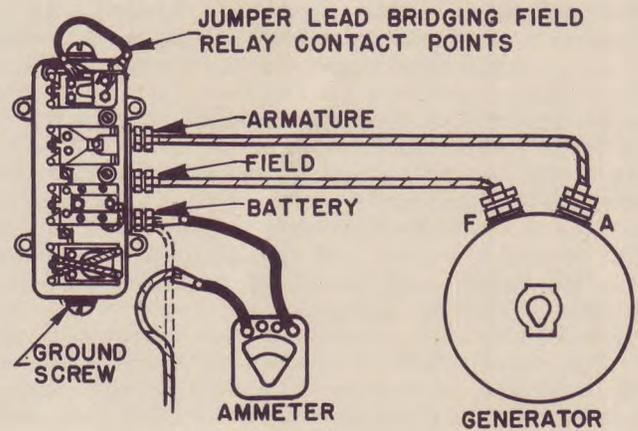


FIGURE 2-33

Meter connections to check current regulator setting

FROM INCREASING TO A VALUE SUFFICIENT TO CLOSE THE CUT-OUT RELAY AND RUN-DOWN BATTERIES WOULD RESULT.

### Current Regulator

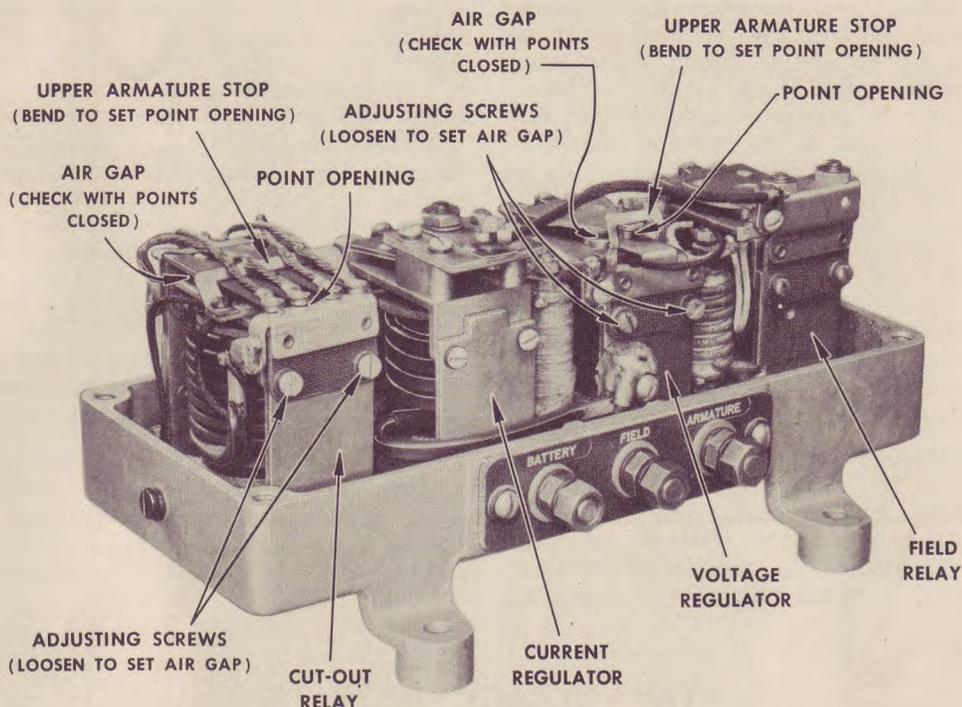
Connect a jumper lead across the field relay contact points, and insert an ammeter into the charging circuit at the regulator BATTERY terminal as shown in Figure 2-33. Increase generator speed until current regulator begins to operate and there is no further rise in current output. To avoid excessive voltage in the system during this check, turn on enough electrical accessories, if possible, so that the load will approximate the current regulator setting. On the test bench, a high capacity resistor may be connected across the battery to provide an electrical load equivalent to the current regulator setting. Adjust current setting by means of the lock screw and eccentric. Check setting by stopping generator and then bringing it back to speed. Remove jumper lead.

### MECHANICAL SETTINGS (Four unit regulator)

#### Cut-Out Relay (Figure 2-34)

**Air gap** is measured between the armature and core—not between the pin in the armature and the core—with the points held closed and is adjusted by loosening the two adjusting screws in the lower contact bracket so the lower contact bracket may be raised or lowered. Be sure all points align and tighten screws securely after adjustment.

# FOUR UNIT REGULATOR



**FIGURE 2-34**  
Cut-out relay and voltage regulator mechanical adjustments

**Point opening** is adjusted by bending the upper armature stop.

### Current Regulator (Figure 2-30)

**Point opening** is measured with the armature pushed down against the armature stop and is adjusted by loosening the lock nut and turning the contact screw. Always loosen the lock nut before turning the contact screw to avoid damaging the contact spring.

### Voltage Regulator (Figure 2-34)

**Air gap** is measured between the brass residual pin in the core and the armature with the points held closed lightly, and is adjusted by loosening the adjusting screws and raising or lowering the lower contact bracket as required. Be sure points align and tighten screws after adjustment.

**Point opening** is adjusted by bending the upper armature stop.

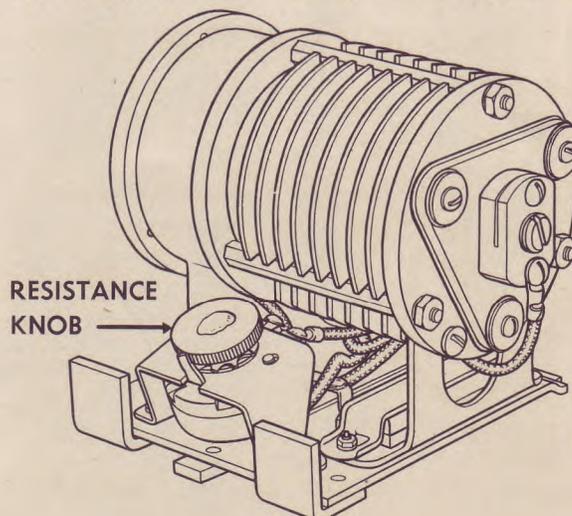
### Field Relay (Figure 2-30)

**Air gap** is checked with contact points closed, and is adjusted by loosening the two lock nuts and turning the two contact screws. Always loosen the two lock nuts before turning the contact screws. The point opening of each set of points must be identical so that the current will be evenly divided. A final check may be made after the regulator is reinstalled and is in operation. If more arcing takes place at one set of points than at the other, it indicates that set is carrying more than its share of current and the points should

be readjusted so that the arcing is the same for each set.

## CARBON-PILE VOLTAGE REGULATOR

Some heavy duty specialized applications use the type regulator shown in Figure 2-35. This is a carbon-pile voltage regulator which makes use of a solenoid and a carbon-pile to control the voltage in the electrical circuit. The carbon-pile is connected in series with the generator field, and the solenoid is connected across



**FIGURE 2-35**  
Carbon-pile voltage regulator

# CARBON-PILE VOLTAGE REGULATOR

the generator armature terminals so that generator and line voltage is impressed across the solenoid. When the generator speed or load conditions are such that the voltage in the system is below the value at which the regulator operates, the tension of spring fingers compresses the carbon-pile so that it has a small resistance. This allows a maximum generator field current and generator output. However, as the speed of the generator increases or the electrical requirements of the system decrease, the voltage tends to increase. This increases the magnetic pull of the solenoid, which partially overcomes the tension of the spring fingers and relieves some of the pressure on the carbon-pile. As pressure is relieved, the resistance of the carbon-pile increases; this cuts down the generator field current and the generator output. When the regulator operates, it maintains a constant voltage under all conditions of generator speed and load within the operating limits.

## REGULATOR ADJUSTMENT

The only adjustment to be made on this regulator is to rotate the resistance knob to change the voltage setting. **THIS SHOULD BE DONE ONLY BY THE AUTHORIZED INDIVIDUAL USING THE APPROVED TESTING INSTRUMENTS.** Promiscuous

adjustment may ruin the regulator and generator. With the regulator **HOT** (at operating temperature), and a voltmeter connected across the generator armature terminals ("B" and "G") so the operating voltage may be checked, operate the generator at a speed 20% above the speed at which it will produce maximum output and note the voltage regulator setting. Switch on and off some fairly heavy electrical load to stabilize the regulator. Adjust operating voltage of regulator by rotating adjusting knob in a clockwise direction to increase, or in a counterclockwise direction to lower, the voltage setting. After each change of adjustment throw a fairly heavy electrical load on and off before taking the voltage reading. **REGULATOR MUST BE HOT—AT OPERATING TEMPERATURE.** Operate for at least 10 minutes before taking voltage reading to make sure the regulator is at operating temperature.

## REGULATOR REPLACEMENT

If the voltage setting cannot be made as outlined above or if the unit does not operate in a normal manner, replace the regulator unit and check for improvement in operation. Continued abnormal operation with a new unit indicates some trouble not resulting from the regulator.

## STEP VOLTAGE CONTROLS

Model No.	VOLTAGE CONTROL UNIT								CUT-OUT RELAY			
	Air Gap (Inches)	Point Opening (Inches)	Contact Spring Tension (Oz.)	Armature Travel (Inches)	Points Open (Volts)		Points Close (Volts)		Air Gap (Inches)	Point Opening (Inches)	Points Close (Volts) 70° F.	Points Open (Amps. Reverse Current)
					70° F.	180° F.	70° F.	180° F.				
5542	.035	.010	.7-.9	.035	8.3-8.7	7.75-8.2	7.25-7.75	6.55-7.1	.015	.020	6.3-6.9	0-3.0
5849	.045	.015	.7-1.4	.045	14.1-14.7	14.1-14.7	12.0 max.	12.0 max.	.015	.020	12.9-13.9	0-4.0
5850	.035	.010	.7-.9	.035	8.3-8.7	7.75-8.2	7.25-7.75	6.55-7.1	.015	.020	6.3-6.9	0-3.0
5859	.015	.022	.7-.9	.060	28.5-31.5	26.5-28.5	15.0 max.	15.0 max.	.020	.030	24.5-27.5	3.0 mx.
5869	.035	.010	.5-1.1	.035	7.45-7.85	6.95-7.35*	6.0 max.	6.0 max.*	.015	.020	6.3-6.9	0-4.0
5888	.045	.015	.7-1.4	.045	14.1-14.7	14.1-14.7	12.0 max.	12.0 max.	.015	.020	12.9-13.9	0-4.0
5889	.035	.010	.5-1.1	.035	7.45-7.85	6.95-7.35*	6.0 max.	6.0 max.*	.015	.020	6.3-6.9	0-4.0
5892	.035	.010	.5-1.1	.035	7.45-7.85	6.95-7.35*	6.0 max.	6.0 max.*	.015	.020	6.3-6.9	0-4.0

\*—Voltage at 150°

# REGULATOR SPECIFICATIONS

## STANDARD REGULATORS (Fig. 2-1)

Voltage Regulator Air Gap ..... .070 in.  
 Current Regulator Air Gap ..... .080 in.  
 Relay Air Gap ..... .020 in.  
 Relay Point Opening ..... .020 in.  
 Relay Points open with 0 - 4.0 amperes reverse current

Model		Current Regulator Setting (Amps) Hot*	Voltage Regulator Setting (Closed Circuit)† (Volts) Hot*	Cut-Out Relay Points Close (Volts) Hot*
5597‡	P	26-28	6.95- 7.15	6.9- 7.6
5598‡	P	16-18	14.1 -14.5	12.8-14.4
1118201	N	32-34	7.2 - 7.4	6.2- 6.7
1118204	P	—	7.2 - 7.4	6.2- 6.7
1118208	P	28-30	7.0 - 7.2	6.2- 6.7
1118210	P	16-18	14.0 -14.2	12.4-13.4
1118212	P	38-40	7.0 - 7.2	6.2- 6.7
1118214	P	24-26	14.0 -14.2	12.4-13.4
1118219	N	24-26	14.0 -14.2	12.4-13.4
1118225	P	14-16	14.0 -14.2	12.4-13.4
1118227	P	—	14.0 -14.2	12.4-13.4
1118229	N	34-36	7.0 - 7.2	6.2- 6.7
1118230	P	26-28	7.0 - 7.2	6.2- 6.7
1118232	P	34-36	7.0 - 7.2	6.2- 6.7
1118233	N	24-26	7.0 - 7.2	6.2- 6.7
1118248	P	9-11	14.0 -14.2	12.4-13.4
1118252	N	24-26	14.0 -14.2	12.4-13.4
1118253	P	28-30	7.0 - 7.2	6.2- 6.7
1118254	N	12-13	14.0 -14.2	12.4-13.4

P—Used with Positive Grounded Battery

N—Used with Negative Grounded Battery

\*—Hot—Operating Temperature

†—Operate Generator at Speed at Which It Will Produce Rated Output and Adjust Current to 8-10 Amps.

‡—Voltage Regulator Air Gap—.063 in., Current Regulator Air Gap—.075 in., V. & C. Reg. Point Opening—.020 in., V. & C. Reg. Contact Spring Tension—3.5 oz., V. & C. Reg. Fibre Bumper Clearance—.010 in.

## HEAVY DUTY REGULATORS (Fig. 2-2)

Voltage Regulator Point Opening ..... .015 in.  
 Current Regulator Point Opening ..... .015 in.  
 Relay Air Gap ..... .057 in.  
 Relay Point Opening ..... .020 in.  
 Relay Points open with 0 - 3.0 amperes reverse current

Spec. No.		CURRENT REG. Cur. Set. (Amps.)	VOLTAGE REGULATOR Volt. Setting (Open Cir.) 135°-145° F.	Generator R.P.M. for Vol. Setting	CT-OUT RELAY Pts. Close (Volts)
5529	P	—	15.0	1500	13.5
5535	P	—	15.0	1500	13.5
5538	P	—	8.5	2000	7.0
5562	—	10	30.0	1500	26.0
5610	N	55	15.0	2000	13.5
5613	N	20	15.0	1500	13.5
5615	—	50	30.0	1500	26.0

Spec. No.		CURRENT REG. Cur. Set. (Amps.)	VOLTAGE REGULATOR Volt. Setting (Open Cir.) 135°-145° F.	Generator R.P.M. for Vol. Setting	CT-OUT RELAY Pts. Close (Volts)
5624	P	10	30.0	1500	26.0
5625	P	25	30.0	1500	26.0
5626	P	10	30.0	1500	26.0
5628	P	25	7.5	1500	6.5-6.9
5629	P	25	15.0	1500	13.5
5632	P	17	15.0	1500	13.5
5633	N	55	15.5	2000	13.5
5634	P	55	15.0	2000	13.5
5635	N	55	15.0	2000	13.5
5636	P	57	15.0	1500	13.5
5638	N	55	15.5	2000	13.5
5639*	N	55	15.0	2000	13.5
5640	P	35	7.5	2000	6.5-6.9
5642	P	10	37.5	1500	33.0
5643	P	20	40.0	1500	35.0
5644	P	20	40.0	1500	35.0
1118453	N	40	15.0	1500	13.5
1118455	P	15	30.0	1500	26.0
1118458	P	10	30.0	1500	26.0
1118459	P	25	30.0	1500	26.0
1118461	P	14	37.5	1500	33.0
1118462	N	50	15.0	3000	13.5
1118463	P	12	30.0	1500	26.0
1118464	P	10	30.0	1500	26.0
1118465	P	25	15.0	1500	13.5
1118466†	P	75	28.0	3000	26.0
1118467	N	15	30.0	1500	26.0
1118468	N	40	7.5	2000	6.5-6.9
1118469	P	10	40.0	1500	35.0
1118470	N	50	30.0	2000	26.0
1118472	N	40	15.0	1500	13.5
1118473	N	50	15.0	3000	13.5
1118474	P	50	30.0	2000	26.0
1118475	P	25	15.0	1500	13.5
1118476	P	25	15.0	1500	13.5
1118478	N	50	30.0	2000	26.0
1118479	N	—	‡	2500	—
1118482	N	50	30.0	2000	26.0
1118483	N	50	15.0	3000	13.5
1118484	P	25	30.0	1500	26.0
1118485	N	20	15.0	1500	13.5
1118486	N	50	28.0	2000	26.0
1118487	N	50	30.0	1800	26.0
1118488	N	55	15.0	2000	13.5
1118489	N	25	15.0	1500	13.5

P—Used with Positive Grounded Battery

N—Used with Negative Grounded Battery

\*—Set Open Circuit voltage at 15.5 when large cylindrical filter and radio equipment are used.

†—Set voltage regulator air gap .018-.020 inch and point opening .005-.008 inch, cut-out relay air gap .050 inch, field relay air gap .010 inch, and field relay open circuit voltage 20 volts. Set field relay before voltage regulator.

‡—Voltage Regulator only. Set on closed circuit at 14.7 volts with 10 amperes current flowing.

# Generators

The generator is a machine which converts mechanical energy into electrical energy and it has the job of supplying current for lights, ignition, radio and other electrical equipment, and keeping the battery in a charged condition by replacing in the battery the energy consumed by the cranking motor in starting.

Generators may be divided into two categories, according to their fundamental design, third brush and shunt. While third brush generators are still in use on some specialized applications where the current demands are small and the operation is more or less constant speed, the shunt generator is in most common use today because of its improved low speed performance and the fact it does not taper off at high speed as does the third brush unit. The shunt generator requires some form of external current regulation, and the usual application incorporates a current regulator, voltage regulator and cut-out relay which operate together to provide control of the generator under all conditions of operation. (See THEORY OF REGULATION in the chapter on REGULATORS.)

## PERIODIC MAINTENANCE

A few simple checks, carried out at regular intervals, will insure that the generator will continue to perform its job and will not fail at some critical instant. The intervals given below are based on average operating conditions, they may be adapted to meet specialized operations.

### 30 DAYS OR 1,000 MILES

Check the connections and wiring in the generator to regulator to battery circuit. Check the pulley nut to be sure it is tight. Make sure the mounting bolts are tight and that the belt tension is correct.

The oil reservoir in the commutator end of the generator should be kept filled with light engine oil to the overflow hole. This usually requires the addition of 8-10 drops of oil every 1,000 miles. Generators with grease cups should have the grease cups turned down one turn. Keep grease cups filled with medium cup grease. Do not lubricate excessively since this might allow oil or grease to get on the commutator where it would gum and burn and reduce generator output.

Since the output of the shunt generator is dependent upon the setting of the current regulator, check the regulator as outlined in the chapter on REGULATORS.

The maximum output of third brush generators is dependent upon the position of the third brush. The third brush on many applications is fixed and cannot be adjusted, but the output on other third brush generators may be adjusted by moving the third brush in the direction of armature rotation to increase the output and in the opposite direction to lower the output. Third brush generator output should be checked and adjusted at the voltage specified since the generator output increases with voltage. Normally if the gen-

erator is checked with an accurate ammeter and a fully charged battery is in the circuit, the proper voltage will be developed. Where a fully charged battery is not available, connect a  $\frac{1}{4}$  ohm variable resistance into the circuit and cut in resistance until the proper voltage is obtained. NEVER SET OUTPUT ABOVE SPECIFIED SETTING AS THIS WILL RESULT IN GENERATOR FAILURE.

### 6 MONTHS OR 6,000 MILES

Remove cover band and inspect commutator and brushes. If thrown solder is found on the cover band, it indicates the generator has been developing excessive output. The generator must be removed, the leads resoldered in the commutator bars, the commutator turned down and mica undercut. After the generator has been reinstalled, the regulator setting must be checked and reduced to the specified value.

If the commutator is dirty, it may be cleaned with a strip of No. 00 sandpaper held against it with a piece of soft wood while the generator is operated. Blow out dust. NEVER USE EMERY CLOTH since emery may embed and wear the brushes rapidly. If the commutator is rough, out of round, or has high mica, it must be turned down in a lathe and the mica undercut.

Replace worn brushes. New brushes may be seated with a brush seating stone, an abrasive material which, when held against a revolving commutator, disintegrates, carries under the brushes, and seats them in a few seconds. If brushes wear rapidly, remove the generator and check for excessive brush spring tension.

### SEASONAL (FALL)

Disassemble the generator, clean all parts, replace worn parts. This provides a safeguard against generator failure in the field from accumulations of dust or grease, and normal wear of parts. The armature and fields should not be cleaned in any degreasing tank since this will injure the insulation. Ball bearings should be thoroughly cleaned and repacked with high melting point ball bearing grease.

The commutator should be trued in a lathe and the mica undercut, if necessary. All wiring connections should be carefully checked and resoldered if necessary, using rosin (not acid) flux.

## CHECKING INOPERATIVE GENERATOR

If the generator is not performing according to specifications, and the tests outlined in the chapter on REGULATORS have disclosed that the generator is definitely at fault, it may be checked as follows to determine location of trouble in the generator.

### NO OUTPUT

When no output can be obtained from the generator, remove the cover band and check for sticking brushes, gummed or burned commutator or other causes of

## CHECKING INOPERATIVE GENERATOR

poor contact between commutator and brushes. If the cause of trouble is not readily apparent, remove the generator from the engine and check further with a test light.

The actual procedure to be followed depends upon which type regulator is used with the generator, since the generator circuits are different for the two types. (Figures 2-1 and 2-2.) If the regulator is of the type shown in Figure 2-1, proceed as follows:

1. Test for ground by raising and insulating the grounded brush from the commutator and checking with the test lamp from the generator "A" terminal to the frame. If test lamp lights, indicating ground, raise other brush and check the field circuit and the commutator separately to locate ground. If a grounded field is found, check the regulator contact points, since this condition may cause burned or oxidized points.
2. If the generator does not show ground, check from the "A" to the "F" terminal with the test lamp. If the test lamp does not light, the field circuit is open.
3. If the field is not open, check for a shorted field with a battery of the proper voltage and an ammeter connected in series with the field. Proceed with care on this check since a shorted field will draw a high current. If a shorted field is found, also check the regulator contact points.
4. Open circuit in the armature is usually readily apparent, since this condition causes burned commutator bars. If the open is apparent (broken lead, bad connection at commutator bar) it may be repaired, the commutator turned down and the mica undercut. Otherwise, the armature may have to be replaced.
5. If the trouble has not yet been located, check the armature for short circuit on a growler.

If the generator from which NO OUTPUT can be obtained employs the regulator illustrated in Figure 2-2, proceed as follows:

1. Test for grounded armature by raising and insulating the grounded brush from the commutator and checking with the test lamp from the "A" terminal to the frame. If test lamp lights, raise other brush and check commutator and "A" terminal separately.
2. Test for grounded field by disconnecting field lead from grounded brush or frame and checking from the "F" terminal to frame.
3. If no ground is found, check the field circuit for open with the test lamp connected from the "F" terminal to the field lead which was disconnected from the grounded brush in the previous check.
4. If the field is not open, check for a shorted field with a battery of the proper voltage and an ammeter connected in series with the field. Proceed with care, since a shorted field will draw a high current. If either a shorted or grounded field is found, check

the regulator contacts since they may be burned or oxidized from these conditions.

5. Open circuit in the armature is usually readily apparent, since this burns commutator bars.
6. If the trouble has not yet been located, remove the armature and check it on a growler for short circuit.

### EXCESSIVE GENERATOR OUTPUT

Excessive output from a generator employing the type regulator as illustrated in Figure 2-1 is usually due to a grounded field circuit. This can be quickly detected by checking with the test lamp from the "F" terminal to the frame after the grounded brush has been raised from the commutator.

On a generator which uses the type regulator illustrated in Figure 2-2, excessive output may result from a shorted field, and this can be detected by measuring the field current draw with a battery and ammeter connected into the field circuit as already explained.

### UNSTEADY OR LOW OUTPUT

This condition may result in any generator from:

1. Loose drive belt.
2. Sticking brushes, low brush spring tension, or other condition which prevents good contact between brushes and commutator.
3. Commutator which is rough, out of round, dirty, or burned. Dirt in the slots or high mica also cause low or unsteady output. With these conditions, the commutator should be turned down in a lathe and the mica undercut. Burned bars, of course, indicate an open circuited armature, and the corrections outlined above should be made.

### NOISY GENERATOR

This condition may be caused by loose mounting, drive pulley or gear. Worn or dirty bearings may also cause noise. Brushes improperly seated may cause noise which can be eliminated by properly seating them with a brush seating stone as already explained. A bent brush holder may cause noise and requires replacement since it is difficult to properly realign a holder.

### POLARIZING GENERATOR

After the generator is reinstalled on the engine, or at any time that generator or regulator tests have been made, the generator must be REPOLARIZED to make sure that it has the correct polarity with respect to the system. This must be done BEFORE THE ENGINE IS STARTED. Two different procedures of polarizing the generator must be used, depending on the type regulator on the application. BE SURE TO ALWAYS DETERMINE WHICH REGULATOR IS USED SO THE CORRECT PROCEDURE WILL BE FOLLOWED.

#### Procedure for type shown in Figure 2-1

If the generator uses the type regulator shown in Figure 2-1, or the step-voltage control (Figure 2-12)

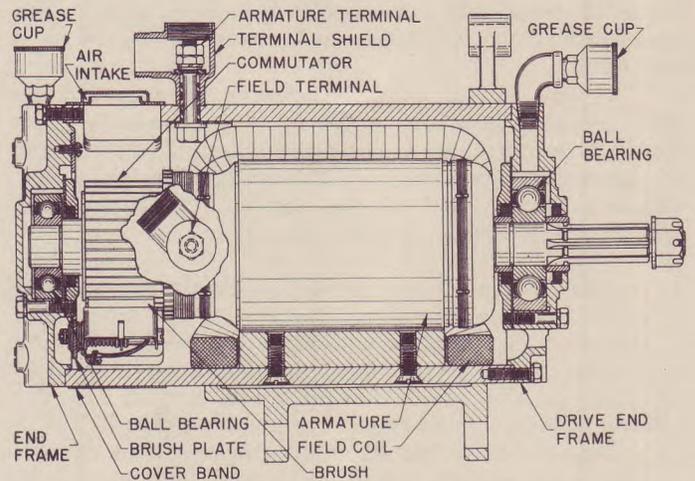
# CHECKING INOPERATIVE GENERATOR

polarize the generator by connecting a jumper lead momentarily between the armature and battery terminals of the regulator. This allows a momentary surge of current to flow through the generator from the battery which correctly polarizes the generator.

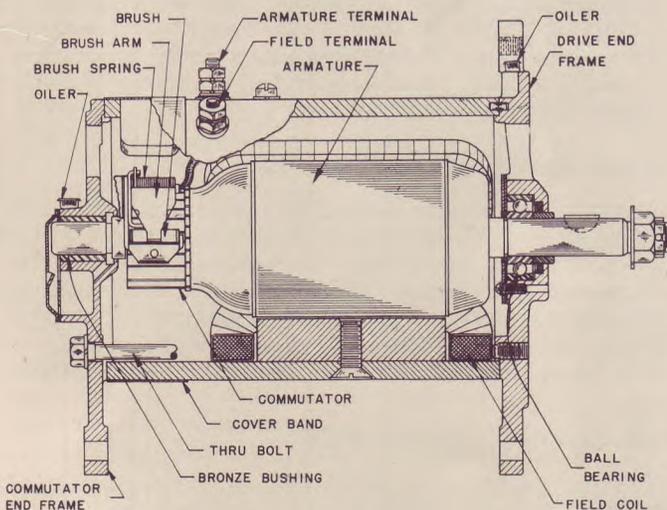
## Procedure for type shown in Figure 2-2

If the generator uses the type regulator shown in Figure 2-2, or the four unit regulator (Figure 2-30), polarize the generator by disconnecting the "F" terminal lead from the generator, and then momentarily connecting between this terminal and the insulated battery terminal with a jumper lead. (On insulated systems, connect momentarily from generator "F" terminal to each battery terminal, "F" terminal lead disconnected from the generator. Current will flow through the generator field windings from one battery terminal only.) This allows a flash of current to flow through the generator field windings which correctly polarizes the generator. The other method of polarizing the heavy-duty generators should not be used, since the armature resistance is low, and a high current will flow, causing damage, if the regulator armature and battery terminals are connected by a jumper lead.

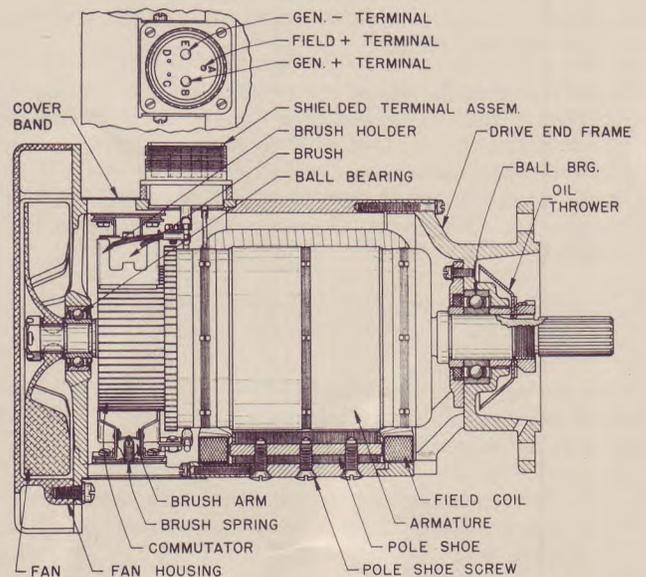
**CAUTION:** Never operate the generator with the field circuit connected and the "A" terminal lead disconnected (OPEN CIRCUIT OPERATION) since this would allow a high voltage to build up within the generator which would damage the fields and armature.



**FIGURE 3-2**  
6 9/16" Frame size, 55 ampere, 12 volt generator



**FIGURE 3-1**  
5 1/16" Frame size, 25 ampere, 6 volt generator



**FIGURE 3-3**  
Special 6" Frame size, 75 ampere generator with socket type fitting for wiring connections to regulator. This type generator is insulated, and the two main terminals are lettered "B" and "E."

# GENERATOR SPECIFICATIONS

## GENERATORS

	Rotation	Brush Spring Tension (oz.)	Field Current at 6 Volts (Amps)	COLD OUTPUT			HOT OUTPUT		
				Amps	Volts	Approx.R.P.M.	Amps	Volts	Approx.R.P.M.
674	C	25	3.53-3.75	28-30	7.0	1000	22-24	7.0	1200
677	CC	25	1.39-1.47*	24-26	13.0	1100	18	13.0	3000
692	C	25	1.26-1.33*	40	13.0	1250	Max. Output Controlled by Current Reg.		
916-G	C	25	1.25-1.45*	17	14.5-14.75	1250	Max. Output Controlled by Current Reg.		
934-D	CC	25	1.25-1.45*	17	14.5-14.75	1250	Max. Output Controlled by Current Reg.		
934-F	C	25	1.7 -2.0	26	8.1- 8.3	1325	Max. Output Controlled by Current Reg.		
934-T	C	25	1.25-1.45*	17	14.5-14.75	1250	Max. Output Controlled by Current Reg.		
948-R	C	25	2.3 -2.6	19-23	8.4- 8.8	2800	16-20	8.1- 8.5	3100
950	C	25	1.09-1.20*	50	13.0	1700	Max. Output Controlled by Current Reg.		
952	C	25	1.54-1.71*	54	13.0	1000	Max. Output Controlled by Current Reg.		
960-C	C	16	2.3 -2.6	19-23	8.4 -8.8	2800	16-20	8.1- 8.5	3100
966	C	25	1.54-1.71*	54	13.0	1000	Max. Output Controlled by Current Reg.		
968-R	C	25	2.8 -3.2	23-26	8.8- 9.2	2000	19-22	8.4- 8.8	2000
983-985	C	25	1.54-1.71*	54	13.0	1000	Max. Output Controlled by Current Reg.		
993	C	25	1.54-1.71*	55	13.0	950	Max. Output Controlled by Current Reg.		
995	C	25	0.76-0.84†	50	26.0	1670	Max. Output Controlled by Current Reg.		
998	C	25	.76- .84†	50	26.0	1670	Max. Output Controlled by Current Reg.		
999	CC	25	.76- .84†	50	26.0	1670	Max. Output Controlled by Current Reg.		
1100452	C	25	2.3 -2.6	17-20	8.2- 8.5	2400	13-15	7.7- 8.0	3000
1100456	C	25	2.3 -2.6	19-23	8.4- 8.8	2800	16-20	8.1- 8.5	3100
1100459	C	25	2.3 -2.6	18-21	8.2- 8.5	2400	15-18	7.9- 8.3	2900
1101354	C	16	3.5 -4.5	13-16	7.7-8.1	1800	9-11	7.3-7.6	1900
1101374	C	16	3.5 -4.5	11-13	7.5- 7.8	1800	9-11	7.3- 7.6	2100
1101382	C	16	3.5 -4.5	11-13	7.5-7.8	1800	9-11	7.3-7.6	2100
1101662	C	17	4.0 -6.1	19-22	8.3-8.7	1550	9-12	7.3-7.7	1800-2000
1101675	C	16	4.0 -6.1	15-17	7.9-8.15	1400	11-14	7.5-7.85	1700-1800
1101681	CC	16	4.0 -6.1	15-17	7.9-8.15	1400	11-14	7.5-7.85	1700-1800
1101714	C	25	1.5 -1.65*	18-21	15.0	3400	15-18	15.0	3500
1101747	C	16	1.5 -1.67*	8-10	14.4-14.9	2200	6-8	14.1-14.5	2400
1101751	C	25	1.5 -1.67*	8-10	14.4-14.9	2200	6-8	14.1-14.5	2400
1102423	C	25	1.4 -1.5	16-19	8.0- 8.4	1700	12-15	7.6- 8.0	1800
1102527	C	16	2.5 -3.0*	11-13	15.1-15.5	1700	7-9.5	14.2-14.8	2000
1102667	C	25	1.67-1.82	30	8.0	1750	Max. Output Controlled by Current Reg.		
1102670	C	25	1.67-1.82	30	8.0	1750	Max. Output Controlled by Current Reg.		
1102673	C	25	1.67-1.82	30	8.0	1750	Max. Output Controlled by Current Reg.		
1102674	C	25	1.67-1.82	30	8.0	1750	Max. Output Controlled by Current Reg.		
1102678	C	25	1.67-1.82	30	8.0	1750	Max. Output Controlled by Current Reg.		
1102690	C	25	1.67-1.82	30§	8.0	1750	Max. Output Controlled by Current Reg.		
1102691	C	25	1.67-1.82	30§	8.0	1750	Max. Output Controlled by Current Reg.		
1102953	C	25	1.6 -1.7*	18	15.0	1480	Max. Output Controlled by Current Reg.		
1102955	C	25	1.6 -1.7*	18	15.0	1480	Max. Output Controlled by Current Reg.		
1102956	CC	25	1.6 -1.7*	18§	15.0	1480	Max. Output Controlled by Current Reg.		
1102957	CC	25	1.6 -1.7	18§	15.0	1480	Max. Output Controlled by Current Reg.		
1105377	C	25	1.35-1.55*	16-18	16.1-16.5	2400	11-13	15.1-15.5	2600
1105380	C	25	1.35-1.55*	16-18	16.1-16.5	2400	11-13	15.1-15.5	2600
1105381	C	25	1.35-1.55*	16-18	16.1-16.5	2400	11-13	15.1-15.5	2600
1105529	C	25	1.7 -2.0	28	8.0	1400	Max. Output Controlled by Current Reg.		
1105530	C	25	1.7 -2.0	28	8.0	1400	Max. Output Controlled by Current Reg.		

\*—Field Current at 12 Volts †—Field Current at 24 Volts ‡—Field Current at 32 Volts §—Output at given speed—not necessarily maximum output

# GENERATOR SPECIFICATIONS

## GENERATORS

	Rotation	Brush Spring Tension (Oz.)	Field Current at 6 Volts (Amps)	COLD OUTPUT			HOT OUTPUT		
				Amps	Volts	Approx.R.P.M.	Amps	Volts	Approx.R.P.M.
				Max. Output Controlled by Current Reg.					
1105734	C	25	1.25-1.45*	17	14.5-14.75	1250	Max. Output Controlled by Current Reg.		
1105753	C	25	0.63-0.69†	5-7	26.0	2000	4.5-6.5	26.0	2000
1105755	CC	25	0.84-0.92‡	6-8	34.0	1800			
1105778	CC	25	1.25-1.45*	17	14.5-14.75	1250	Max. Output Controlled by Current Reg.		
1105780	C	25	1.25-1.45*	17	14.5-14.75	1250	Max. Output Controlled by Current Reg.		
1105854	C	25	1.7 -1.9	25	8.0	1150	Max. Output Controlled by Current Reg.		
1105859	C	25	1.7 -1.9	25	8.0	1150	Max. Output Controlled by Current Reg.		
1105860	C	25	1.82-1.94	40	8.0	1850	Max. Output Controlled by Current Reg.		
1105861	C	25	1.82-1.94	40	8.0	1850	Max. Output Controlled by Current Reg.		
1105862	C	25	1.70-1.90	25§	8.0	1150	Max. Output Controlled by Current Reg.		
1105863	C	25	1.82-1.94	40	8.0	1850	Max. Output Controlled by Current Reg.		
1105864	C	25	1.82-1.94	40	8.0	1850	Max. Output Controlled by Current Reg.		
1105866	C	25	1.70-1.90	25§	8.0	1150	Max. Output Controlled by Current Reg.		
1105867	C	25	1.82-1.94	40	8.0	1850	Max. Output Controlled by Current Reg.		
1105868	C	25	1.70-1.90	25§	8.0	1150	Max. Output Controlled by Current Reg.		
1105902	C	25	1.1 -1.2*	26	15.0	1500	Max. Output Controlled by Current Reg.		
1105903	C	25	1.1 -1.2*	26	15.0	1500	Max. Output Controlled by Current Reg.		
1106257	C	25	1.53-1.67	26-28	7.0	1400	21-23	7.0	1600
1106403	C	25	1.77-2.0	35	8.0	1040	Max. Output Controlled by Current Reg.		
1106408	C	25	1.77-2.0	35	8.0	1040	Max. Output Controlled by Current Reg.		
1106453	C	25	1.2 -1.26*	16	15.0	1050	Max. Output Controlled by Current Reg.		
1106454	CC	25	1.2 -1.26*	16	15.0	1050	Max. Output Controlled by Current Reg.		
1106457	C	25	1.2 -1.27*	50	13.0	2500	Max. Output Controlled by Current Reg.		
1106458	C	25	1.40-1.48*	50	13.0	2750	Max. Output Controlled by Current Reg.		
1106459	C	25	1.40-1.48*	50	13.0	2750	Max. Output Controlled by Current Reg.		
1106501	C	25	0.78-0.84‡	10	32.5	1080	Max. Output Controlled by Current Reg.		
1106502	C	25	0.58-0.63†	10	26.0	1200	Max. Output Controlled by Current Reg.		
1106503	CC	25	0.58-0.63†	10	26.0	1200	Max. Output Controlled by Current Reg.		
1106504	C	25	0.58-0.63†	10	26.0	1200	Max. Output Controlled by Current Reg.		
1106505	CC	25	0.58-0.63†	10	26.0	1200	Max. Output Controlled by Current Reg.		
1106506	C	25	0.58-0.63†	10	26.0	1200	Max. Output Controlled by Current Reg.		
1106507	CC	25	0.58-0.63†	10	26.0	1200	Max. Output Controlled by Current Reg.		
1106539	C	25	0.8 -0.89†	12	26.0	1200	Max. Output Controlled by Current Reg.		
1106540	C	25	0.59-0.63†	15	26.0	1390	Max. Output Controlled by Current Reg.		
1106541	CC	25	0.49-0.53‡	10	35.0	1175-1225	Max. Output Controlled by Current Reg.		
1106542	C	25	0.49-0.53‡	10	35.0	1175-1225	Max. Output Controlled by Current Reg.		
1106543	C	25	.59- .63†	12	26.0	1200	Max. Output Controlled by Current Reg.		
1106544	C	25	.78- .84	10	35.0	1000	Max. Output Controlled by Current Reg.		
1106584	C	25	1.54-1.67	40	7.5	1080	Max. Output Controlled by Current Reg.		
1106593	C	25	0.91-0.98	35	8.0	1400	Max. Output Controlled by Current Reg.		
1106631	C	25	1.2 -1.27*	25	13.0	1300	Max. Output Controlled by Current Reg.		
1106635	CC	25	1.2 -1.27*	25	13.0	1300	Max. Output Controlled by Current Reg.		
1106638	C	25	1.20-1.27*	25	13.0	1300	Max. Output Controlled by Current Reg.		
1106647	C	25	1.2 -1.27*	25	13.0	1300	Max. Output Controlled by Current Reg.		
1106654	C	25	1.20-1.27*	25	13.0	1300	Max. Output Controlled by Current Reg.		
1106656	CC	25	1.2 -1.27*	25	13.0	1300	Max. Output Controlled by Current Reg.		
1106658	C	25	1.2 -1.27*	25	13.0	1300	Max. Output Controlled by Current Reg.		
1106659	C	25	1.2 -1.27*	25	13.0	1300	Max. Output Controlled by Current Reg.		

\*—Field Current at 12 Volts †—Field Current at 24 Volts ‡—Field Current at 32 Volts §—Output at given speed—not necessarily maximum output

# GENERATOR SPECIFICATIONS

## GENERATORS

	Rotation	Brush Spring Tension (oz.)	Field Current at 6 Volts (Amps)	COLD OUTPUT			HOT OUTPUT		
				Amps	Volts	Approx.R.P.M.	Amps	Volts	Approx.R.P.M.
1106702	CC	25	6.3 -6.8†				140	28.5	2500
1106703	C	25	2.54-2.67†	75	26.0	2475	Max. Output Controlled by Current Reg.		
1106706	CC	25	5.0 -5.35†				100	28.5	2500
1117032	C	25	1.26-1.33*	18	13.0	800	Max. Output Controlled by Current Reg.		
1117034	C	25	1.26-1.33*	18	13.0	800	Max. Output Controlled by Current Reg.		
1117040	C	25	.91-1.03‡	14	32.0	1250	Max. Output Controlled by Current Reg.		
1117041	C	25	1.26-1.33*	40	13.0	1250	Max. Output Controlled by Current Reg.		
1117042	CC	25	1.26-1.33	40	13.0	1250	Max. Output Controlled by Current Reg.		
1117205	C	25	1.28-1.39‡	20	35.0	900	Max. Output Controlled by Current Reg.		
1117207	C	25	0.96-1.05†	25	24.0	1300	Max. Output Controlled by Current Reg.		
1117208	CC	25	0.96-1.05†	25	24.0	1300	Max. Output Controlled by Current Reg.		
1117211	C	25	0.96-1.05†	25	24.0	1300	Max. Output Controlled by Current Reg.		
1117218	CC	25	0.78-0.84‡	25	35.0	1550	Max. Output Controlled by Current Reg.		
1117220	C	25	.96-1.05†	25	24.0	1300	Max. Output Controlled by Current Reg.		
1117301	C	25	.76- .84†	50	26.0	1670	Max. Output Controlled by Current Reg.		
1117303	CC	25	.76- .84†	50	26.0	1670	Max. Output Controlled by Current Reg.		
1117304	CC	25	.76- .84†	50	26.0	1670	Max. Output Controlled by Current Reg.		
1117305	CC	25	1.54-1.71*	55	13.0	950	Max. Output Controlled by Current Reg.		
1117307	C	25	1.54-1.71*	55	13.0	950	Max. Output Controlled by Current Reg.		
1117308	C	25	1.54-1.71*	55	13.0	950	Max. Output Controlled by Current Reg.		
1117547	C	25	.55- .60†	50	26.0	985	Max. Output Controlled by Current Reg.		
1117550	C	25	.55- .60†	50	26.0	985	Max. Output Controlled by Current Reg.		
1117551	C	25	.55- .60†	50	26.0	985	Max. Output Controlled by Current Reg.		
5362404	CC	25	5.0 -5.35†				100	28.5	2500

\*—Field Current at 12 Volts †—Field Current at 24 Volts ‡—Field Current at 32 Volts §—Output at given speed—not necessarily maximum output

# Cranking Motors

The automotive type cranking motor is a special overload motor capable of delivering a high horsepower for its size for short periods of time. In order to obtain this power from the unit without increasing the size, it is necessary to build the cranking motor with a minimum of resistance so a large current will be taken through it while cranking. It is consequently obvious that the cranking motor should be used for short periods only—approximately 30 seconds maximum—to avoid the possibility of failure due to overheating.

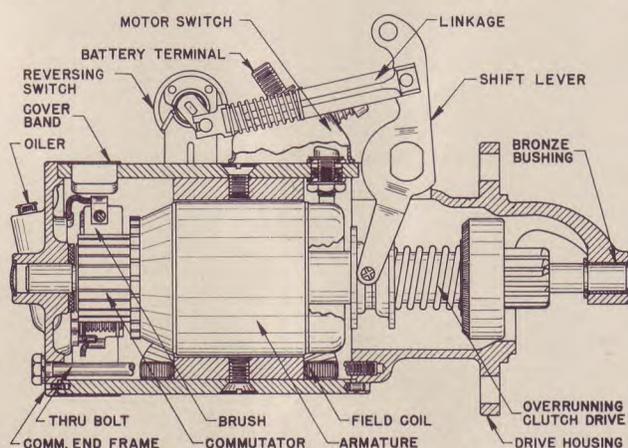


FIGURE 4-1

Cranking motor with overrunning clutch drive and reversing switch. (Page 48.)

## CRANKING MOTOR CONTROLS

Because of the high current flow from the battery to cranking motor during cranking, some positive means of connecting and disconnecting the battery and crank-

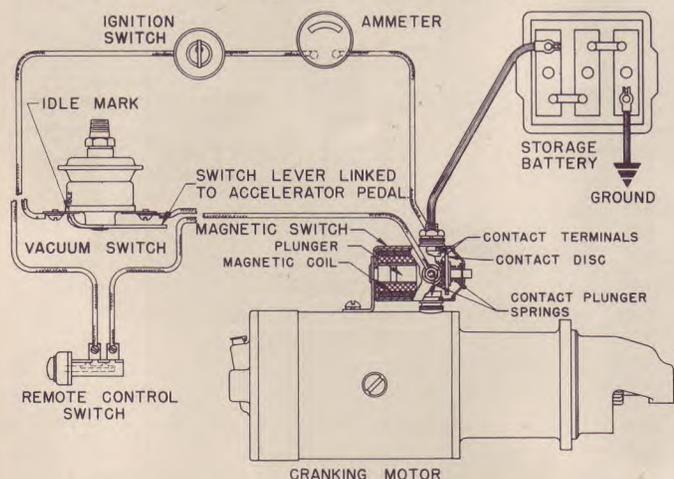


FIGURE 4-2

Bendix drive cranking motor with magnetic switch and control circuit.

ing motor must be used and the switch used must have contacts of adequate size to carry the current without burning. The manually operated switch (Figure 4-1)

mounted either on the floor board or the cranking motor frame, is the simplest type of switch and the one in most universal use.

Some applications with Bendix drive use a magnetic switch, a small electromagnet, which, when energized draws in a plunger and causes a contact disc to make contact between two terminals to complete the circuit from the battery to cranking motor. The magnetic switch winding may be energized in a number of ways; by a dash push button, a vacuum switch, the ignition switch, and combinations of these. (Figure 4-2)

Some applications with the overrunning clutch or Dyer type drive use a somewhat larger magnetic switch, called a solenoid switch, wherein the plunger not only thrusts against a contact disc to close the battery to cranking motor circuit, but the plunger is also linked to the shift lever so that the drive pinion is shifted into mesh with the flywheel teeth by the solenoid action. The solenoid switch may be controlled in various ways; dash push button, ignition switch, solenoid relay, and vacuum switch, and combinations of these.

## CRANKING MOTOR DRIVES

The cranking motor drive provides a means of meshing the cranking motor pinion with the flywheel to secure cranking and demeshing after the engine has started to avoid the excessive high cranking motor armature speed which would otherwise result. Two types of drives are in widespread use, the Bendix and the Overrunning Clutch, although there is a third type, the Dyer Drive, in use on heavier duty applications.

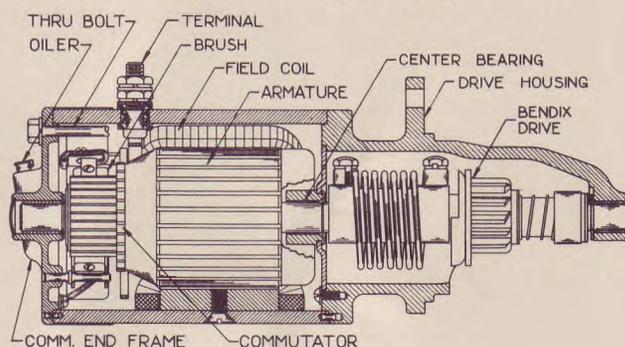


FIGURE 4-3

Bendix drive cranking motor

**Bendix Drive** (Figure 4-3). The pinion of the Bendix drive is mounted on a threaded sleeve which matches internal threads in the pinion. When the armature revolves, carrying the threaded sleeve with it, the inertia of the pinion does not allow it to pick up speed as rapidly as the armature. The result is that the threaded sleeve turns within the pinion, moving the pinion endwise and into mesh with the flywheel teeth so that cranking is accomplished. The Bendix spring takes up the sudden shock of meshing. When the engine begins to operate, the flywheel drives the pinion at a higher

# CRANKING MOTORS

speed than the threaded shaft is revolving; this causes the pinion to be turned relative to the threaded shaft, and in such a direction that the pinion is demeshed from the flywheel teeth.

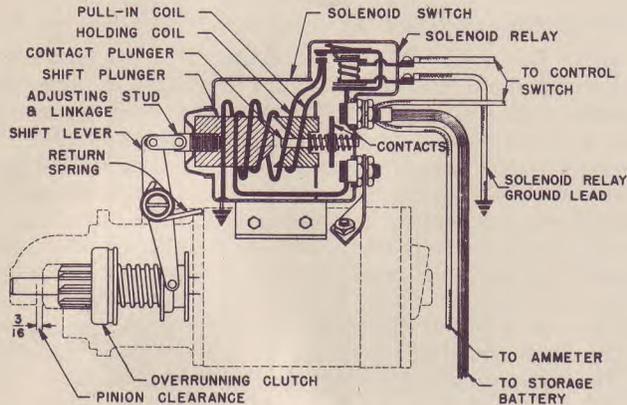


FIGURE 4-4

Overrunning clutch drive cranking motor with solenoid switch and relay.

**Overrunning Clutch Drive.** Regardless of whether the overrunning clutch type cranking motor is operated by a manual switch and shift (Figure 4-1) or by a solenoid switch and shift (Figure 4-4), the operation of the overrunning clutch is the same. In either case the shift lever moves the clutch assembly on the splined section of the armature shaft, shifting the pinion into mesh with the flywheel teeth. As the shift lever reaches its limit of travel, it closes the cranking motor switch contacts. Occasionally instead of meshing, the pinion teeth and flywheel teeth butt. When this happens, the clutch spring compresses and when the switch contacts close, the cranking motor armature turns only enough to align the teeth before full meshing takes place and cranking is accomplished.

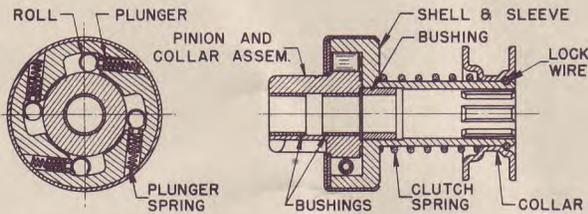


FIGURE 4-5

Details of overrunning clutch drive

After the engine begins to operate and before the pinion can be withdrawn from the flywheel teeth, the overrunning clutch (Figure 4-5) permits the pinion to overrun the cranking motor armature, thus preventing the armature from being driven at excessive speed. The overrunning clutch consists of a pinion and collar assembly, an outer shell with four rollers which tighten between the pinion collar and shell so cranking torque is transmitted, but loosen to permit the pinion to overrun the shell when the torque is in the opposite direction.

**Gear Reduction (Figure 4-6).** Some applications use a gear reduction in order to obtain improved cranking torque. Both the Bendix and Overrunning Clutch type cranking motor may use gear reduction.

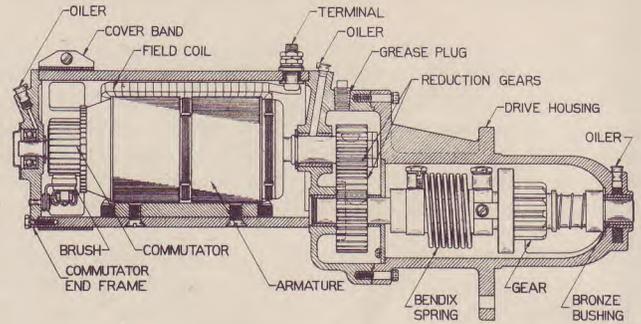


FIGURE 4-6

Bendix drive cranking motor with gear reduction

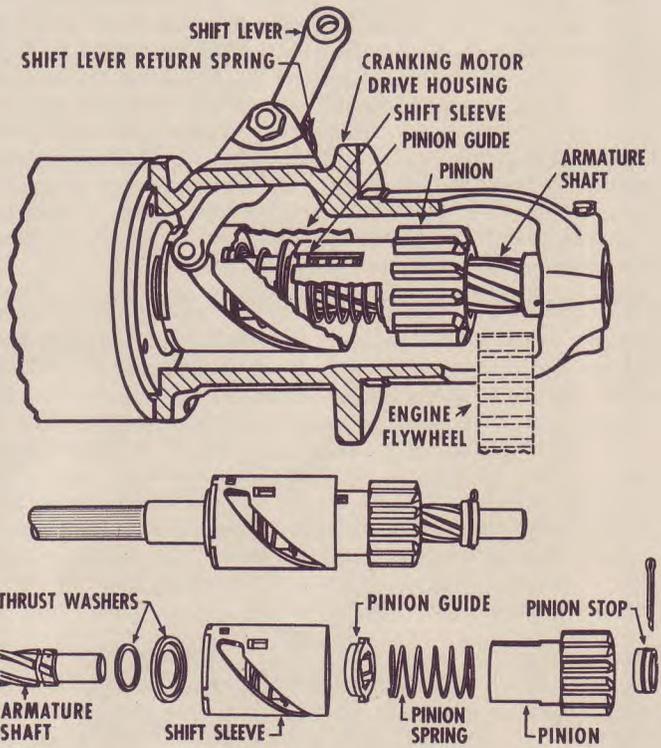


FIGURE 4-7

Dyer drive assembly. Lower view shows exploded view of component parts

**The Dyer Shift Drive** provides for positive meshing of the drive pinion with the flywheel before the cranking motor switch is closed and before the armature begins to rotate. This eliminates clashing of pinion teeth with flywheel teeth and the possibility of broken or burred teeth on either the engine flywheel or the drive pinion. The Dyer Shift Drive is used on heavy-duty applications where it is very important to avoid clashing of gears because of the high horsepower developed in cranking such engines.

## PERIODIC MAINTENANCE

The Dyer drive mechanism consists of thrust washers, a shift sleeve, pinion guide, pinion spring, pinion, pinion stop and cotter pin. The pinion guide is a snug fit on the spiral splines of the armature shaft, while the pinion, which has internal splines matching the armature splines, fits loosely on the armature shaft splines.

In the position shown in Figure 4-7, the drive assembly is at rest. The drive pinion is retained in this position by the pinion guide which drops into milled notches in the armature shaft splines. The pinion can be released from this position only by movement of the pinion guide through operation of the shift lever.

When the shift lever is operated, the movement causes the shift sleeve, pinion guide, pinion spring and pinion to be moved endwise along the armature shaft so the pinion meshes with the flywheel teeth, provided the teeth align properly. Further movement of the shift lever closes the cranking motor switch, and cranking takes place. If the teeth are not aligned and meshing cannot take place at once, the pinion is rotated against the flywheel teeth until the teeth do align and meshing is accomplished. The reason the pinion rotates is that it is a loose fit on the armature shaft splines, while the pinion guide is a tight fit. The continued forward movement of the pinion guide causes it to rotate as it follows the spiral splines on the shaft. This rotation is transmitted by means of the two lugs on the pinion guide to the pinion. The pinion rotates without any forward movement until alignment of the teeth takes place, then the pinion is thrust forward into mesh.

The pinion stop limits forward movement of the pinion. As the shift lever completes its travel, it closes the cranking motor switch which is linked mechanically with the shift lever. The motor armature begins to rotate. The shift sleeve is carried back to its original position, rotating back out of the way. The instant that the engine begins to operate, it attempts to drive the pinion faster than the armature is turning, with the result that the pinion and pinion guide are spun back out of mesh with the flywheel teeth. The pinion guide drops into the milled section of the shaft splines, locking the pinion in the demeshed position.

It is impossible to start another cranking cycle without completely releasing the shift lever. The shift lever must drop all the way back to the "at rest" position. Then, when the cranking motor shift lever is again operated, it picks up the shift sleeve and causes it, the pinion guide, spring, and pinion to again move along the shaft into the meshing position.

### PERIODIC MAINTENANCE

A few simple checks, carried out at regular intervals, will go far in preventing failure of the cranking motor at some critical instant. The intervals given below are based on average operating conditions, they may be adapted for specialized operations.

#### 30 DAYS OR 1,000 MILES

Visually check connections, cables between cranking motor and battery. Check mounting bolts.

Lubrication and inspection — Add a few drops of light engine oil to the hinge cap oiler. On the type motor with grease cups, turn the grease cup down one turn, make sure the cup is filled with medium cup grease.

#### 6 MONTHS OR 6,000 MILES

Remove the cover band and inspect the commutator and brushes. If the commutator is dirty, it may be cleaned with a strip of No. 00 sandpaper held against it with a piece of soft wood while the cranking motor is operated with the ignition switch off. NEVER USE EMERY CLOTH since emery will embed in the commutator and cause rapid brush wear. Blow out dust. If the commutator is rough, out of round, or has high mica, it should be turned down in a lathe and the mica undercut. Replace worn brushes. If the brushes wear rapidly, it may be advisable to remove the cranking motor and check for excessive brush spring tension and roughness or high mica on the commutator.

#### SEASONAL (FALL)

Remove the cranking motor, disassemble it so all parts may be cleaned and worn parts replaced. Never clean the armature or fields in any degreasing tank since this would damage the insulation. Check the brush holders to make sure they are free on their pivots and have the proper spring tension. The commutator may be trued in a lathe if necessary and the mica undercut. Bearings, after cleaning, may be repacked with the proper grease. The gear housing on the gear reduction type unit may be repacked with graphite grease. On the type unit with oil wicks, the wicks should be saturated with oil before reassembly. Put a few drops of light engine oil on the oilless type bushing. Avoid excessive oiling.

The Bendix drive should be well cleaned and lubricated by the addition of a small amount of light engine oil. Avoid over oiling since this might cause the pinion to stick. If the pinion teeth are burred, replace the pinion. Check the drift pin spring since the pinion might tend to drift into mesh with the flywheel teeth while the engine is running if the spring is weak.

The Overrunning Clutch Drive internal mechanism is packed with a special high melting point grease in initial assembly and requires no further lubrication. Do not attempt to clean the clutch by grease dissolving or high temperature methods, since this would cause the clutch to lose its lubricant. If the pinion does not turn freely in the clutch in the overrunning direction, if it tends to slip in the opposite direction, or if the pinion is excessively loose, replace the clutch.

In reassembling the cranking motor, use rosin flux (never acid flux) to make soldered connections. It is desirable to submit the reassembled unit to No-load and Torque tests if such testing equipment is available, in order to make sure the unit will perform according to specifications.

Where the overrunning clutch shift is solenoid operated (Figure 4-4), the clearance between the pinion and the housing should be checked when the pinion is in the operating condition. This clearance should be 3/16" and is adjusted by turning the stud in the solenoid plunger in or out as required.

## SERIES-PARALLEL SYSTEM

On the Dyer Drive type cranking motor, extreme care must be used to reassemble the Dyer Drive parts in the correct relationship as shown in Figure 4-7. Notice particularly that the lugs on the pinion guide are assembled toward the pinion. When reassembling the stop, a new cotter pin should be used. A light grade of

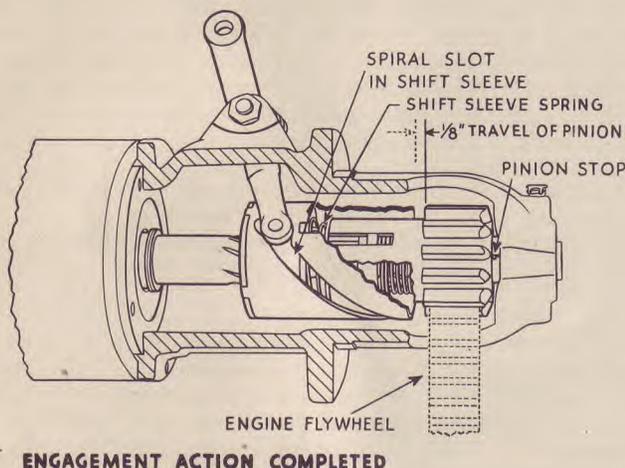


FIGURE 4-8

Pinion travel in Dyer drive assembly with pinion in cranking position

oil should be used on the parts before reassembly. No further lubrication will be required. Heavy oils or greases should not be used, as they would hinder the action of the drive.

The Dyer Drive adjustment may be checked, to make sure the travel of the pinion against the pinion spring is correct when the pinion is in the cranking position (Figure 4-8). When the shift lever is in the extreme forward position and the switch contacts in the solenoid or the switch are closed, there should be at least  $\frac{1}{8}$  to  $\frac{3}{16}$  inch travel of the pinion against the pinion spring pressure as indicated. This adjustment can be checked on solenoid controlled cranking motors by disconnecting the lead from the cranking motor to the solenoid and then using battery current through the solenoid to hold the shift lever in the cranking position. It will be necessary to move the solenoid plunger in by hand but the hold-in winding will hold it in so the pinion travel can be measured. Adjustment may be made on solenoid operated units by turning the plunger stud in or out of the solenoid plunger, as necessary. Adjustment may be made on the mechanically operated cranking motors by means of the screw and lock nut on the shift lever.

### SERIES-PARALLEL SYSTEM

On Diesel engines and similar applications where the cranking requirements are high, a higher voltage is often necessary in order to insure adequate cranking

performance. The series-parallel system is designed to provide a means of connecting two batteries in series to provide increased voltage for cranking, and reconnecting the two batteries in parallel for normal operation of the equipment after starting of the engine has been accomplished.

If, for example, two 12-volt batteries are connected in series, they will supply 24 volts. If the two 12-volt batteries are connected in parallel, they will supply but 12 volts. Two 6-volt batteries connected in series will supply 12 volts, and connected in parallel will supply 6 volts.

The series-parallel system makes use of a series-parallel switch which, when operated, disconnects the batteries from their parallel connections and reconnects them in series to the cranking motor. The diagram on page 35 shows the series-parallel switch contact position and the circuit with the batteries connected in series for cranking.

The cranking motor solenoid circuit is connected to ground, or to the plus terminal of the "A" battery, through a pair of contacts in the series-parallel switch. The other side of the solenoid is connected to the minus terminal of the "B" battery. This imposes 24 volts on the solenoid, so that it operates, pulling in the plunger, causing the cranking motor drive pinion to mesh with the engine flywheel, and closing the circuit from the batteries to the cranking motor. Since the two batteries are connected in series through the heavy contact disc and heavy contacts of the series-parallel switch, 24 volts are thus imposed on the cranking motor.

After cranking has been accomplished, the series-parallel switch pedal is released and the two batteries become connected in parallel to provide 12-volt operation of the equipment. Spring tension pulls the heavy series-parallel switch disc away from the heavy contacts, opening the series connections at the A-minus and B-plus terminals of the switch. At the same time, the small contacts within the switch, connected to the B-minus, the SW, or switch, and ground terminals, move to complete the circuit connecting batteries in parallel. Thus current from the generator, passing down this lead (A terminal) splits at the A-minus terminal, half of it entering the A battery, the other half going through the contacts in the series-parallel switch, down to the cranking motor and from there to the minus terminal of the B battery. The current from the A battery flows directly to ground back to the generator. The current from the B battery flows through the series-parallel switch to ground and then back to the generator. The ammeter at this terminal registers one-half the total current flowing from the generator to the batteries, the half which is entering and charging battery B. This provides a check on the operation of the system. When load demands require withdrawal of current from the batteries, with the batteries connected in parallel, the load is split between the two batteries, half the current required being withdrawn from each.

During the cranking interval, the 12-volt supply for lights and other accessories is taken from the A battery only, as can be seen from Figure 4-9.

## SERIES-PARALLEL SYSTEM

Extremely high currents are taken through the series circuits when the cranking motor is operated. It is consequently necessary to use care in operating the equipment, as well as in any repair work which might be performed on the vehicle. Careless grounding of a terminal by a wrench, or by an oil measuring stick, for example, may cause such a tremendous surge of current as to seriously damage the equipment. Normally, fuses are incorporated in the parallel circuits of the system to provide protection against damage from some careless action. The fuses may be inside the series-parallel switch terminals as shown here, or they may be included in the circuits outside the switch.

In addition to using fuses, all exposed terminals are often taped and shellacked so that terminals cannot be easily grounded.

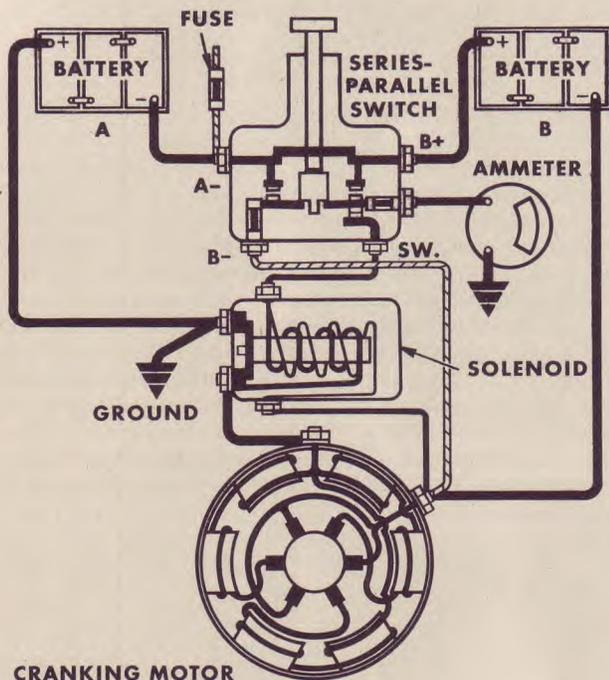


FIGURE 4-9

Series-parallel switch circuit. Switch shown in cranking position, with the series connections

This application, as with all cranking motors, is a special type cranking motor designed for intermittent service only. It must not be used for more than 30 seconds at a time, without an interval of two or more minutes to permit the cranking motor to cool off. Excessively long cranking periods will cause serious damage to the cranking motor.

### RADIAL ENGINE CRANKING MOTORS

Radial engines employ special direct cranking motors with provision for hand cranking.

The drive mechanism is a Bendix multiple-disc clutch and meshing jaw. The meshing jaw is thrust forward into engagement with the driven member of the engine as the cranking motor starts to operate. This is ac-

complished by means of a friction oil seal in the cranking motor baffle plate or oil seal assembly which puts a drag on the outer diameter of the meshing jaw so it cannot rotate and is forced to move axially by action of the driving screw until the jaw engages with the engine. The multiple-disc clutch, consisting of a number of spring-loaded plates, transmits cranking torque to the meshing jaw but permits slippage to relieve the shock of engagement and protect the motor against damaging overload. After the engine starts to run, the driven jaw of the engine overrides the cranking motor meshing jaw (provided for by spring loading of the meshing jaw) and the engine rotation cannot be transmitted back to the cranking motor.

The hand crank arrangement is provided so engine can be turned over by hand after standing idle thus eliminating the possibility of damage to engine due to presence of oil in the lower cylinders. Hand cranking

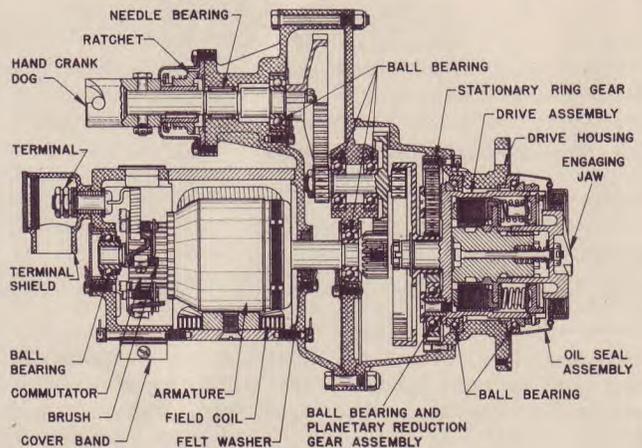


FIGURE 4-10

Special direct cranking motor with provision for hand cranking. Engagement of the driving jaw depends upon the friction of the oil seal against the outer flange of the engaging jaw. The clutch, an integral part of the drive assembly, slips upon initial engagement to take up the shock of engagement, and then transmits cranking torque without slipping. Failure to transmit cranking torque usually means the clutch has loosened and requires tightening. Special instruments and testing devices are required for this adjustment. The cranking motor, exclusive of the drive and gear train, operates, and is serviced, in a manner similar to other cranking motors.

also provides a means for timing the engine more easily. A ratchet is built into the hand crank drive to permit rotation in the cranking direction only. The purpose of the ratchet is to prevent harm to the cranking motor or to an operator who might be hand cranking at the time of an engine backfire.

Conventional type cranking motors normally transmit cranking torque to the engine through a flywheel ring gear, thus obtaining considerable gear reduction. In this direct cranking type as used on radial engines, an internal gear reduction is provided to enable the unit to deliver sufficient torque for direct cranking. A planetary gear set is used to obtain the final gear reduction step. Briefly, the operation of the planetary gear system and the drive mechanism is as follows: A sun gear mounts on a shaft at the center of the clutch barrel and is free to rotate on that shaft. Around the

## CHECKING AN IMPROPERLY OPERATING CRANKING MOTOR

sun gear and engaging with it are three planet gears mounted in ball bearings to studs on the clutch barrel. The planet gears also mesh with a fixed ring gear bolted and pinned in place in the drive housing. Rotation of the sun gear imparts rotation to the barrel through the planetary train.

Rotation of the barrel transmits motion through the multiple-disc clutch to an engaging nut which in turn imparts motion to the meshing jaw shaft. The meshing jaw nut has spiral splines on its inner bore that engage similar spiral splines on the outer diameter of the meshing jaw shaft. The meshing jaw shaft has external straight driving splines that match internal splines on the meshing jaw, imparting positive rotation to it but permitting axial movement.

Sealed lubrication is provided in all bearings in this type motor and no lubrication is required between overhaul periods. One caution should be noted in lubricating the gears at regular overhaul. Use only medium graphite grease (similar to Gredag No. 31) and avoid using too much grease. Excessive grease on the gears will cause serious frictional drag and impair the operation of the unit. Be sure to lubricate the hand crank ratchet and spline assembly.

Adjustment of clutch may be necessary occasionally when motor fails to transmit necessary torque for cranking. To tighten the clutch adjustment, the oil seal assembly must be removed and the wire locking ring lifted from the clutch adjusting nut. A special spanner wrench must then be used to turn the clutch adjusting nut. The correct adjustment of the clutch is tested by operating the motor against a special brake arranged to indicate running torque and slippage torque.

### CHECKING AN IMPROPERLY OPERATING CRANKING MOTOR

If the cranking motor does not develop rated torque and cranks the engine slowly or not at all, some indication of the source of trouble may be gathered by turning on the lights and attempting to crank.

1. If the lights go out as the cranking motor switch is closed, it is probable that a poor connection exists at the battery terminals or elsewhere in the circuit.
2. If the lights dim considerably, but still burn, it is likely that the battery is run-down. Or possibly there is some mechanical trouble either in the cranking motor or in the engine which makes it difficult for cranking to take place and an excessively high current drain on the battery consequently results.
3. If the lights do not dim, it indicates there is no current flowing to the cranking motor, due either to the cranking motor or the cranking motor switch being open.

The above checks give only an approximate idea of the source of trouble so that in an emergency it might be possible to effect a temporary repair which would bring in the vehicle. To make a systematic analysis of the cranking motor system, the first step would be to check

the battery specific gravity. Then the battery connections and cables should be checked, along with the cranking motor switch.

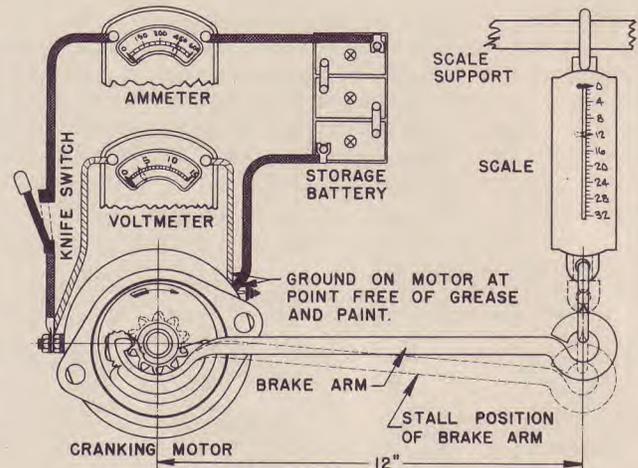


FIGURE 4-11  
Stall torque test of cranking motor

If all these are in order, remove the cover band and inspect the brushes and commutator. The brushes should form good contact with the commutator and the commutator must be reasonably clean and smooth. If it is not, it should be cleaned or turned down in a lathe as explained under PERIODIC MAINTENANCE, 6 MONTHS or 6,000 MILES above. If there are burned bars on the commutator, it may indicate open circuited armature coils which will prevent proper cranking. The remedy is to resolder the connections at the commutator riser bars and turn down the commutator in a lathe.

If leads have been thrown out of the armature slots, the indication is that the overrunning clutch caused the armature to be spun at an excessive speed due either to a defective clutch or to the fact that the operator of the vehicle was not starting the engine in the proper manner. If the operator opens the throttle too wide on initial starting or if he keeps the starter pedal depressed for too long after the starting has been accomplished, the overrunning clutch may overheat and partially bind so that the armature is spun at excessive speeds. In addition to ruining the armature, the overrunning clutch also will be ruined by such abuse. Evidences of excessive overrunning of the clutch are galling of the clutch bearings, depositing of bearing material on the armature shaft, and a smooth face in the collar on the side closest to the pinion.

Tight or dirty bearings or worn bearings, bent shaft or loose pole shoe screws which would allow the armature to drag will reduce armature speed or prevent the armature from turning.

If the brushes, brush spring tension, commutator, etc., all appear in good condition, it will be necessary to remove the cranking motor for further test.

### BENCH CHECKS

**No-Load Test**—Connect the cranking motor in series with a battery of the specified voltage and an ammeter

# CHECKING AN IMPROPERLY OPERATING CRANKING MOTOR

capable of reading several hundred amperes. If an r. p. m. indicator is available, read the armature r. p. m. also.

**Torque Test**—Torque testing equipment such as illustrated in Figure 4-11 may be used to determine if the cranking motor will develop rated torque. A high current carrying variable resistance should be connected into the circuit so the specified voltage at the cranking motor may be obtained since a small variation in the voltage will produce a marked difference in the torque developed.

## INTERPRETATION OF NO-LOAD AND TORQUE TESTS

1. Low free speed and high current draw with low torque:
  - a. Tight, dirty, or worn bearings, bent shaft or loose pole shoe screws.
  - b. Grounded armature or field. Check further by raising grounded brushes and insulating them from commutator and checking with a test lamp between the insulated terminal and frame. If test lamp lights, raise other brushes from commutator and check fields and commutator separately to determine whether the fields or armature are grounded.
  - c. Shorted armature. Check armature further on growler.
2. Failure to operate with high current draw:
  - a. Direct ground in switch, terminal or fields.
  - b. Frozen shaft bearings.
3. Failure to operate with no current draw:
  - a. Open field circuit. Inspect internal connections and trace circuit with a test lamp.
  - b. Open armature coils. Inspect commutator for badly burned bars. Running free speed, an open armature will show excessive arcing at the commutator bar which is open.

- c. Broken or weakened brush springs, worn brushes, high mica on the commutator or other causes which would prevent contact between the brushes and commutator.
4. Low no-load speed, with low torque and low current draw:
    - a. An open field winding. Raise and insulate ungrounded brushes from commutator and check fields with test lamp.
    - b. High internal resistance due to poor connections, defective leads, dirty commutator and causes listed under 3. c. above.
  5. High free speed with low developed torque and high current draw indicates shorted fields. There is no easy way to detect shorted fields, since the field resistance is normally low. If shorted fields are suspected, replace the fields and check for improved performance.

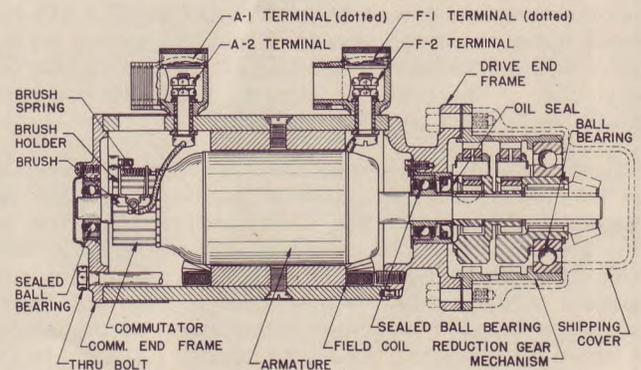


FIGURE 4-12

The unit illustrated here is not, strictly speaking, a cranking motor. It is included because it illustrates one special type of motor which Delco-Remy is supplying for specialized applications. This motor is a reversible type, and develops a high torque at the end of the gear train at the drive end. The unit has four terminals, so the leads from each brush and both ends of the field circuit, may be brought out to a control. On this particular unit, the ball bearings are of the sealed type, to minimize the service required.

# CRANKING MOTOR SPECIFICATIONS

## CRANKING MOTORS

Model	Rotation	Brush Tension oz.	NO-LOAD TEST			LOCK TEST		
			Amps	Volts	R.P.M.	Amps	Volts	Torque lbs. ft.
412	C	36-40	80	11.2	4500	670	5.35	32
494	C	24-28	70	5.0	2500	600	3.0	28
542	C	34-40	75	8.0	2000	500	3.5	45
572	CC	36-40	75	8.0	2000	500	3.5	45
578	C	36-40	65	12.0	4500	725	4.8	44
590	C	36-40	80	11.2	4500	670	5.35	32
644	C	36-40	75	8.0	2000	500	3.5	45
700	C	36-40	70	5.0	3000	500	3.0	19
702	C	36-40	85	22.0	6000	500	3.0	25
707	C	36-40	85	22.0	6000	500	3.0	25
711	C	36-40	85	22.0	6000	500	3.0	25
713	C	36-40	75	11.25	2400	700	5.0	51
721-G	C	24-28	70	10.0	3000	490	6.5	28
724	C	36-40	80	11.2	4500	670	5.35	32
733	C	36-40	100	12.0	6000	600	3.0	24
737B	C	24-28	65	5.0	6000	570	3.15	15
737-R	C	24-28	65	5.0	6000	570	3.15	15
737-T	C	24-28	65	5.0	6000	570	3.15	15
737-Z	C	24-28	65	5.0	6000	570	3.15	15
739	C	36-40	85	22.0	6000	500	3.0	25
753	C	36-40	65	12.0	4500	725	4.8	44
772	C	36-40	85	22.0	6000	500	3.0	25
790	C	36-40	75	11.25	2400	700	5.0	51
796	C	36-40	85	22.0	600	500	3.0	25
798	C	36-40	75	8.0	2000	500	3.5	45
815	C	36-40	90	23.3	6800	800	4.35	60
824	C	36-40	90	23.3	6800	800	4.35	60
829	C	36-40	100	30.8	8000	700	5.0	56
831	C	36-40	100	30.8	8000	700	5.0	56
833	C	36-40	90	23.3	6800	800	4.35	60
835	C	36-40	100	30.8	8000	700	5.0	56
1107009	C	24-28	65	5.0	5000	525	3.37	12
1107012	C	24-28	65	5.0	5000	525	3.37	12
1107033	C	24-28	65	5.0	5000	525	3.37	12
1107041	C	24-28	65	5.0	5000	525	3.37	12
1107047	C	24-28	65	5.0	5000	525	3.37	12
1107055	C	24-28	65	5.0	5000	525	3.37	12
1107059	CC	24-28	65	5.0	5000	525	3.37	12
1107410	C	24-28	65	5.0	6000	570	3.15	15
1107413	C	24-28	65	5.0	6000	570	3.15	15
1107418	C	24-28	65	5.0	6000	570	3.15	15
1107431	C	24-28	65	5.0	6000	570	3.15	15
1107813	C	24-28	65	11.35	6000	450	7.5	15
1107829	C	24-28	65	11.35	6000	450	7.5	15
1107905	C	24-28	60	5.0	6000	600	3.0	15
1107906	C	24-28	60	5.0	6000	600	3.0	16
1108114	C	24-28	80	10.0	7000	530	6.7	16
1108209	C	24-28	70	5.0	3500	600	3.0	22
1108210	C	24-28	70	5.0	3500	600	3.0	22

# CRANKING MOTOR SPECIFICATIONS

## CRANKING MOTORS

Model	Rotation	Brush Tension oz.	NO-LOAD TEST			LOCK TEST		
			Amps	Volts	R.P.M.	Amps	Volts	Torque lbs. ft.
1108212	C	24-28	70	5.0	3500	600	3.0	22
1108404	C	24-28	70	10.0	3000	490	6.5	28
1108406	C	24-28	70	10.0	3000	490	6.5	28
1108407	C	24-28	70	10.0	3000	490	6.5	28
1108408	C	24-28	70	10.0	3000	490	6.5	28
1108451	C	24-28	70	5.0	2500	600	3.0	28
1108531	C	24-28	70	10.0	2800	530	6.7	33
1108533	C	24-28	70	10.0	2800	530	6.7	33
1108537	C	24-28	70	10.0	2800	530	6.7	33
1108538	C	24-28	70	10.0	2800	530	6.7	33
1108563	C	24-28	20	23.8	3700	212	19.75	20
1108676	C	24-28	65	11.35	6000	450	7.5	15
1108678	C	24-28	65	11.35	6000	450	7.5	15
1108679	C	32-36	100	11.0	150	240	9.7	150‡
1108681	C	32-36	50	23.0	160	130	21.6	150§
1108704	C	36-40	100	11.6	5000	570	2.3	20
1108705	C	36-40	100	11.6	5000	570	2.3	20
1108713	CC	36-40	100	11.6	5000	570	2.3	20
1108714	C	36-40	100	11.6	5000	570	2.3	20
1108730	C	36-40	100	11.6	5000	570	2.3	20
1108907	C	36-40	80	11.2	4500	670	5.35	32
1108920	C	36-40	70	5.0	3000	500	3.0	19
1108923	C	36-40	80	11.2	4500	670	5.35	32
1109104	C	36-40	65	12.0	4500	725	4.8	44
1109118	C	32-36	30	32.0	8400	200	7.4	28
1109306	C	36-40	115	30.7	7250	500	4.3	25
1109312	CC	36-40	85	22.0	6000	500	3.0	25
1109313	CC	36-40	85	22.0	6000	500	3.0	25
1109314	CC	36-40	85	22.0	6000	500	3.0	25
1109315	C	36-40	85	22.0	6000	500	3.0	25
1109316	*	36-40	85	22.0	6000	500	3.0	25
1109317	CC	36-40	85	22.0	6000	500	3.0	25
1109318	CC	36-40	85	22.0	6000	500	3.0	25
1109319	CC	36-40	85	22.0	6000	500	3.0	25
1109406	CC	36-40	100	23.4	375	500	19.8	600
1109407	*	47-52	10	24.0	200	74	23.4	90‡
1109454	C	24-28	60	5.7	6000	540	3.3	11.5
1109655	CC	24-28	75	11.25	7000	590	6.1	18

\*—Clockwise and counterclockwise rotation  
‡—Running torque at 45 r.p.m.  
||—Running torque at 75 r.p.m.

‡—Running torque at 60 r.p.m.  
§—Running torque at 74 r.p.m.

# The Ignition System

The ignition system (Figure 5-1) consists of a source of power (the battery or generator), the ignition coil, distributor, condenser, low and high tension wiring and spark plugs. The ignition has the function of producing and delivering high voltage surges to the correct cylinder spark plugs at the correct intervals and with the correct timing with respect to the engine. Each high voltage surge produces a spark at the spark plug gap

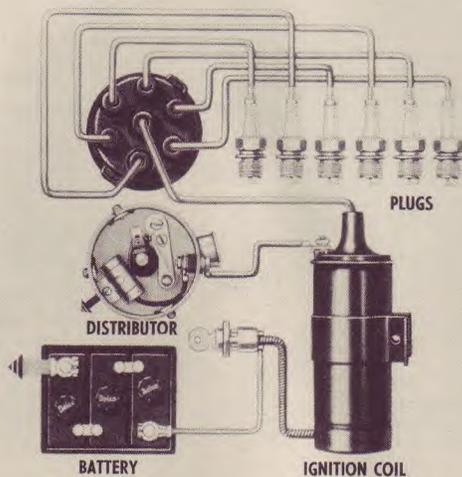


FIGURE 5-1

Schematic diagram of ignition system

which ignites the mixture of air and fuel drawn into the cylinder.

## OPERATION

There are two circuits in the ignition system, the primary and the secondary. The primary circuit is opened and closed by means of the circuit breaker cam and contact points on the distributor. When the contact points close, current from the battery begins to flow in the primary circuit. This causes a magnetic field to build up in the ignition coil. But the flow of current and consequently the magnetic field do not reach their maximums instantly. It takes a definite period, called the build-up time, for this to occur. This is because any change in the amount of current flowing in a winding, causing a change of magnetic strength, produces a **counter-voltage** which opposes the voltage causing the change. Normally the current and magnetic strength do not reach their possible maximum because the points remain closed for such a short time. However, coil characteristics are balanced with available build-up time so that even at top speed there is sufficient build-up for good ignition.

The points open when a cam lobe strikes the breaker lever rubbing block. The current attempts to continue to flow in the primary circuit as the points open and if it were not for the ignition condenser connected across the contact points the current would establish an arc across the points. The energy stored in the coil (in the form of magnetic flux) would be dissipated in this arc and

no high voltage surge would be induced in the coil secondary. However, the condenser momentarily provides a place for the current to flow and brings the flow of current to a quick, controlled stop. Consequently, the magnetic field in the coil, produced and sustained by the current flow, quickly collapses. The quick collapse of the magnetic field induces high voltages in both the primary and the secondary windings of the coil. The voltages induced are proportional to the turns of wire in the windings. A voltage of as much as 250 volts may be induced in the primary winding, and, therefore, the voltage in the secondary could go as high as 25,000 volts. However, the secondary voltage increases only to a value sufficient to establish a spark at the spark plug gap. Variations in voltage required are due to engine compression, speed, mixture ratios, spark plug temperatures, width of spark gap, etc.

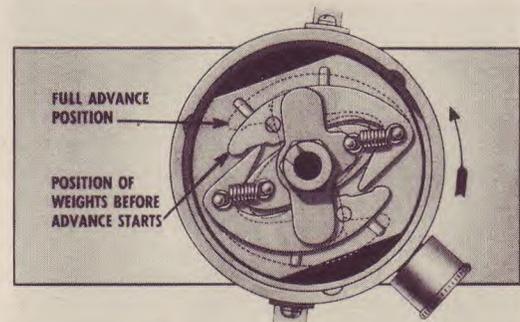


FIGURE 5-2

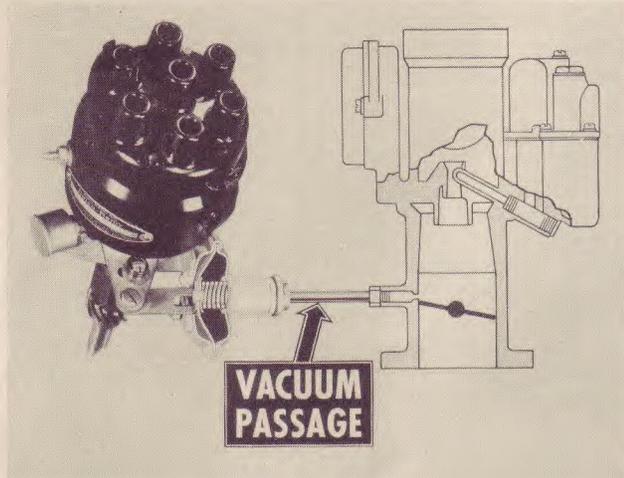
Centrifugal advance mechanism

The timing of the spark to the engine should vary according to engine speed and vacuum conditions in the intake manifold in order to realize maximum power and efficiency. Consequently, Delco-Remy distributors are equipped with a centrifugal advance mechanism (Figure 5-2) which consists of two weights which throw out against spring tension to advance the breaker cam with increased engine speed. This advances the timing of the spark in accordance with engine speed. The correct centrifugal spark advance for a particular engine is determined by operating that engine at wide-open throttle and varying the spark advance at each speed until the advance is found which gives maximum power. Centrifugal advance parts such as the weights, centrifugal cam and springs, are then selected to provide this advance.

Under part throttle operation there is a vacuum in the intake manifold and consequently the charge taken into the cylinder is not so highly compressed. With this condition an additional spark advance will increase fuel economy. Consequently on many applications where part throttle operation predominates, a vacuum advance mechanism (Figure 5-3) is used to secure this additional advance. The vacuum mechanism consists of a spring loaded diaphragm connected through linkage to the distributor. The spring loaded side of the diaphragm is air tight and is connected through a vacuum passage

## THE IGNITION SYSTEM—OPERATION

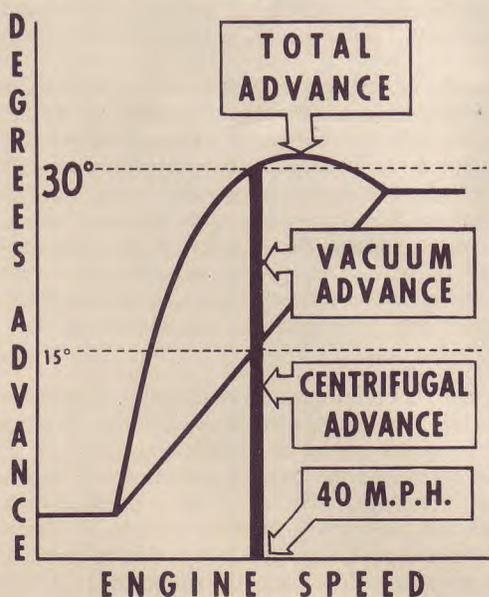
to an opening in the carburetor. This opening is on the atmospheric side of the throttle valve when the throttle is in the idling position. There is consequently no vacuum advance. When the throttle is opened, it swings past the opening of the vacuum passage. The intake



**FIGURE 5-3**  
Vacuum advance mechanism

manifold vacuum then moves the diaphragm and the distributor is rotated in its mounting. This produces a spark advance based on intake manifold vacuum. In addition to the type application which causes the complete distributor to be rotated for vacuum advance, there is another type where the breaker plate is supported on bearings and linked to the vacuum advance diaphragm so that the breaker plate alone is rotated for vacuum advance.

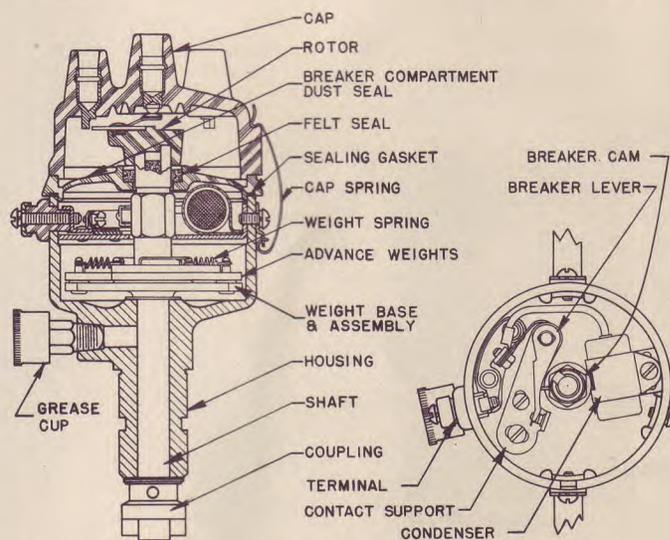
The total advance obtained is the result of centrifugal advance plus the vacuum advance. For example, in Figure 5-4, the centrifugal advance mechanism provides 15° advance at 40 m. p. h. Under part throttle op-



**FIGURE 5-4**  
Curve of vacuum and centrifugal advances

eration the vacuum mechanism may provide up to 15° additional advance for a total of 30° advance. With wide-open throttle, however, this vacuum advance would not be obtained; all advance would then be based on the operation of the centrifugal mechanism.

Some distributors which are liable to be operated in particularly dusty climates, are supplied with a breaker compartment seal and gasket assembly which seals off the breaker compartment and thus protects the contact points and other parts from dust (Figure 5-5).



**FIGURE 5-5**  
Dust proof distributor with breaker compartment dust seal

An inner felt washer seals against an extension on the breaker cam, while a gasket fits between the breaker compartment seal and the distributor housing. Whenever the cap and seal are removed, care must be taken to make sure the felt seal and gasket are in place on reinstallation of the cap and compartment seal. If the felt seal has become hard and filled with grit or dust, it should be replaced.

### MAINTENANCE

**Reversing switches** are used on some applications to reverse the flow of current through the distributor contact points every time the engine starts, as explained in Chapter 7. On this type of application, a special condenser is used. This condenser has a higher capacity than most condensers, and cannot be satisfactorily used on applications without the reversing switch. Therefore, if the reversing switch is removed from any vehicle, the condenser also should be removed, and a condenser of standard capacity installed. Neglecting to do this may cause rapid distributor point failure due to pitting.

**Contact Points** may be cleaned with a contact file or stone if they are pitted or burned and then readjusted. **NEVER USE EMERY CLOTH TO CLEAN POINTS,** since particles of emery may embed and burn. Contact points after considerable use will not appear smooth and bright, but this is not necessarily an indication that

## THE IGNITION SYSTEM—OPERATION

they are not functioning satisfactorily, since they may be making contact over a greater area than new points.

**Contact point opening** on or off the vehicle may be checked with a dial indicator, Figure 5-6, a device which measures accurately the movement of the mov-



DIAL INDICATOR  
METHOD OF SET-  
TING CONTACT  
POINT OPENING

FIGURE 5-6

Setting points with dial indicator

able point. A feeler gauge cannot successfully be used to accurately check the contact point opening of used contacts since it measures from high point to high point and not the true contact point opening. A feeler gauge may be used, however, in an emergency, but it must be remembered that the accurate settings required for best operation of modern engines cannot be made with a feeler gauge.



FIGURE 5-7

Cam or contact angle

Another method of measuring the point opening is by use of a cam or contact angle meter. The cam or contact angle (Figure 5-7) is the number of degrees the cam rotates between the instant the points close and the

instant they open again. This angle increases as the point opening is lowered and decreases as the point opening is increased.

**Contact point opening or cam angle** may be adjusted by loosening the locking screw holding the stationary contact support and turning the eccentric. After adjustment is made, tighten the locking screw and recheck the setting.

**Contact point pressure** is checked by using a spring gauge hooked to the lever arm as shown in Figure 5-8, and the pull exerted in the direction indicated. For the two types of arms, the tension should be as shown. Adjustment may be made by bending the breaker lever spring to increase or decrease the tension as required.

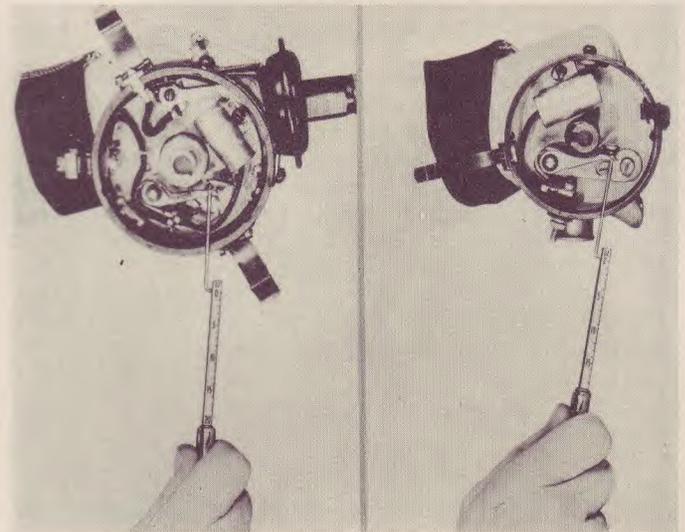


FIGURE 5-8

Measuring contact point pressure

**NOTE:** New breaker lever springs may have too much tension, therefore, after installing new points, always check the point pressure and adjust it if required.

**The centrifugal and vacuum advance mechanisms** may be tested on a synchroscope or distributor tester which checks their operation at the various distributor speeds and vacuum conditions the unit will encounter in operation. If the centrifugal advance mechanism does not provide the proper advance, it should be disassembled, the parts cleaned and oiled lightly and reassembled. A new vacuum advance mechanism should be installed if the original unit is not functioning properly since repair of this unit is not usually advisable.

**Timing** is accomplished by several methods, depending upon the provision made for timing by the engine manufacturer and the equipment available. Most applications have some marking on the flywheel or dynamic balancer which aligns with a pointer on the housing when number one cylinder is ready to fire. Other applications require the use of a piston position gauge. Whatever the method, timing is accomplished by loosening the distributor clamp and rotating the distributor in its mounting so the contact points will open with the proper relation to the position of the pistons in the cylinders.

## PERIODIC INSPECTION—TROUBLE SHOOTING

The **Ignition coil** requires a special testing instrument in order to determine its condition accurately. Two types of instruments are in general use, the spark gap or neon tube method, and the high frequency method wherein the condition of the coil is measured on a meter. There is always the possibility of error in the spark gap method but if properly handled, it will disclose a definitely bad coil in comparison with a known good coil of the same model number operated under identical conditions. The high frequency method (using a radio circuit type tester) on the other hand eliminates the human element in testing and will accurately determine the actual condition of the ignition coil and will detect such defects as shorted primary or secondary turns, high voltage breakdown in the secondary, high resistance in the primary, as well as an open circuited primary or secondary.

The **ignition condenser** also requires a special testing instrument in order to check the four conditions which affect condenser performance. These conditions are (1) breakdown of the insulation or shorting of the condenser internally, (2) low insulation resistance or leakage which prevents the condenser from holding a charge, (3) high series resistance due to a defective lead or poor connections and (4) capacity which determines the amount of electrical charge the condenser will take. All of these conditions must be taken into consideration in a complete check of the ignition system.

### PERIODIC INSPECTION

It is recommended that a systematic procedure of checking the units in the ignition system be followed. In addition, the distributor should be lubricated periodically.

#### 30 DAYS OR 1,000 MILES

Lubricate the distributor by turning the grease cup down one turn. Keep grease cup filled with medium cup grease. On the type unit with hinge cap oilers, add 8 to 10 drops of light engine oil every 1,000 miles. Lubricate high pressure grease fittings every 1,000 miles.

Remove the cap and check cap and rotor for chips, cracks or burned paths which would allow high tension leakage. Wipe out cap with a soft cloth. Check high tension wiring for frayed or damaged insulation and poor connections at cap, coil, or plugs. Inspect contact points. The contact point opening may be checked with the distributor on the vehicle by using either a dial indicator or a contact angle meter. If the points need cleaning this may be done on the vehicle. Use a clean, fine-cut contact file or stone. Never use emery cloth or sandpaper, since particles of sand or emery may embed in the point surface where they would cause arcing and burning. If points need replacement, remove the distributor from the vehicle, as this job can be done more easily on the bench. The position of the distributor and rotor should be noted before removing the distributor so the distributor can be replaced in approximately the same position. Only a small adjustment will then be required to complete the timing.

Check the vacuum advance mechanism on the type distributor which rotates the complete distributor for

vacuum advance by rotating the distributor in its mounting. It should rotate freely and the vacuum advance spring should bring it back to its original position when released, without sticking. On the type distributor where the breaker plate is supported on balls for vacuum advance, rotate the breaker plate. Check the centrifugal advance mechanism by rotating the breaker cam in the direction of its normal rotation. It should rotate freely and the advance springs should bring it back to its original position when released. These checks give a quick indication of the condition of the advances, a complete check requires the use of a synchroscope or distributor tester.

#### 6 MONTHS OR 6,000 MILES

In addition to the lubrication supplied the distributor every 30 days or 1,000 miles at the 6 month or 6,000 mile period the breaker cam should be lubricated with a trace of petrolatum and a few drops of light engine oil should be added to the felt wick under the rotor. Where the breaker plate is supported on balls, put a drop or two of light engine oil on each ball. Avoid excessive lubrication.

In order to eliminate the effects of the normal wear which takes place, it is advisable to remove the distributor, disassemble it, clean all parts, replace worn parts and reassemble the unit. While this can be done every 6 months or 6,000 miles, it may be necessary only seasonally, as every fall.

If testing equipment is available, the distributor may then be checked on a synchroscope, which will test the vacuum and centrifugal advances and the contact or cam angle. Test the condenser and coil on the proper testing instruments.

### IGNITION TROUBLE SHOOTING

Failure of the ignition system to perform in a normal manner may result from three fundamental causes:

1. Loss of energy in the primary circuit.
  - a. Resistance in circuit due to loose connections, defective leads, burned contact points or ignition switch contacts, open or partially open ignition coil primary winding.
  - b. Condenser defective; shorted, low insulation resistance, high series resistance.
  - c. Discharged battery.
  - d. Grounded primary circuit in coil, wiring or distributor terminal.
2. Loss of energy in secondary circuit.
  - a. Defective high tension wiring.
  - b. Defective connections in high tension circuit.
  - c. Plugs fouled, cracked, or out of adjustment.
  - d. High tension leakage across coil head, distributor cap or rotor.
  - e. Defective ignition coil—shorted primary or secondary turns, open or grounded secondary.
3. Out of time.
  - a. Timing off.
  - b. Centrifugal advance defective.
  - c. Vacuum advance defective.
  - d. Bearing or shaft worn, or shaft bent.

## QUICK CHECKS TO LOCATE TROUBLE

### QUICK CHECKS TO LOCATE TROUBLE

In order to determine which of the above is causing the trouble, a definite system of checking should be used. The following must be considered merely as quick checks to get an approximate idea of the location of trouble. This may be an aid in temporarily correcting the trouble in an emergency so the vehicle can be brought in for a more complete check. A complete analysis of the ignition system requires accurate testing instruments. Two separate sets of quick checks may be made, according to whether the engine will or will not operate.

**Engine will not run.** If the cranking motor cranks the engine at normal cranking speed, but the engine will not start, remove lead from one spark plug and hold lead terminal about 3/16 inch from engine block. If a good spark occurs while engine is being cranked, the ignition primary and secondary circuits are probably okay (1. and 2., p. 44) and the trouble is likely arising from an out of time condition (3., p. 44) or from some other trouble in the engine such as carburetion, etc.

If a spark does not occur, check the dash ammeter reading while cranking.

- A. If there is a small reading which shows some fluctuation while cranking, the primary is probably okay. The secondary is not delivering a spark due to d. or e. under condition 2., p. 43 (loss of energy in secondary circuit) or the condenser is defective.
- B. If there is no reading, the primary circuit is open, due to loose connections, defective wiring or switch, distributor points not making contact, or an open coil primary. Visual inspection of the points and the use of a test light will locate the source of this trouble.

- C. If the ammeter shows a reading of several amperes and the needle does not fluctuate while cranking, either the contact points are out of adjustment so they are not breaking, or the coil primary circuit is grounded, in the coil or externally.

If the cranking motor cranks the engine slowly or not at all, then the trouble probably lies either in the battery, cables or connections, or in the cranking motor.

**Engine runs, but will not perform satisfactorily.** This condition is probably the most difficult of all to analyze, because of the many other factors in addition to ignition which influence engine performance. While the usual recourse is a complete engine tune up which includes ignition, some indication of the cause of the trouble, if due to ignition, may, however, be deduced from the type trouble being experienced.

- A. Overheating may be caused by improper ignition timing.
- B. Detonation or spark rap, other than that produced by certain grades of fuel, may be caused by improper timing, improper operation of centrifugal or vacuum advance, points out of adjustment, worn distributor bearing or shaft, bent shaft, or plugs of wrong heat range.
- C. With missing, hard starting, or loss of power, a complete check of the ignition system should be made, since these conditions may be caused by anything from a low battery to defective spark plugs.

NOTE: The above complaints (A, B, and C,) may arise from other conditions in the engine besides ignition, but only a study of ignition is presented herein.

# DISTRIBUTOR SPECIFICATIONS

## DISTRIBUTORS

Model	Rotation	Cam Angle Deg.	START ADVANCE		INTERMEDIATE ADVANCE		MAXIMUM ADVANCE	
			R.P.M. Eng.	Deg. Eng.	R.P.M. Eng.	Deg. Eng.	R.P.M. Eng.	Deg. Eng.
622-D	CC	35	600	2.0	---	---	2200	16.0
623-H	C	35	600	1.0	1200	9.0	2200	17.0
640-Z	CC	35	600	1.0	---	---	2000	20.0
642-S	CC	35	600	2.0	---	---	2200	16.0
649-C	CC	35	400	1.0	---	---	1800	27.5
649-E	CC	35	600	3.0	1800	15.5	2200	17.0
4156	CC	37	500	3.0	800	14.0	3200	34.0
4169	CC	37	400	2.0	1200	17.0	1600	20.0
4178	CC	37	400	3.0	---	---	900	34.0
4212	CC	37	400	3.0	---	---	900	34.0
4223	CC	37	400	3.0	---	---	900	34.0
4241	CC	37	400	3.0	---	---	900	34.0
4242	CC	37	400	3.0	---	---	900	34.0
1110008	CC	35	600	1.75	---	---	3600	50.0
1110025	C	35	400	2.0	---	---	2200	18.5
1110030	CC	35	600	2.0	1400	14.5	2300	26.0
1110031	CC	35	500	3.0	800	14.0	3200	34.0
1110032	CC	35	500	3.0	800	14.0	3200	34.0
1110034	C	35	600	2.0	---	---	2200	22.0
1110039	CC	35	600	2.0	---	---	2600	20.0
1110052	CC	35	800	4.0	1200	11.0	3100	37.0
1110054	C	35	No Advance					
1110057	C	35	600	2.0	---	---	2200	22.0
1110059	CC	35	500	3.0	800	14.0	3200	34.0
1110062	CC	33	800	4.0	1200	11.0	3100	37.0
1110070	CC	35	400	2.0	1000	14.0	1600	20.0
1110075	CC	35	400	2.0	800	10.0	3400	32.0
1110081	CC	35	No Advance					
1110086	CC	35	600	2.0	---	---	2600	20.0
1110090*	CC	38	600	1.0	1200 2000	13.0 20.0	3450	39.5
1110095	C	35	600	2.0	1600	12.0	2600	18.0
1110098	CC	35	400	2.0	800	14.0	1800	24.0
1110100	CC	35	400	2.0	800	10.0	3400	32.0
1110104	CC	35	600	3.0	1200	11.5	3000	28.0
1110106	CC	35	600	1.0	1200 2000	13.0 20.0	3450	39.5
1110110*	CC	38	600	1.0	1200 2000	13.0 20.0	3450	39.5
1110111*	CC	38	600	1.0	1200 2000	13.0 20.0	3450	39.5
1110112	CC	35	600	2.0	---	---	2800	22.0
1110113	C	35	600	2.0	1600	12.0	2600	18.0
1110114	C	35	400	2.0	800	8.0	2400	22.0
1110115	C	35	400	2.0	---	---	2200	18.5
1110120	CC	35	400	2.0	800	10.0	3400	32.0
1110123	C	35	600	2.0	---	---	2200	17.0
1110125	CC	35	700	2.0	1000	8.0	2600	24.0

**NOTE:** Point opening on all distributors .018-.024 inch unless otherwise indicated.

\*—Point Opening .015-.021 inch.

# DISTRIBUTOR SPECIFICATIONS

## DISTRIBUTORS

Model	Rotation	Cam Angle Deg.	START ADVANCE		INTERMEDIATE ADVANCE		MAXIMUM ADVANCE	
			R.P.M. Eng.	Deg. Eng.	R.P.M. Eng.	Deg. Eng.	R.P.M. Eng.	Deg. Eng.
1110133	CC	35	400	2.0	1000	14.0	1600	20.0
1110134	CC	35	600	2.0	2400	12.0	3000	14.0
1110135	CC	35	400	2.0	800	10.0	3400	32.0
1110136*	CC	38	600	1.0	1200 2000	13.0 20.0	3450	39.5
1110137	CC	35	400	2.0	----	----	2000	32.0
1110143	C	35	400	1.0	----	----	1400	22.0
1110148*	CC	38	600	1.0	1200 2000	13.0 20.0	3450	39.5
1110149	CC	38	600	1.0	1200 2000	13.0 20.0	3450	39.5
1110150	C	35	600	2.0	1600	12.0	2600	18.0
1110151	CC	35	400	2.0	1000	14.0	1600	20.0
1110152	C	33	----	----	----	----	----	----
1110153	CC	35	400	2.0	800 1200	4.0 9.0	2000	14.0
1110156	CC	35	500	4.0	750	8.0	3400	32.0
1110157	C	35	400	2.0	----	----	2200	18.5
1110158	CC	35	500	3.0	800	14.0	3200	34.0
1110159	CC	35	600	2.0	----	----	2800	22.0
1110160	C	35	600	2.0	1600	12.0	2600	18.0
1110161	CC	35	300	0.5	1000	14.5	1800	22.5
1110162	CC	35	400	2.0	----	----	2100	24.0
1110163	CC	35	400	2.0	600	8.0	1200	37.0
1110165	CC	35	400	2.0	800	8.0	2400	22.0
1110167	CC	37	600	3.0	1200	11.5	3000	28.0
1110417	CC	32	500	4.0	----	----	1200	18.0
1110507	CC	35	800	2.0	2400	11.5	2800	12.0
1110609*	CC	31	1000	1.0	----	----	4000	24.0
1110810	CC	31	1000	1.0	----	----	4000	24.0
1111212	CC	37	430	2.0	----	----	1400	27.0
1111214	C	37	430	2.0	----	----	1400	27.0
1111404	CC	37	400	2.0	800	14.0	1800	24.0
1111405	CC	35	600	1.0	----	----	2000	20.0
1111506	C	35	500	3.0	----	----	1250	27.0
1111527	CC	37	500	2.0	2500	18.0	3000	22.0
SM1310	CC	35	400	2.0	----	----	1400	12.0

**NOTE:** Point opening on all distributors .018-.024 inch unless otherwise indicated.

\*—Point Opening .015-.021 inch.

## DISTRIBUTOR VACUUM CONTROL

Model	Inches of Hg. to Start Movement of Plunger	In. of Hg. for Full Plunger Travel	Total Plunger Travel (Inches)	Nominal Max. Advance Degrees (Engine)
680-N	7.0 Min.	9-13	5/32	10
1116009	4.5 Min.	8-10	3/16	15
1116011	6.0 Min.	12-15	7/32	16
1116015	5.0-7.0	11-14	1/4	12
1116017	5.0-7.0	11-14	1/4	12
1116019	5.0-7.0	11-14	1/4	12
1116026	7.0-8.5	16-20	11/64	20

# Horns and Horn Relays

Electrically operated horns are vibrating type units which operate on magnetic principles to produce the warning signal. They may be used singly or in matched pairs. When the circuit to the horn power plant is closed, the horn armature is attracted toward the pole causing a tension and slight movement of the diaphragm. This movement opens the horn contact points which allows the armature to return to its original position, relieving the tension on the diaphragm and permitting the horn contact points to close again. This cycle is repeated a great number of times a second, causing a rapid vibration of the diaphragm. Each horn is designed to operate at a predetermined number of cycles a second; the pitch of the horn depending upon the number of vibrations a second. The higher the frequency, the higher the pitch of the sound.

## MAINTENANCE

Other than checking the wiring connections and mounting, the horn will normally require no attention in service. If trouble is experienced, the following conditions which affect horn performance may be kept in mind.

**LOW VOLTAGE** at horns, due to a low battery, loose or corroded connections in the circuit, bad mounting or burned or pitted horn relay contact points, will cause a weak horn signal.

**LOOSE OR DAMAGED PARTS** in the horn will cause a rasping sound.

**OPEN, SHORTED, or GROUNDED CIRCUITS IN THE HORN** will prevent normal operation. These may be checked for with a test lamp and by connecting an

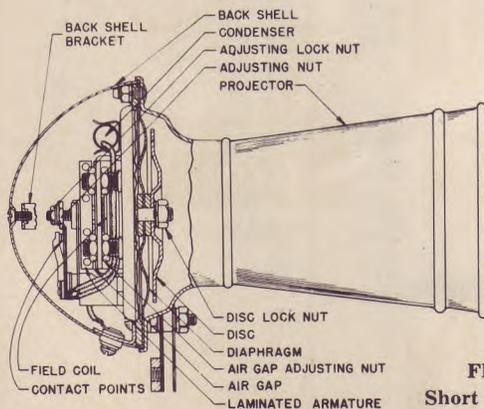


FIGURE 6-1  
Short projector horn

ammeter in series with the horn and a battery to check the horn current draw.

**ARCING AT THE CONTACT POINTS** may be caused by improper current adjustment, an open circuit in the condenser, or resistance unit normally connected across the contact points. Arcing produces oxide on the contacts which may be cleaned with a thin, fine-cut contact file.

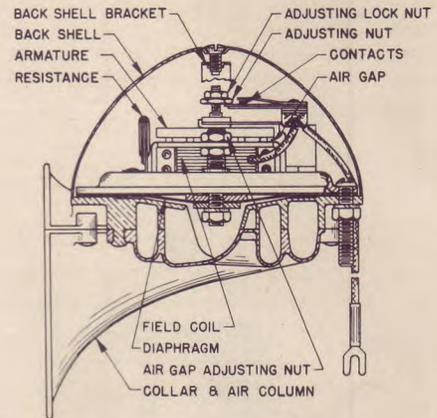


FIGURE 6-2  
Sea-shell horn

## ADJUSTMENTS (Figures 6-1, 6-2)

Remove the backshell and connect an ammeter into the circuit at the horn. Adjust horn current consumption by loosening the lock nut and turning adjusting nut. Turn to the left to increase the current and to the right to lower the current. Too much current causes a sputtering sound. This adjustment is very sensitive, therefore, turn the adjusting nut 1/10 turn and lock into position each time before trying horn.

The air gap between the armature and core must be uniform across the entire surface of the armature and may be adjusted by loosening the air gap adjusting nuts so the armature may be moved nearer or further from the core.

**NOTE:** On matched pairs of horns, the shorter projector horn has the higher note and should be so adjusted.

## HORN RELAY

Some applications use a horn relay, a magnetically operated switch connected into the horn and battery circuit and remotely controlled by a horn push-button.

(Figure 6-3). The relay completes the horn circuit directly from the battery to the horn, through the relay contact points. This eliminates the horn push-button and wiring in the steering column from the horn circuit, thereby increasing the voltage at the horns and providing improved performance.

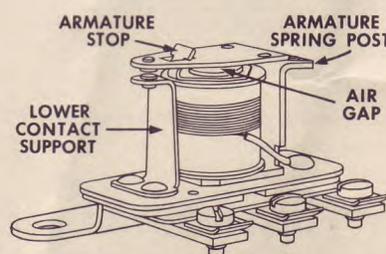


FIGURE 6-3  
Horn relay adjustments

## MAINTENANCE

Little attention need be given the horn relay other than checking the wiring connections and the mounting to see that they are tight. If the relay becomes inoperative, it should be checked as follows:

# Chapter 7 Switches

Various types of switches are used between the battery and the electrical units in the electrical system of the vehicle. The only service operation normally required is to check the connections and mounting for tightness. Inoperative switches normally are replaced since it is not practical to repair them.

## LIGHTING SWITCHES

A special type lighting switch, known as a **BLACK-OUT SWITCH** (Figure 7-1) is in use on many Army vehicles. This switch has a button on the switch knob which must be pushed down before the knob can be

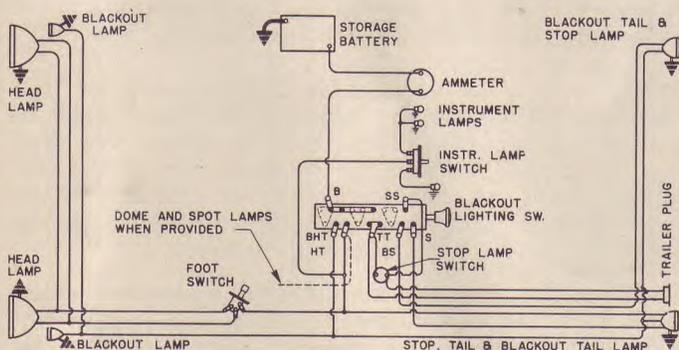


FIGURE 7-1

Wiring diagram of lighting circuit with black-out switch

pulled all the way out to obtain the service lights. If the button is not depressed, the knob can be pulled out only to an intermediate position to obtain the black-out lights. On other switches of a similar design, there are four, instead of three, positions. The fourth position provides stop lights only. Stop lights are inoperative with the light switch knob in the first position as shown in Figure 7-1.

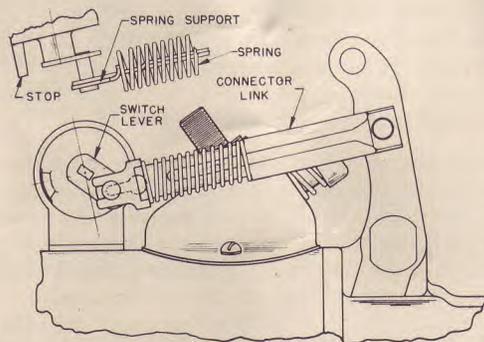


FIGURE 7-2

Details of reversing switch mounting

## REVERSING SWITCH

On some of the Chevrolet applications, a special reversing switch is used, the purpose of which is to reverse the direction of current through the distributor contact

points each time the cranking motor is operated. The reversing switch is mounted on the cranking motor and linked to the cranking motor shift lever as shown in Figure 7-2, and is connected into the ignition primary circuit as shown in Figure 7-3.

The breaker plate of the distributor is insulated from the housing and is connected through an insulated terminal to one of the switch terminals. The other insulated terminal of the distributor is connected to another of the switch terminals, while the third switch terminal is connected to the coil primary. When the three contactors are in the position shown dotted in Figure 7-3, the current flows in the circuit and through the contact points as shown by the arrows. When the cranking motor is operated, the contactors are carried around 60° to the position shown in Figure 7-4. In this position the current flows as shown by the arrows. This reversal of the direction of current flow each time the engine is started, cancels out any tendency to pit and as a result the points stay serviceable over a longer period of time.

On applications using the reversing switch, a special condenser is used. This condenser has a higher capacity than most condensers, and cannot be satisfactorily used on application without the reversing switch. Therefore, if the reversing switch is removed from any vehicle, the condenser also should be removed, and a condenser of standard capacity installed. Failure to do this may cause distributor contact point pitting.

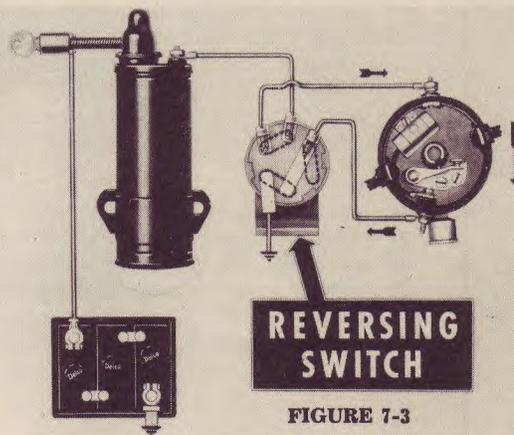


FIGURE 7-3

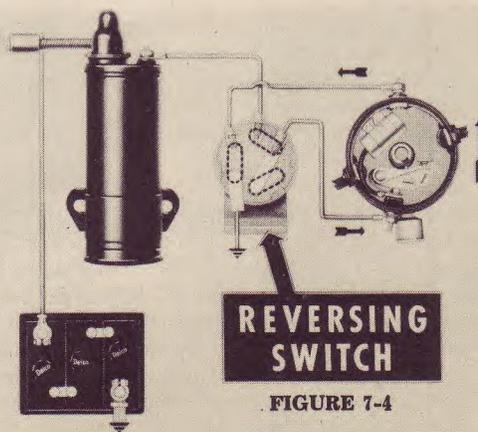


FIGURE 7-4

## MAINTENANCE—HORN RELAYS

AIR GAP between the armature and core is measured with the points held closed. Adjust by bending the lower contact support.

POINT OPENING is adjusted by bending the armature stop.

CLOSING VOLTAGE is checked by connecting a source of variable voltage (10 ohm resistance and battery is satisfactory) to the relay and increasing the voltage until the relay points close. Adjust by bending the spring post to increase or decrease the flat spring tension. Increasing the tension increases the closing vol-

tage, decreasing the spring tension lowers the closing voltage.

If the relay contact points are pitted or burned, they may be cleaned with a thin, fine-cut contact file.

### HORN RELAYS

Model	Air Gap (Points Closed) Inches	Point Opening Inches	Points Close— Volts
1116755*	.015	.020	7.0 -7.5
1116775	.015	.025	2.75-4.0

\*—3.5 oz. armature spring tension

## Chapter 8

# Radio Interference Elimination

In every motor vehicle there are a number of devices which produce radio interference. The ignition system is the worst offender because of the rapidly changing high voltage surges which take place in its circuits. These surges cause interference in two ways. First, some of their energy is radiated from the high tension leads, is picked up by the radio aerial, and produces interference. Second, some portion of the energy, in the form of high current surges, is sent from the coil primary back into the battery. If the same battery supplies power to a radio receiver, these high current surges will produce serious interference.

The generator circuits are also capable of causing serious radio noise. As each commutator bar passes under a brush, a tiny arc occurs and these arcs may cause interference in two ways, as above, by radiation, or by being conducted to the battery and hence to the radio receiver. The regulator also may be a source of radio interference.

All of the above interfering factors may be eliminated by the use of two different types of devices. The first, known as a shield, restricts the high frequency fields to the near vicinity of the wires in which the high frequency currents are flowing and the second, known as filters, are those which prevent high frequency currents from flowing in certain parts of the circuit.

### SHIELDS

The interfering fields which are set up about a wire have the wire as a starting place and the ground as a stopping point. In shielding, the wire is enclosed in a metallic sheath which is grounded so that none of the interfering radiation can escape and be picked up by the radio aerial.

### FILTERS

The filter systems employed in the Delco-Remy shielding systems use inductance and capacity. Inductance passes low frequency currents very freely, but opposes the flow of high frequencies. Capacity has the property of passing high frequency current, but opposing the flow of low frequency and of stopping direct current. The manner in which these are combined is illustrated

in Figure 8-1. The undesirable impulses enter at "A". The by-pass condenser furnishes an easy path to ground so that most of the high frequency impulses flow to ground through the by-pass. Any of the impulses which get past the condenser find it difficult to get through the inductance coil because of its strong opposition to the high frequency currents.

The filter, then, removes the undesirable impulses which enter with the direct current from "A" and permit only the direct current to get through. Such filters may be used between the regulator "BATTERY" terminal and the battery, and between the battery terminal of the ignition coil and the ignition switch.

It is well to consider the shielding as one component of the automotive electrical system and not as a separate device. A shielding system should be used only with the electrical equipment for which it has been designed and which has been designed to be used with shielding.

## MAINTENANCE

The only maintenance the shielding system will require is to periodically check the connections to make sure they are tight. A poor connection between a shield and ground may result in as much radio interference as if the electrical system had no shield at all.

One quick check which will disclose whether or not undue noise in the radio is caused by defective shielding or by the radio itself, is to disconnect the radio from the vehicle battery and operate it from an independent battery. Noise in the radio operated under this condition is due to some defect in the radio itself.

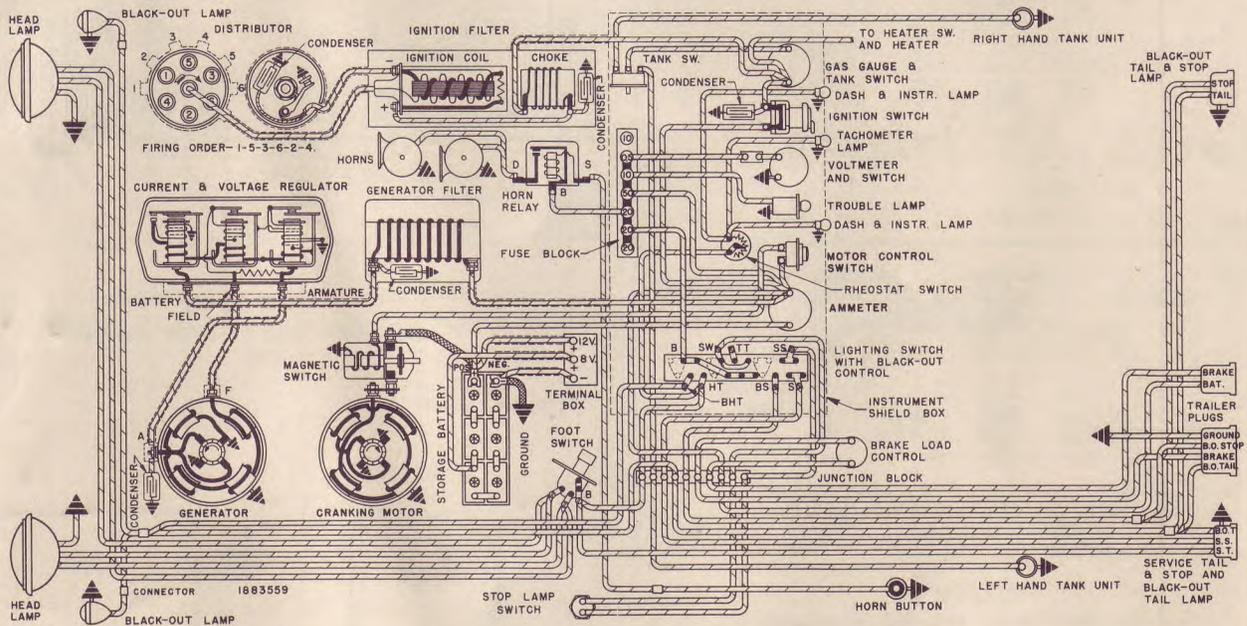
In order to assure proper assembly of spark plug cable shielding to the spark plug and to the distributor shield, the suggested order of procedure is as follows: (Refer to Figure 8-2).

- A. Unscrew the knurled nut indicated by (1) on the diagram. This separates the spark plug shield from the cable conduit.
- B. Assemble the spark plug into the plug shield. Place the spark plug gasket (4) over the threaded

# MAINTENANCE

- end of the plug **OUTSIDE** of plug shield. Assemble plug in engine and tighten securely.
- C. Before attaching cable conduit to spark plug shield, check to see that terminal spring (5) extends just  $7/32$  inch beyond the end of the bakelized tube (6).
- D. Place the terminal spring over the spark plug terminal stud and secure the cable conduit to the spark plug shield by screwing knurled nut (1) tight.

- E. In assembling cable conduit to distributor shield, first slide gasket (7) up tight to ferrule on conduit.
- F. Insert end of high tension wire into distributor shield and join cable conduit to distributor shield by tightening nut (9).
- G. After connecting all spark plug leads as described above, insert the high tension wires into the distributor cap terminals according to the engine firing order and direction of distributor rotation.



Typical wiring diagram of Army vehicle with shielded circuits, filters, and black-out lighting switch.

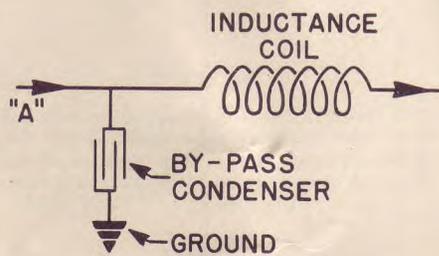


FIGURE 8-1

Coil and condenser circuit used with radio shielding

## SUPPRESSION TYPE SYSTEM

Instead of the combination filter and shielding system, described on p. 50, many applications make use of a number of small filters (Figures 8-6 to 8-7) and do not employ any shielding of the wiring between the electrical units. The filters, consisting of inductance and capacity, are placed at various points in the electrical system, where they operate to prevent interfering factors from entering the radio. Some filters consist of one condenser and inductance coil as shown in Figure 8-1, while others have two condensers, one on

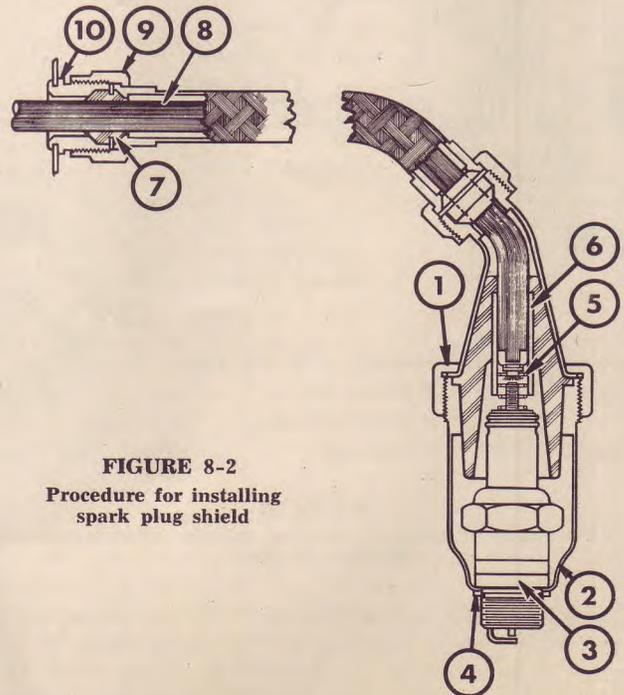
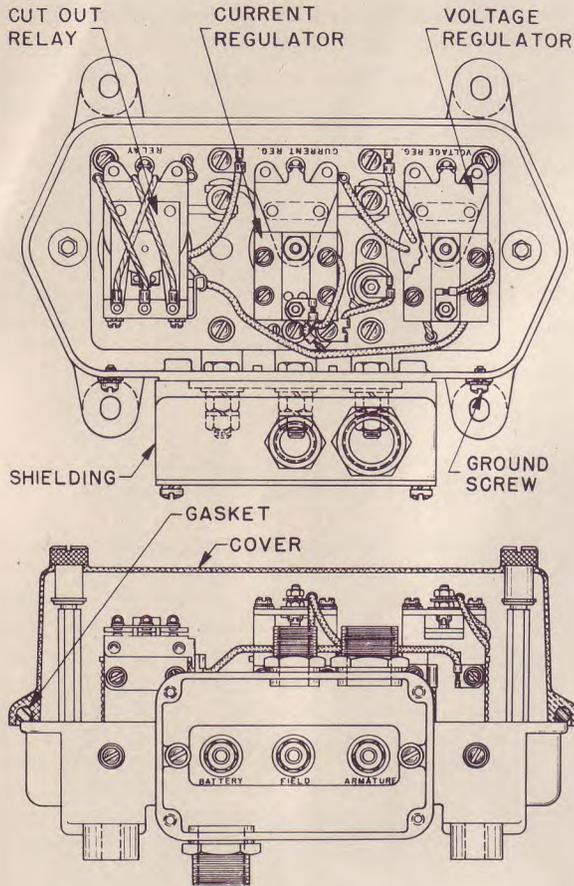
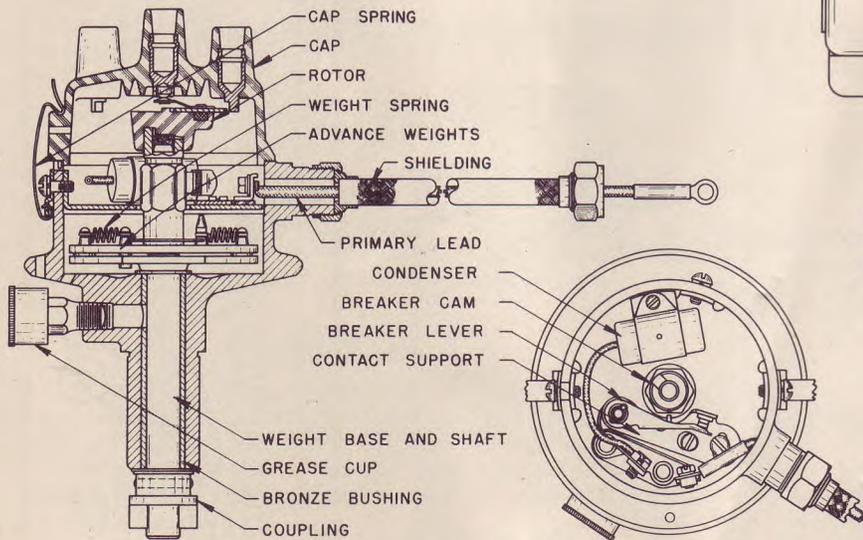


FIGURE 8-2  
Procedure for installing spark plug shield

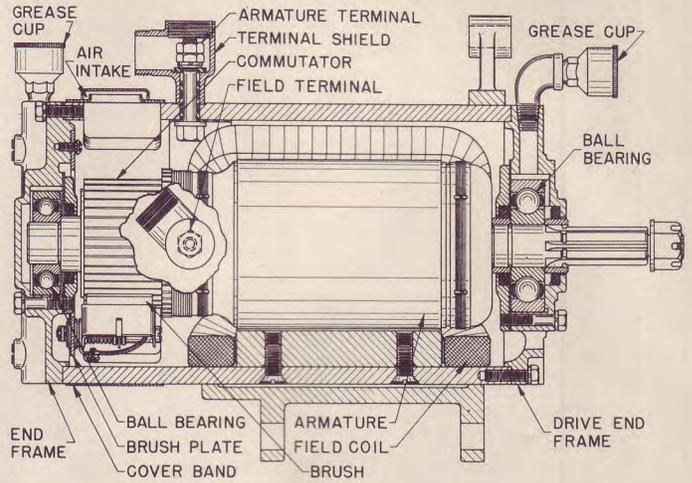
# MAINTENANCE



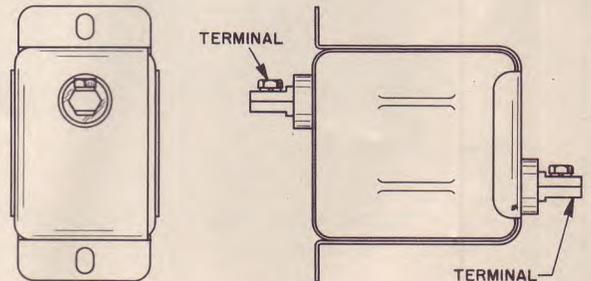
**FIGURE 8-3**  
Regulator with shielded terminals



**FIGURE 8-4**  
Distributor designed for shielding showing primary lead shielding in place.



**FIGURE 8-5**  
Generator with shielded terminals



**FIGURE 8-6**  
This type filter may be mounted on either side of the engine bulkhead for connection into the generator charging circuit. One terminal connects to the dash ammeter, and the other terminal connects to the regulator "BAT" terminal.

each side of the inductance coil. These filters, combined with proper bonding of the components in the engine compartment as described below, and the proper suppressors in the ignition secondary circuit,

reduce radiations to a value at which they will not interfere with radio communication. The filters are mounted and connected into the system as described below.

One filter mounts on the generator and is connected into the charging circuit between the generator and regulator. Another filter, also connected into the charging circuit between the generator and regulator,

## SUPPRESSION TYPE SYSTEM

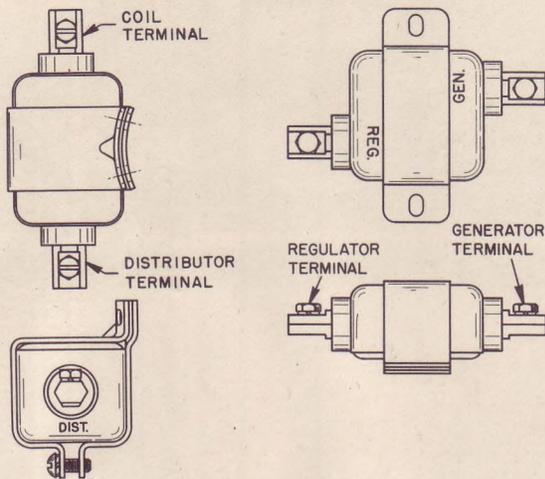


FIGURE 8-7

Filters for connection into ignition primary and charging circuits

mounts on the engine bulkhead. A third filter connected into the charging circuit, between the regulator and

ammeter, also mounts on the bulkhead. A filter connected into the ignition primary circuit between the ignition coil and switch, mounts on the bulkhead. Another filter connected into the ignition primary between the igniton distributor and coil, mounts on the distributor. A filter connected between the regulator field terminal and the generator field terminal is mounted at the regulator.

In addition to these filters and the suppressors, numerous bonds between the metallic parts of the vehicle are used. Fender and radiator grill mounting bolts are treated, and woven mesh leads are bolted between body panels and the vehicle frame.

### FILTER TESTING

Filters may be tested for continuity with a test lamp and test points. The resistance of the inductance coil, particularly on the smaller, suppression type unit, should be very small. The condenser, or condensers, may be checked for capacity and high series resistance. If poor connections develop in the condenser circuits, so that high series resistance results, operation of the filter will be seriously impaired.



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