# TOYOTA REPAIR MANUAL

## MODEL FJ

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ELECTRICAL SYSTEM
STARTING MOTOR
GENERATOR
VOLTAGE REGULATOR

# ELECTRICAL SYSTEM

The electrical system on the Toyota Land Cruiser and Model FA 60 consists of the following circuits:

1. Starting Circuit

The circuit from the battery through the starting switch and to starter motor, controlling the starting of the engine.

2. Charging Circuit

The circuit from the generator through the voltage regulator and ammeter to the battery, controlling the charging of the battery.

3. Ignition Circuit

The circuit controlling the ignition of the air-fuel mixture inside the engine cylinders. This circuit extends from the battery or generator through the ammeter and ignition switch to the primary windings of ignition coil and contact points of distributor to form the primary circuit, and from the secondary windings of ignition coil through the distributor and to the spark plugs to form the secondary circuit.

4. Lighting Circuit

The circuit from the battery or generator through the ammeter, fuses, and lighting switch to the various lamps on the vehicle. The wiring for this circuit is of the one-wire system in which all (—) terminals are grounded.

The source of power is the battery or generator and their (—) terminals are also grounded.

5. Horn Circuit

The circuit from battery or generator through horn button to horn relay and horns.

6. Gasoline Gauge Circuit

The circuit from generator or battery through ammeter, ignition switch, and dash unit to the tank unit to indicate the existing amount of gasoline in the tank.

7. Winker and Flasher Circuits

The circuit from the battery or generator through the ammeter, winker switch to the winkers or through flasher unit to the turn signal lamp.



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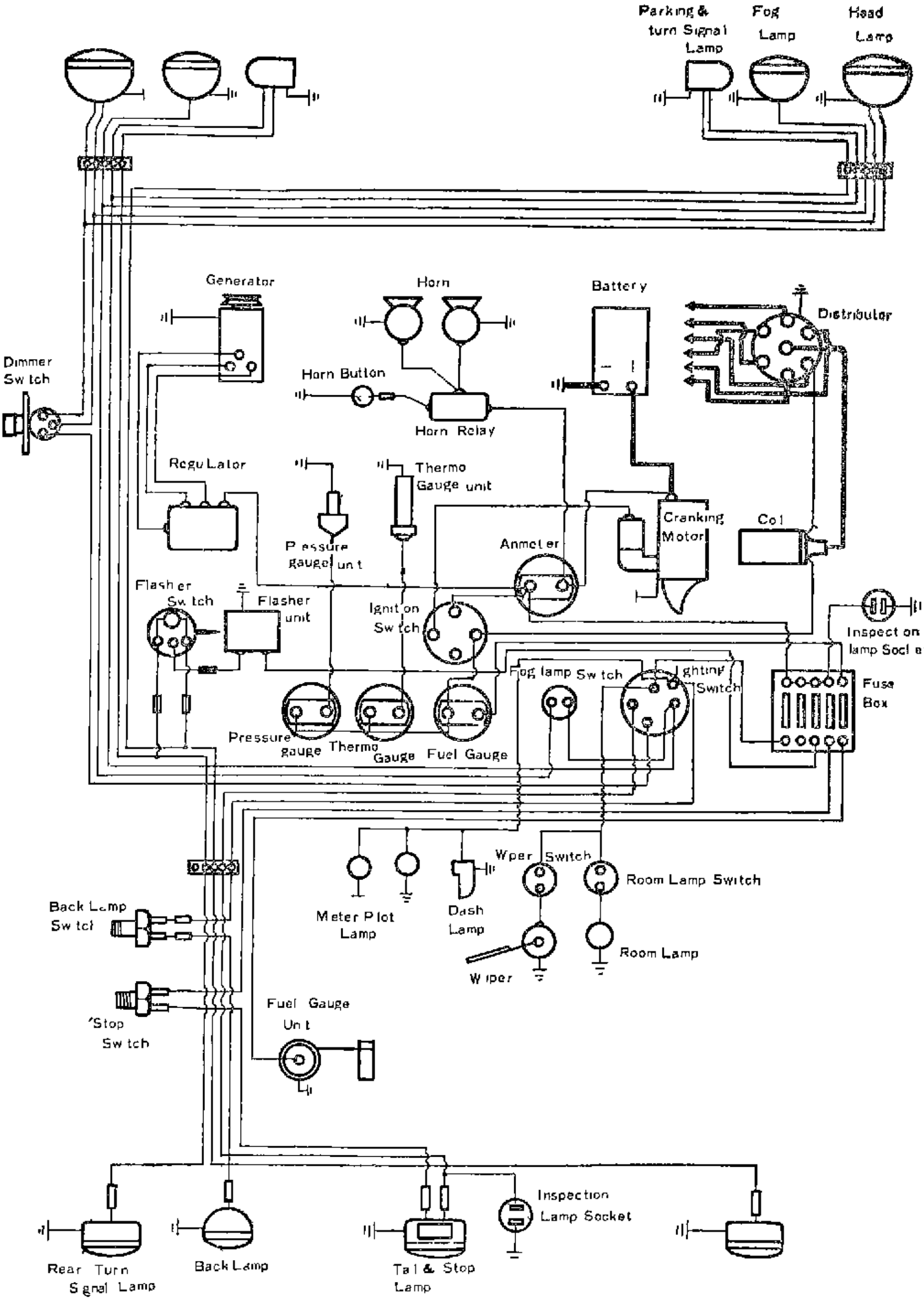


*Toyota Model FA 60 Cargo Truck Wiring Diagram*

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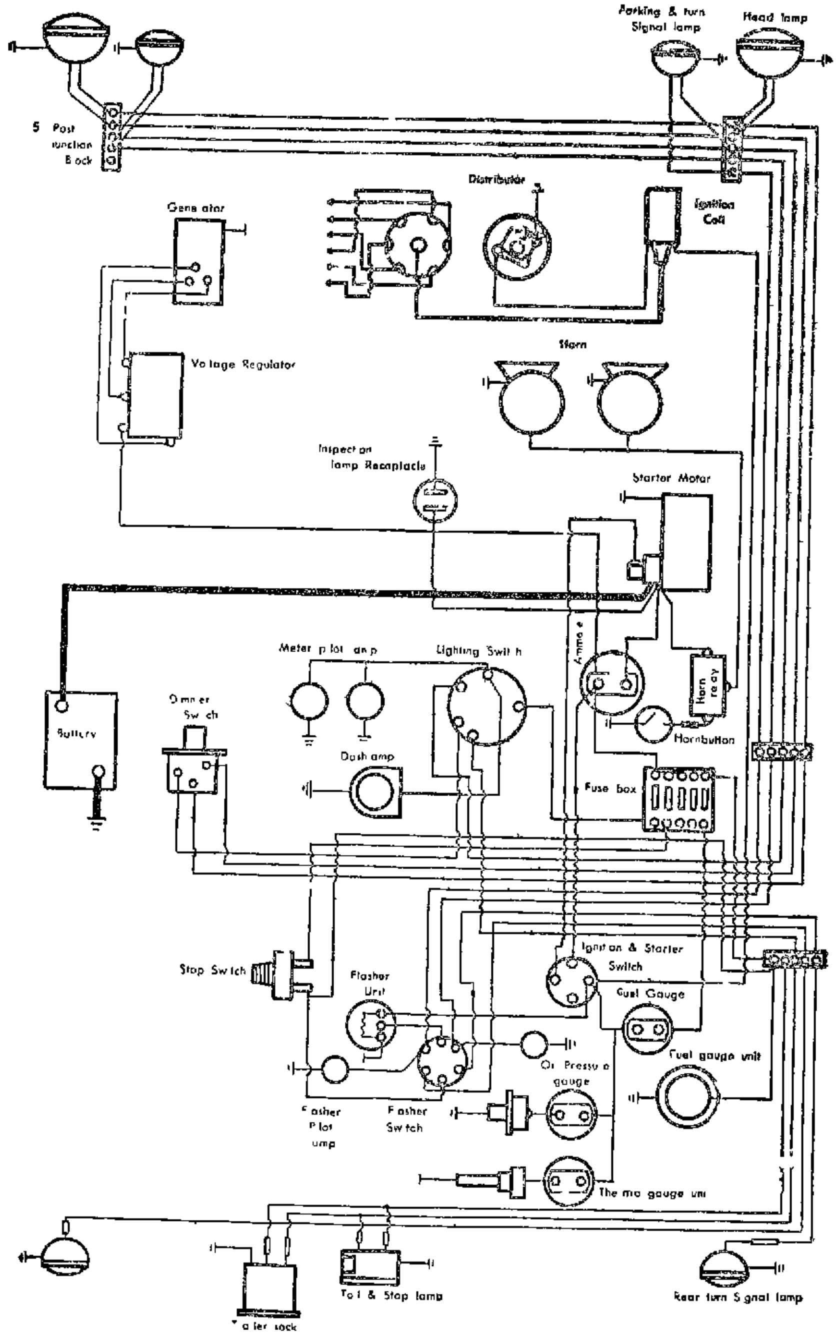


*Toyota Model FJ25L Land Cruiser Wiring Diagram*

(VACUUM WIPER MOTORS)

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# BATTERY

The battery used is 12 volts and is carried inside the battery box located under the front seat.

## 1. BATTERY SPECIFICATIONS

| | |
|---|---|
| Model | MG 4-12 or RS 4—12 |
| Part Number | N— |
| | K—RS 28800 |
| | F— |
| Voltage | 12 volts |
| Lighting Capacity | 55 amp-hrs (20-hr rate @ 77°F) |
| Starting Capacity | More than 4 min (150 amp discharge rate) |
| Voltage after 5 minutes | More than 5 v (150 amp discharge rate) |
| Electrolyte Capacity | 530 cc approx. (32.3 cu in) |
| Weight | 22.4 kg approx. (49.4 lbs) |
| Ground Terminal | Negative |
| Dimensions: Height | 185 cm (7.28 in) |
| Width | 180 cm (7.09 in) |
| Length | 288.5 cm (11.36 in) |

## 2. BATTERY REPLACEMENT

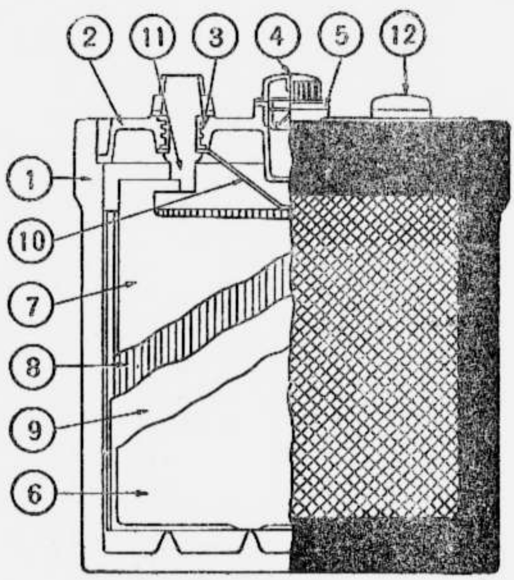
Remove front seat, unhook battery box cover clamps, and take off cover. Normally, the battery is inspected and serviced in this state.

The battery can be removed by unscrewing the nuts from the 3 clamp screws holding down the battery setting plate and taking off this plate.

## 3. BATTERY CONSTRUCTION

The battery is composed of the following component parts:

1. Battery Case
2. Cover
3. Bushing
4. Filler Cap
5. Filler Cap Gasket
6. Positive Plate
7. Negative Plate
8. Separator
9. Glass Mat
10. Splash Plate
11. Terminal Post
12. Connector Bar



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The battery plates are made up of lead-antimony alloy grids, the openings of which are filled with paste composed of powdered oxidized lead and sulfuric acid which when dried forms the pasted type battery plates. These are of two kinds, the negative and positive plates.

The grids in the positive plates are filled with lead peroxide $PbO_2$ as positive active material and the negative plates are filled with sponge lead Pb as negative active material.

As these grids serve as passages for the electric current during charging and discharging, lead-antimony alloy is used in their construction to provide the necessary hardness and resistance against corrosion.

Note: Active Material

These are substances which take part directly in the action of the battery and are as follows:

(1) Lead Peroxide
A fairly hard, brittle, chocolate colored material with chemical formula $PbO_2$.

(2) Sponge Lead
Pure soft lead in sponge state, that is, made exceedingly porous, with chemical formula Pb.

(3) Diluted Sulfuric Acid
A mixture of sulfuric acid and water being a colorless, and transparent solution with chemical formula $H_2SO_4$ and termed battery electrolyte.

Separators are provided between the positive and negative plates to prevent any direct and indirect shorting between the plates. These separators are made of glass fibers.

Glass mats are provided between the positive plates and separators to prevent the active substances in the positive plates from falling off and also to prevent the separators from oxidizing.

The electrolyte used is chemically-pure dilute sulfuric acid. As it takes only a small amount of impurities to affect the battery performance, not only the sulfuric acid but the water used in diluting this acid should be selected with care as to its pureness.

Normally chemically-pure sulfuric acid and distilled water are used but the allowable limit of impurities is as follows:



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## ALLOWABLE LIMIT OF IMPURITIES IN SULFURIC ACID AND WATER

| | Sulfuric Adid | Water |
|---|---|---|
| Appearance | Colorless, transparent | Colorless, transparent |
| Specific Gravity | 1.840 | 1.000 |
| Iron | Less than 0.005% | Less than 0.0005% |
| Chlorine | Less than 0.005% | Less than 0.0005% |
| Nitrogen | Less than 0.003% | Trace |
| Copper | Less than trace | None |
| Manganese | Less than trace | None |
| Residue | Less than 0.02% | Less than 0.0003% |

The electrolyte contains 27% by volume or 38% by weight sulfuric acid and its specific gravity is 1.280 at 20°C (68°F)

The battery case is of ebonite with rubber and sulfur being its main constituents

To prevent reversing the connections on the terminals by mistake, the positive terminal (upper end diameter 0.69″) is made 0.06″ larger than the negative terminal (upper end diameter 0.63″).

### 4. MAKING UP ELECTROLYTE

In making up the electrolyte with sulfuric acid and distilled water, the following procedures should be observed.

(1) The container used should be of glass, ebonite, lead-lined wood, or other material strongly resistant to sulfuric acid.

(2) Pour distilled water into the container first and then add concentrated sulfuric acid slowly.
Never reverse this order and pour the distilled water into the sulfuric acid as this is extremely dangerous practice

(3) Keep mixing the solution while adding the acid as the temperature will rise. Cooling from outside will be found helpful.
Avoid pouring this solution into the battery until it has cooled down to about 85°F.

(4) The percentage of concentrated sulfuric acid to distilled water is as shown below

| Specific Gravity of Electrolyte at 68°F | Amount Distilled Water to One Part Concentrated Sulfuric Acid (by volume) |
|---|---|
| 1.15 | 6.4 |
| 1.20 | 4.6 |
| 1.22 | 4.0 |
| 1.24 | 3.6 |



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| | |
|---|---|
| 1.26 | 3.2 |
| 1.28 | 2.8 |
| 1.30 | 2.6 |
| 1.32 | 2.4 |
| 1.34 | 2.2 |
| 1.36 | 1.9 |
| 1.38 | 1.8 |
| 1.40 | 1.7 |

(5) To measure the specific gravity of the electrolyte, float the hydrometer in the electrolyte. The reading at the level where the fluid surface rises up the hydrometer due to surface tension is the specific gravity.

(6) Specific Gravity of Electrolyte and Temperature.

The specific gravity of the electrolyte is affected by the temperature, that is, the specific gravity of any electrolyte will become less as the temperature rises. Thus, when expressing specific gravity, the temperature at which the reading was taken should be made clear or else the reading should be corrected to the standard temperature.

The standard temperature is taken as 20°C (68°F). Any specific gravity reading at other temperatures must be corrected to that at 68°F and expressed as such.

The specific gravity becomes 0.00041 less for 1°F rise in temperature and reversely, becomes 0.00041 greater for 1°F drop in temperature.

This temperature correction of specific gravity is calculated by the following equation.

Taking Ss as specific gravity at standard temperature 68°F, the specific gravity St at any temperature t°F will be

$$Ss = St + 0.00041\ (t - 68)$$

The efficiency of the battery decreases as the temperature becomes lower. Also during cold weather, there is danger of the electrolyte freezing if its specific gravity is low.

## 5. CHEMICAL ACTION IN BATTERY

The battery stores chemical energy in form which is readily available as electrical energy when desired. The following are brief descriptions of chemical actions which take place during charging and discharging.

### (1) Chemical Action Taking Place During Discharging.

Discharging is meant the drawing out of electrical energy from the battery. When the battery is discharging, the lead peroxide in the positive plates and the spongy lead in the negative plates react with the sulfuric



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acid in the electrolyte to form lead sulfate.

For this reason, the sulfuric acid content in the electrolyte decreases with formation of water to gradually lower the specific gravity.

The amount of drop in specific gravity is approximately proportional to the amount of electrical discharge so that by measuring the specific gravity, the condition of the battery charge or the amount of charge remaining in the battery can be approximated.

| | | | |
|---|---|---|---|
| Positive Plates | Lead peroxide ($PbO_2$ | **Discharge** $\longrightarrow$ | Lead Sulfate ($PbSO_4$) |
| Electrolyte | Sulfuric Acid ($H_2SO_4$) | **Discharge** $\longrightarrow$ | Water ($H_2O$) |
| Negative Plates | Sponge lead (Pb) | **Discharge** $\longrightarrow$ | Lead Sulfate ($PbSO_4$) |

(2) **Chemical Action Taking Place During Charging**

Charging is meant the storing up of chemical energy into the battery by supplying electrical energy from outside sources and reconverting the lead sulfate formed on both plates during discharging back to the active materials of lead peroxide and sponge lead.

The sulfuric acid formed on both plates returns back to the electrolyte to enrich and raise its specific gravity.

The chemical action taking place are as follows.

| | | | |
|---|---|---|---|
| Positive Plates | Lead Sulfate ($PbSO_4$) | **Charge** $\longrightarrow$ | Lead peroxide ($PbO_2$) |
| Electrolyte | Water ($H_2O$) | **Charge** $\longrightarrow$ | Sulfuric Acid ($H_2SO_4$) |
| Negative Plates | Lead Sulfate ($PbSO_4$) | **Charge** $\longrightarrow$ | Sponge Lead (Pb) |

When the lead sulfate on both plates have all been practically reconverted back to the original active substances, the charging is almost complete and the charging current through electrolysis of water contained in the electrolyte vigorously discharges out oxygen gas from the positive plates and hydrogen gas from the negative plates.

The chemical action taking place during charging and discharging is reversible and is shown by the following chemical equation.

$$\underset{(-)}{Pb} + 2H_2SO_4 + \underset{(+)}{PbO_2} \underset{\xleftarrow{\textbf{Charge}}}{\xrightarrow{\textbf{Discharge}}} \underset{(-)}{PbSO_4} + 2H_2O + \underset{(+)}{PbSO}$$

Through this reversible chemical action, it is possible to discharge the discharged battery and restore it back to its original substances.

## 6. BATTERY CAPACITY

The capacity of the battery is the product of the discharge current by the time when the battery is discharged at a constant rate and is expressed in ampere-hours.

In a battery, the discharge time becomes exceedingly short as the discharge



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current rises to make their product, that is, the battery capacity, smaller. For this reason, in determining the size of the battery, the discharge current or else the discharge time must also be known together with the capacity. As an example, if the battery is discharged at a constant current and it takes approximately 10 hours to discharge down to the final discharge voltage, the capacity in this case will be expressed as 10-hour rate capacity.

(Note)

Discharge Termination Voltage

In discharging the battery, its terminal voltage drops suddenly at the beginning of discharge, then drops gradually but again begins to drop suddenly at the final stages so that discharging should be discontinued before the battery is overdischarged. The limiting value is known as the discharge termination voltage.

The final discharge voltage limiting battery discharge are as follows.

| Discharge Rate | Discharge Termination Voltage |
|---|---|
| 20 | 1.85 |
| 10 | 1.80 |
| 5 | 1.75 |
| 3 | 1.70 |
| 1 | 1.65 |
| High Rate Discharge | 1.50 |

The above shows the limiting values when the discharge is made continuously. Under actual conditions, it is perferable to discontinue at higher voltages.

Under intermittent discharge or at very low discharge rate, the final discharge voltage should be from 1.85 to 1.90 volts.

## 7. DISCHARGE

The battery is the electric power source of the car and supplies its required electric load current. When the car is in operation, the generator constantly charges the battery and maintains it in completely charged state. However, if the current consumption is large and the generator fails to give adequate charging, the battery will gradually be reduced to a discharged condition.

The specific gravity of the electrolyte in this case will drop in practically straight line proportion to the discharged amount.

When the battery discharges, the active materials lead dioxide ($PbO_2$) and sponge lead ($Pb$) on the plates change into lead sulfate ($PbSO_4$) and tend to expand. This expansion rate is in direct proportion to the discharge current but if the battery is discharged rapidly, the active materials will expand suddenly with dangers of warping the plates.

If a discharged battery is left as is, self discharge will be promoted. In addition, if a battery is overdischarged, the lead peroxide on the plates will change to lead



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sulfate and expand over the limit so that when recharged, it will fail to return to its original state to result in permanent damage to the positive plates.

Also if the battery is overdischarged, the electrolyte will become thinner with dangers of freezing in cold weather. Furthermore, if the overdischarged battery is used, the active materials on the plates will stick to the separators to make charging. impossible.

For the above reasons, it is extremely important that the battery be inspected constantly to see that is does not become overdischarged.

The voltage drop during the early stages of discharging is gradual but as the final stages of discharging is approached, the voltage begins to drop suddenly. Special care should be taken at the stage when the voltage begins to drop suddenly as there is danger of overdischarging.

## 8. SELF DISCHARGE

Even if the battery is not in use, the pure chemical reaction and the electro-chemical reaction caused by the impurities, taking place inside the battery will constantly use up the stored energy to decrease the capacity This phenomena is termed self discharge.

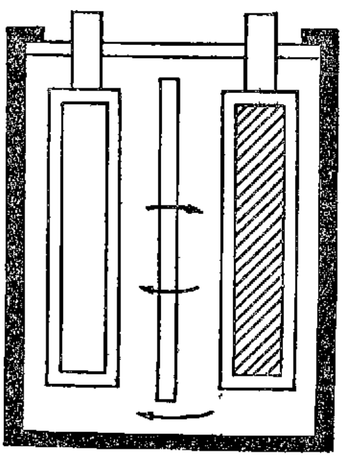
With the exception of lead, lead peroxide, and dilute sulfuric acid, all other matters contained inside the battery are considered impurities. Among these which are most likely to enter the battery and cause self dischaıge are antimony, iron, manganese, and ammonia.

Self discharge will become greater with rising temperature.

The lead sulfate formed by self discharge if allowed to remain will gradually crystallize and in time will cause sulfation of the plates

Although the amount of self discharge will vary, the battery if left alone will always self discharge so that it should be recharged periodically about once a month.

Self discharge is the action which takes place inside the battery and is differentiated from leakage discharge to the outside due to defective insulation and other causes.





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## 9. CHARGING

The battery should never be permitted to remain in a discharged state. This is due to the fact that the self discharge action mentioned above will affect the battery performance to an exceedingly large degree.

Once the sulfation occurs on the battery plates, recharging will not restore these plates to their former condition so that if sulfation is allowed to continue, the battery will eventually become useless.

Even if a battery is partially discharged, it should always be brought to a fully charged state.

The following are the method used in charging the battery.

**(1) Constant Current Method**

A method in which constant current is used in charging from the start to the finish. Charging is carried out with constant current of 3 to 4 amperes for long period of time.

**(2) Constant Voltage Method**

A method in which constant valtage is maintained throughout the charging period. A large current flows at the beginning of the charge but as charging progresses, the current gradually becomes smaller.

**(3) Stepped Current Method**

A comparatively large current is used at the initial stage but as charging progresses, the current is reduced and at the final stage, the current is further reduced.

The principal methods used in charging the battery are the constant current and constant voltage methods.

For the battery installed inside the automobile, the conventional method of charging employed is the constant voltage method by using the voltage regulator.

When the battery becomes badly discharged, it is removed from the car and recharged from outside sources. This method of removing the battery from the car and recharging from outside sources is termed bench charging.

Bench charging becomes necessary in the following cases.

1). When the specific gravity of the battery electrolyte becomes less than 1.120 (68°F).

2). When the voltage of any one cell in the battery becomes less than 1.80 volts.

**(1) Constant Current Method**

In the constant current method, the batteries are connected in series and are charged with a constant current of 3 to 4 amperes. As the charging progresses,



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oxygen will first be produced at the positive plates and later hydrogen will be produced at the negative plates. When the charging approaches completion, this production of gasses become very vigorous and the electrolyte turns milky

This condition is termed gassing. After 1 to 2 hours after gassing appears, the the charging can assumed to be complete

The production of gas is due to part of the charging current decomposing the water through electrolysis This gas given off is highly explosive so that flames should never be allowed in the vicinity when charging batteries.

As the charging progresses, the voltage rises gradually and when the cell voltage reaches 2.3 to 2.4 volts, this voltage rise becomes very rapid and finally reaches a steady voltage of 2.5 to 2.8 volts. After continuing this fairly constant voltage for over 1 hour and if all cells are gassing freely, the battery can be assumed to be fully charged. Since the value of this constant voltage will not always be the same due to differences in amount of charge originally in the battery, temperature, specific gravity of electrolyte and other factors, it is difficult to determine the charged condition through voltage alone.

The specific gravity of the electrolyte rises as the battery becomes charged. This rise is gradual at first but rises rapidly at the same time the voltage shows its rapid rise, and finally reaches a constant value.

This specific gravity unlike the voltage which is affected by many factors, will rise correspondingly with the amount of battery charge. Thus, specific gravity should be used as means of determining completion of battery charging with the voltage and gassing used for reference purposes only.

If after the completion of charging, the specific gravity is found to be much higher than 1.280 (68°F), distilled water should be added to the electrolyte to adjust its specific gravity to this value. If the cells show more than 0.01 difference in specific gravity, charging should be continued until all cells show specific gravity of 1.275 to 1.285. If the specific gravity fails to reach 1.280, add dilute sulfuric acid (specific gravity 1.400 @ 68°F) to adjust, but this should always be done at a shop specializing in battery repairs.

(Note)

After adding either distilled water or sulfuric acid, charge battery at least 30 minutes to allow this to mix thoroughly.

**(2) Constant Voltage Method**

In the constant voltage method, the batteries are connected in parallel. In this method, a constant voltage is maintained throughout the charging period For a 12-volt battery, the charging voltage is from 14 to 14.8 volts.

During charging, a large current will flow at the initial stage but this charging current will gradually become less until at the final stage there will be practically



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no current flowing. Consequently, by this method, gassing will not occur as in the case of the constant current method.

The advantages of the constant voltage method are that the batteries can be charged efficiently in short time and because of the fact that the batteries are connected in parallel, any battery can be taken out at any time to enable efficient charging of each battery to its best condition.

### (3) Charging Precautions

1. Before charging, check electrolyte level in all cells to see that it from 3/8″ to 1/2″ above the plates and add distilled water as required.
2. In filling electrolyte into the battery, make sure that its temperature is below 85°F.
3. During charging, have vent plugs removed from all cells.
4. During charging, take care not to have the temperature rise over 110°F. If it begins to get hotter than this, reduce charging current to one-half or discontinue charging and wait until the battery cools down before continuing.
5. Keep all open flames away from the batteries when charging.

## 10. OVERCHARGING OF BATTERIES

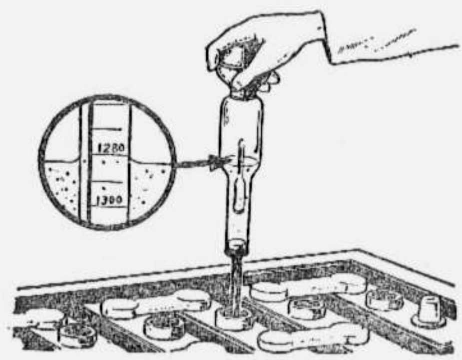
Overcharging of the battery is harmful for the following reasons.

1. The water in the electrolyte will be decomposed to produce gasses which in turn will act on the active matter in the plates causing them to flake off.
2. The water in the electrolyte will be decreased to gradually concentrate the sufuric acid and carbonize the separators with resultant breaking down of the negative plates.
3. The temperature will become high to result in early corrosion of the positive plate grids.
4. The positive plates will become warped to puncture the separators and become the cause for shorting.

## 11. BATTERY TESTING

### (1) Hydrometer Tests

The most common method of determining the condition of the battery is through measuring the specific gravity of its electrolyte with a hydrometer. Since the specific gravity of the electrolyte varies with the temperature, the reading taken should always be corrected to that of standard temperature.



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| Specific Gravity of Electrolyte and Charged Condition | | |
|---|---|---|
| Specific Gravity Electrolyte 68°F | Terminal Voltage | Amount of Charge |
| 1.100 | 1.80 | Fully Discharged |
| 1.145 | 1.82 | 1/4 Charged |
| 1.190 | 1.96 | 1/2 Charged |
| 1.235 | 2.01 | 3/4 Charged |
| 1.280 | 2.14 | Fully Charged |

**Specific Gravity of All Cells Are Low**

If the starter motor fails to turn the engine, measure specific gravity and if found below 1.100, remove battery from car and recharge by bench charging method.

In the meantime, make careful check of the generator, voltage regulator, and wiring to verify that these parts are not at fault.

**Specific Gravity of Only One Cell Is Low**

In this case, the cell with the low specific gravity is usually shorted. This is probably caused by the separators being fatigued, enough sediment collected in the bottom to touch the plates, or some metallic object which may have fallen inside to short the plates.

In such cases, check for the cause and make necessary repairs. If the separators require replacement, they should alse be replaced on all the cells.

**Sulfated Plates**

If the specific gravity of a cell remains constantly low and requires frequent replenishment of distilled water, the upper parts of the plates in that cell will temporarily be exposed to the air.

These parts will then be sulfated and if this sulfation progresses until all of the plates become useless, the specific gravity of this cell will not rise no matter how long it is charged. At the same time, considerable heat will be evolved during charging to hasten evaporation of water.

**Specific Gravity Drops Below 1.100 or Too Low to Read**

A battery in this condition will not only be unable to crank the engine but will have difficulty in keeping the lamps lit.

As it is difficult to measure such low specific gravity with common hydrometer, the battery condition cannot be diagnosed fully with just a hydrometer. Some other method of test should be made and the nature of the trouble determined



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accurately to enable making repairs.

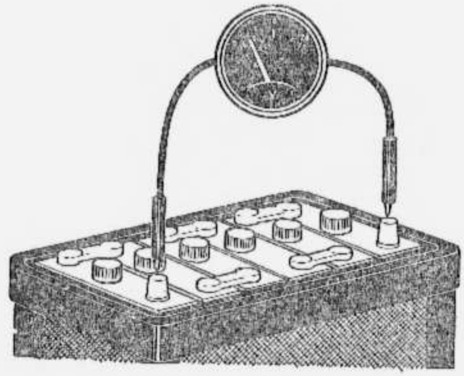
(2) **Voltmeter Tests**

**Voltage of All Cells Are Low**

If the voltage of all cells are measured and found to be less than 1.75, the battery is completely discharged and should be benchcharged.

**Difference in Cell Voltages Is More Than 0.15 volts**

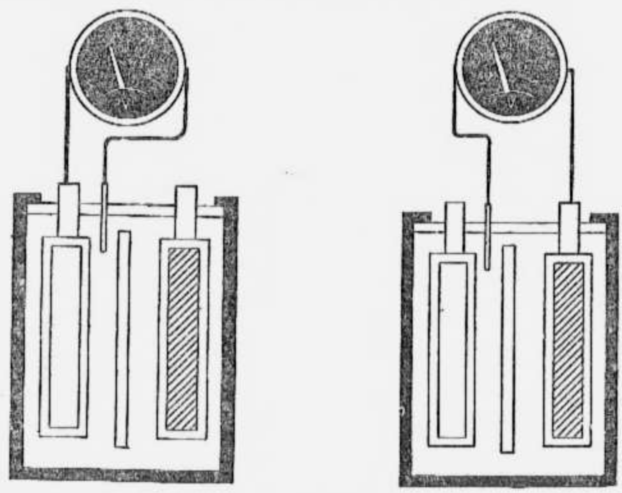
Charge until voltages become uniform. If unable to restore, battery should be overhauled.



(3) **Cadmium Voltage Test**

The charged condition of a battery can normally be determined with a hydrometer or a voltmeter but if the battery capacity is reduced, exact determinations cannot be made as to whether the positive or the negative plates are at fault.

In such a case, measurements are made with a cadmium auxiliary electrode. This electrode is immersed in the electrolyte and the voltage between the cadmium auxiliary electrode and each positive and negative plate is measured to determine which of the positive or negative plates are defective.





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**During discharging,** the cadmium electrode also becomes the load electrode for the positive plates so that the terminal voltage becomes the difference of the cadmium voltages measured.

An example of cadmium voltage tests taken on 3 cells in which the terminal voltages have dropped to 1.8 volts at end of discharge period is as follows.

| | A | B | C |
|---|---|---|---|
| Cadmium positive plate voltage | 2.10 | 2.00 | 1.95 |
| Cadmium negative plate voltage | −0.30 | −0.20 | −0.15 |
| Terminal Voltage | 1.80 | 1.80 | 1.80 |

A battery in good condition will show 1.95 to 2.10 volts between the cadmium and positive plate, and 0.15 to 0.39 volt between the cadmium and negative plate.

In the above example, the terminal voltages are the same 1.80 volts in the 3 cells but it can be seen that in cell A, the negative plate controls the cell and in the cell C, the positive plate limits the cell.

**During charging,** the cadmium electrode near completion of charge becomes a positive electrode with reference to the negative plate. Conseqently, the terminal voltages will be the sum of the voltages between the cadmium electrode and the positive and negative plates.

A battery in good condition when amply charged will show 2.49 to 2.55 volts between the cadmium electrode and positive plate and 0.1 to 0.4 volt between the cadmium electrode and negative plate. Consequently, the cell terminal voltage will be 2.40+0.1=2.5 to 2.55+0.4=2.95 volts.

In this manner, it is possible to determine the condition of the positive and negative plates in the battery.

(Reference)

The capacity of the battery is determined by discharging the battery from its fully charged state until discharge termination voltage is reached and measuring the time required for making this discharge. There are two methods of making this discharge, i.e., low rate discharge and high rate discharge.

The test requisites are as follows:

1. Low Rate Discharge Capacity Test

| | |
|---|---|
| Specific Gravity of Electrolyte Before Discharging | 1.280 ± 0.01 (68°F) |
| Time to Begin Discharging | 1 hr. in undisturbed state after charging is completed |
| Discharge Current | 2.75 amperes |
| Discharge Termination Voltage | 1.85 volts per cell |
| Electrolyte Temperature During Discharge | 25° ±2°C (77° ±3.6°F) |

2. High Rate Discharge Capacity Test



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| | |
|---|---|
| Time to Begin Discharging | Over 24 hrs in undisturbed state at atmospheric temperature of 59°F after charging is completed |
| Discharge Current | 150 amperes |
| Electrolyte Temperature At Beginning of Charge | 59°F |

## 12. TROUBLE SHOOTING BATTERY

If it appears that the battery is defective, check to see if the battery is fauity by charging and comparing its cells as to voltage, specific gravity, and gassing condition during charging.

The following are clear symptoms of battery troubles.

(1) Specific gravity of electrolyte is exceedingly low,

(2) During charging, specific gravity fails to reach specified value although voltage reaches high constant value and ample gassing occurs.

(3) Voltage changes abnormally during charging.

(4) Temperature rises abnormally.

When any of the above symptoms are present, inspect the battery.

Battery troubles are not limited to external defects such as damaged case, damaged terminals, etc., but will also have internal defects as well.

The following are some of the principal internal defects together with brief outlines of their causes and repairs.

### (1) Internal Short in Battery

When the battery is internally shorted, very little or no gassing occurs at the end of the charging. In addition, the voltage and electrolyte specific gravity will be abnormally low while the temperature rises considerably.

The probable causes of internal shorting are:

a. Sediment accumulated in bottom of cell and shorting the plates.

b. Separators damaged by warping plates to cause shorting.

c. Foreign object between plates.

d. Damaged separators.

These points should be checked for and eliminated to remedy shorting.

### (2) Sulfation

Sulfation is the conversion of lead peroxide in the plates to white (crystallized) lead sulfate and results in increasing the internal resistance and decreasing battery capacity.

When sulfation occurs, electrolyte specific gravity becomes low and during charging, the voltage and temperature will rise abnormally.



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The procedure for attempting to restore a sulfated battery is to overcharge it at one-half the normal current until temperature rises to about 115°F. The charging is then discontinued until the battery cools down after which charging is recontinued. This is repeated until the specific gravity reaches a constant value.

If this method fails to restore the battery back to its former capacity, drain out all the electrolyte and fill with distilled water. Then charge the battery at one-half the normal charging current.

If the specific gravity rises to 1.15, drain out the fuid and fill again with distilled water. Keep charging until the specific gravity rises again to 1.15 and repeat the above procedure several times. If this restores the voltage to specified value, adjust the final solution to give specific gravity of 1.280 (68°F).

If this method also fails to restore the battery, replace the plates.

**(3) Low Specific Gravity of Electrolyte**

If the electrolyte specific gravity of any cell is lower than the others, first check for the cause of trouble before adding dilute sulfuric acid to raise its specific gravity.

If no troubles are present, charge until the specific gravity fails to rise any higher and then adjust the specific gravity to the required value.

**(4) Impurities in the Electrolyte**

If foreign matters become mixed in the electrolyte or if it becomes contaminated. the electrolyte should be replaced immediately.

To replace the electrolyte, empty after discharging the battery, and wash the interior of the cells thoroughly with clean water several times and finally rinse with distilled water.

Next prepare electrolyte with specific gravity 0.03 to 0.05 higher than that which was emptied from the battery. After making sure that the battery is clean, fill this solution and charge.

After completion of charge, adjust specific gravity to 1.280 (68°F).

**(5) Warped or Deteriorated Plates**

Warped plates are usually seen on the positive side. The main causes for warping are, overdischarging, use at too high a temperature, long exposure to direct sunlight, too low a charging rate, and battery freezing.

Warped plates are repaired by completely discharging the battery and taking out the plates and correcting.

After a certain period of usage, the active matter in the positive plates will flake off to a certain degree and the active matter in the negative plates will begin to harden to result in reducing their capacities. Plates which become deteriorated in this manner will have smaller capacities when fully charged and becomes charged much faster so that when this stage is reached they should be replaced.



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### (6) Battery Overheating

When battery overheats, this is mainly caused by overcharging. As this is due to too large a charging current from the generator, the charging circuit should be checked for the cause of the trouble.

The temperature of the battery should not rise over 115°F.

Overheating will cause rapid evaporation of the water content in the electrolyte to reduce the amount of fluid and expose the tops of plates and separators which not only will affect the life but will become the cause of the plates and separators buckling.



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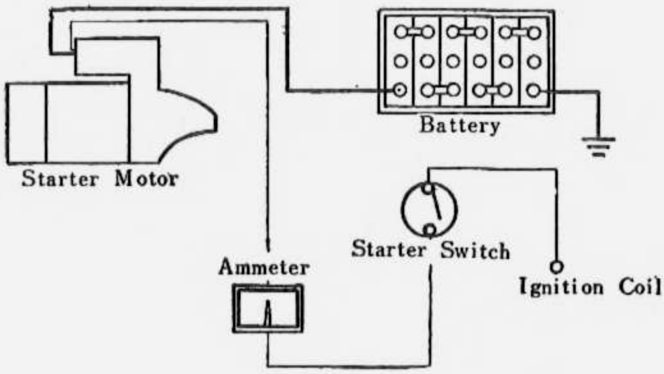
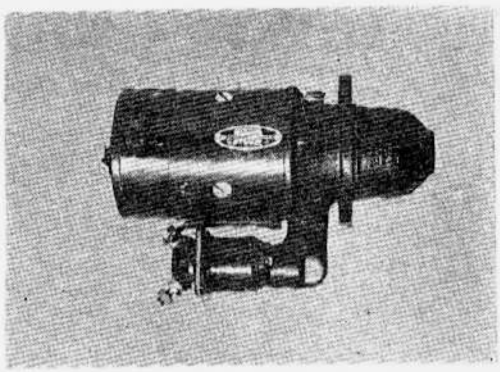
# STARTER



### 1. STARTER SPECIFICATIONS

| | |
|---|---|
| Model | Bosch |
| Part Number | FA 70 28000 |
| Drive | Overrunning Clutch |
| Drive Actuator | Magnetic Switch, Screw-push Type Meshing |
| Motor | |
| Type | Series |
| Direction of Rotation | Clockwise as viewed from pinion side |
| Rating | 30 seconds |
| Rated Voltage | 12 volts |
| Rated Horsepower | 1.4 |
| Output Characteristics | |
| No Load: Voltage | 12 volts |
| Current | 60 amperes |
| RPM | 4000 |



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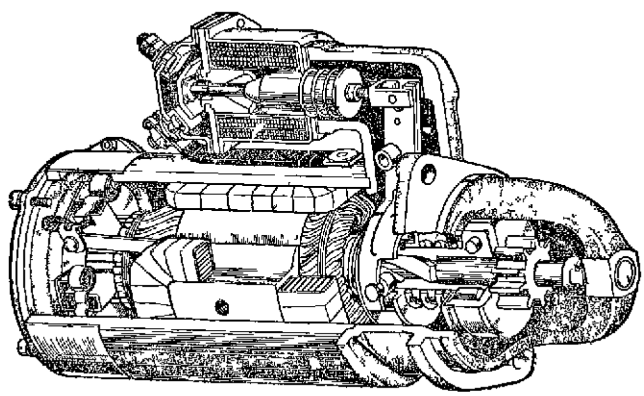
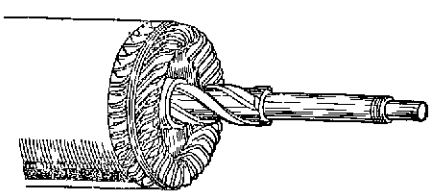
| | | |
|---|---|---|
| Full Load: | Voltage | 10 volts |
| | Current | Less than 260 amperes |
| | RPM | 1000 |
| | Torque | 1.0 kg-m (7.23 ft-lbs) |
| Locked: | Voltage | 8 volts |
| | Current | Less than 550 amperes |
| | Torque | More than 2.0 kg-m (14.5 ft-lbs) |
| Speed Ratio | | 136 : 9 (Motor to engine) |
| Brush Spring Tension | | 800 to 950 grams (28 to 33 oz) |
| Pinion Gear: | Tooth Form | Special |
| | No of Teeth | 9 |
| | Outside Diam. | 30 mm (1.81″) |
| Pinion to Ring Gear Backlash | | 0.6 to 0.8 mm (0.024″ to 0.32″) |
| Magnetic Switch Activating Voltage | | 6 to 7 volts |
| Voltage Drop through Contacts | | Less than 0.2 volts @ 200 amperes |
| Weight | | 9.5 kg (21 lbs) |

## 2. CONSTRUCTION OF STARTER



The principal parts of this starter are the starting motor, magnetic or solenoid switch, and overrunning clutch. In this Bosch type starter, which is a special design of the Bosch Co., the method employed in shifting the overrunning clutch to engage the ring gear is of the screw-push type instead of the push-in type commonly used on most vehicles.

The starter motor is of the series type in which the field coils are connected in series with the armature circuit. Since a very large current of from 150 to 600 amperes may flow for an instant during starting, the field coil windings are of heavy copper wires.





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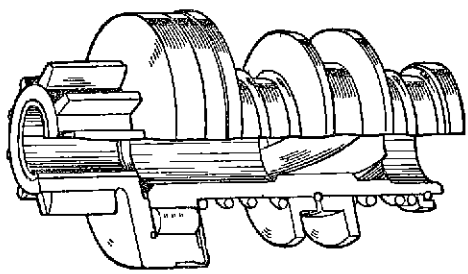
The splined part of the armature shaft on which the overrunning clutch slides on when shifting is made helical.

For this reason, the overrunning clutch is already turning when pushed out by the drive lever to engage the ring gear during starting. As the pinion begins to engage the ring gear, the turning force of the armature sends the pinion into complete mesh without further reliance on force of the drive lever. Because of the small force required in actuating the drive lever, the magnetic or solenoid switch is made very small in comparison to that used on the conventional push-in type of starter.

In the usual type of overruning clutch, the slots into which the clutch rollers fit in are on the outer side and the pinion is made integral with the inner side. In this Bosch type, these slots are on the inner side and the pinion is made integral with the outer side.



Consequently, this makes the inner surface of the outer part smooth so that the clutch rollers remain steady when subjected to the centrifugal force of the high no-load speed of the armature during starting to impose no strain on the drive lever housing.

The drive ring is split into two parts with comparatively strong drive spring attached to the forward part and a weak helical spring attached to the rear part, this type of construction being necessary because of the helical splines on the armature shaft. Since both of these springs are not very strong, the contact between the drive lever pins and the ring sides is light to cause practically no wear in these parts.

The armature brake is provided inside the commutator end plate at front end of starter motor, its purpose being to brake the exceedingly high speed possible with the startor motor if run without load. The two brake shoes are made to turn together with the armature shaft on pins and are pressed against the frame with springs. These springs are not strong enough to affect the armature torque when starter motor is running under load.



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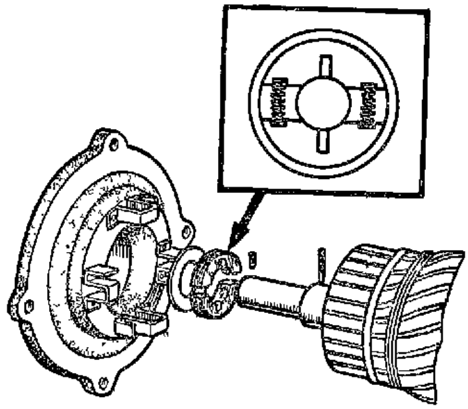
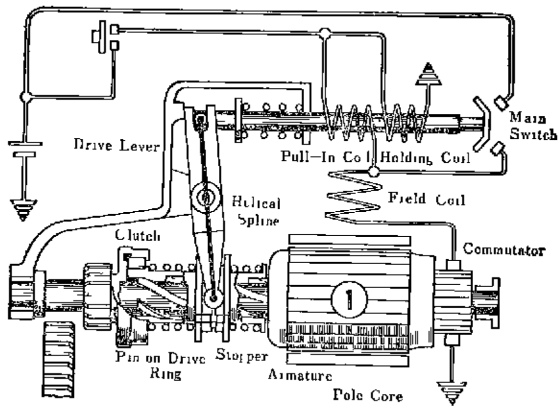


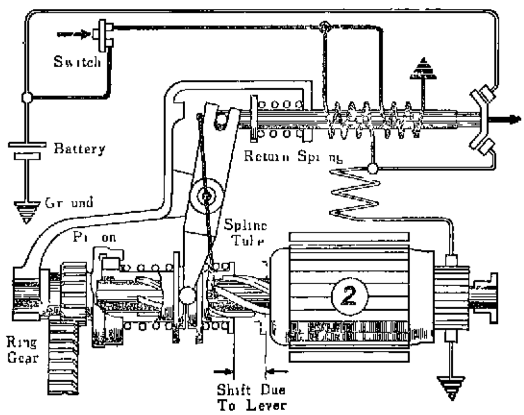
## 3. OPERATION OF STARTER MOTOR

The starter motor operates as follows:

a. When the starter motor is at rest, the condition is as shown in the figure.




b. Pressing the starter switch allows the current to flow through the pull-in coil and holding coil of the magnetic switch to create magnetic field and move the lever. The pinion is brought partially into mesh before the main switch closes.



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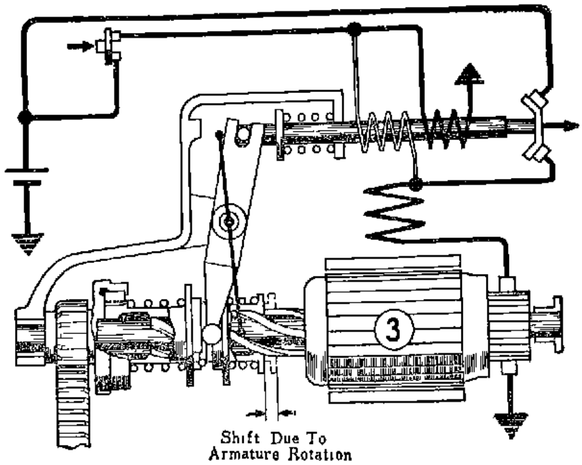
c. When the main switch closes, the main current flows to create a large torque and and shift the overrunning clutch further by means of the helical splines to bring the starter in condition to to crank the engine.



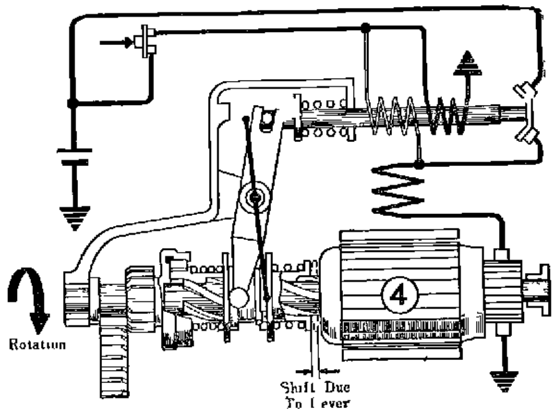

In cranking condition:

The drive spring will not be compressed and the helical spring will only be slightly compressed.

The drive ring forward and rear parts will be slightly apart.

As the main switch is closed, the current will flow through this circuit and there will be no current flowing through the pull-in coil.

d. If pinion strikes against the ring gear.




If the pinion strikes against the ring gear without meshing, the drive spring becomes fully compressed. With the main switch closing in this state, the pinion will press against the ring gear more strongly as the armature will also be turning with greater torque to make these parts mesh in easily.

e. Upon turning off the starter switch after starting, the current will flow from the main switch through the pull-in and holding coils. As these coils are wound to have their attracting forces act in opposite directions, their holding force on the main switch becomes nullified and the switch opens. When the main switch opens, the motor torque becomes zero and the armature stops rotating in short time due to the actions of the armature brake.

f. Action of Overrunning Clutch

The clutch rollers are in tapered slots between the outer part (integral with pinion) and inner part (shaft side), and are pressed into the narrow end of the



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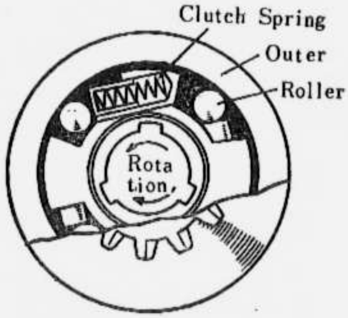
slots with clutch roller springs.



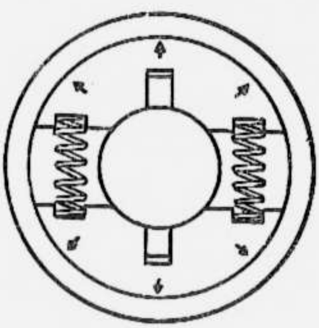

When the armature shaft rotates (clockwise rotation), these rollers are jammed tightly into the narrow end of the slots by the frictional force of the shaft to lock the inner and outer parts together and transmit the armature torque to the pinion.

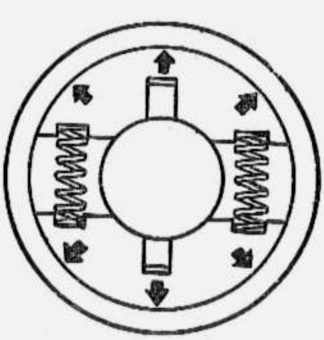
After the engine starts and the pinion (outer part) begins to turn faster than the armature shaft (inner part), the frictional force of the outer part on the rollers becomes large enough to overcome the pressure of the clutch roller springs. This causes the rollers to shift over to the wider end of the slots to release the upper and lower parts and allowing the pinion to turn free. Through this action, the armature is protected from being turned by the engine.

g. Action of Armature Brake

In the series motor, running under no load will cause its speed to rise exceedingly high with dangers of reaching the critical speed. Also, if the engine fails to start and the starter switch is turned on for another trial before the armature stops rotating, the pinion will mesh into the ring gear suddenly to subject the various parts to severe and probably damaging shock.

To protect against these dangers, the starter is equipped with a brake on the armature shaft. When the speed of the armature rises, the centrifugal action presses the brake shoes against the frame to restrain high speed rotation.







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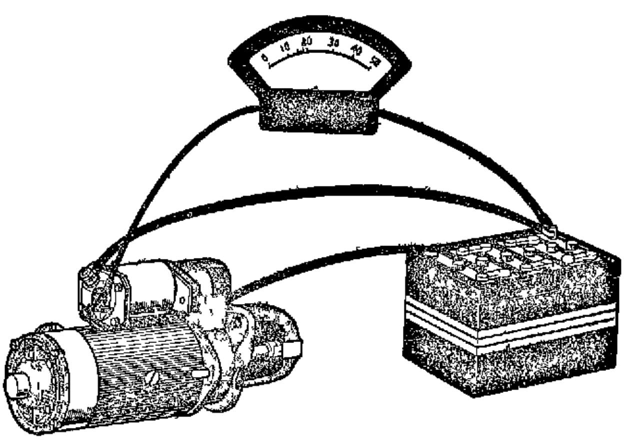
These brakes are capable of stopping the rotation of the armature in very short time after the starter switch is turned off to make restarting possible in about 3 seconds.

## 4. STARTER MOTOR TESTS

In the starter motor tests, there are the no-load tests and loaded tests. As the loaded tests require considerable equipment, the starter motor is usually tested at no load to determine its condition.

The voltage, current, and speed at no-load is tested.

Connect up a fully charged 12-volt battery, an ammeter (500 amps) and the starter motor in series. If with a current of less than 50 amperes, the motor turns smoothly at a constant speed, the motor can be assumed to be without defects.



Lock the pinion so that the armature does not turn. If under this state the current flowing through is within the range of 270 to 350 amperes, the motor is satisfactory. The voltage for this test should be 8 volts.

To make the motoring test with the starter motor on the car, it is only necessary to short the large terminals on the magnetic switch If under this state, the starter motor turns at high speed, it can be assumed that there is no electrical defect in the starter motor.

## 6. DISASSEMBLY OF STARTER MOTOR

(1) Remove cover band and unloosen connections between field coils and brushes.

(2) Disconnect main starter leads from magnetic switch.



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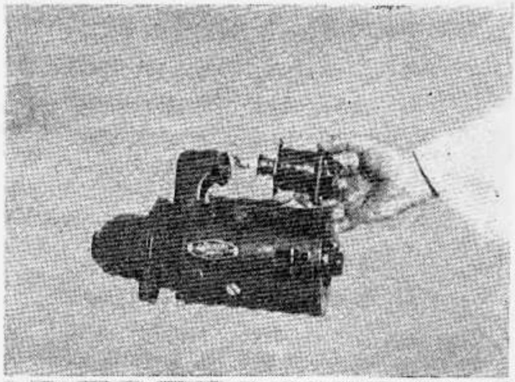
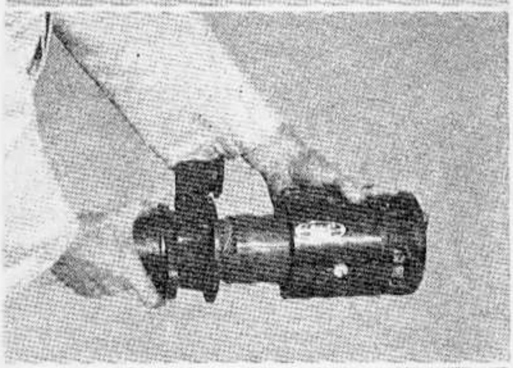
(3) Unscrew 2 bolts mounting magnetic switch and pull out magnetic switch from drive lever housing.



(4) Unscrew nuts from 2 housing bolts and separate lever housing from yoke complete.

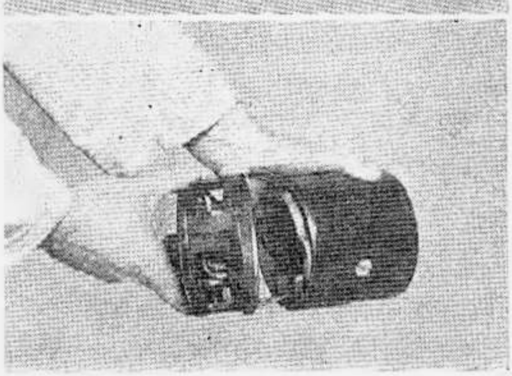
(5) Unloosen lever set bolt on lever housing and remove overrunning clutch and armature together with lever.

(6) The overrunning clutch can be removed from the armature shaft by pulling out cotter pin and unscrewing nut on the end of armature shaft.



(7) The commutator end frame can be removed from the yoke complete by unscrewing the 4 attaching bolts and removing the brush springs.

The brake shoes, brake springs, and thrust washer are inside the brake groove in this end frame.





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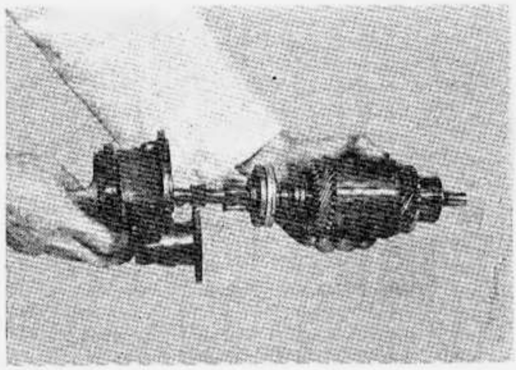
## 6. ASSEMBLY OF STARTER MOTOR

(1) Assemble thrust washer, brake shoes, and brake springs into commutator end frame, and bolt down frame to yoke.

Apply thin coat of grease to these parts when assembling.

(2) Fit overrunning clutch on to armature shaft, fit on snap ring, and screw on stop nut.
Insert cotter pin into nut to prevent turning.

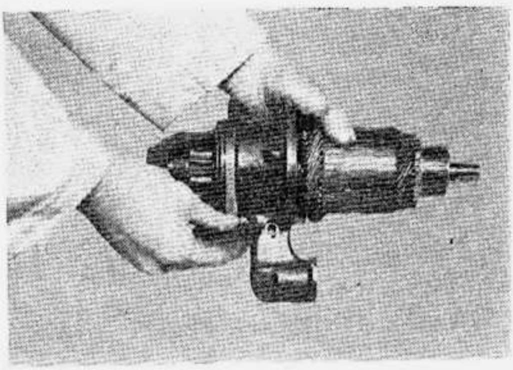
(3) Hook on lever pin into drive ring on overrunning clutch and insert assembly into lever housing.



(4) Fix lever on to lever housing with lever set pin.

(5) Pass armature with the lever housing assembled through yoke and insert shaft end into commutator end frame.

Have the commutator flange open toward the outside.



(6) Check end play on armature shaft.

If the play is too large, place 1 or 2 compensating washers on the end of armature shaft.

Bolt down lever housing to yoke.

The armature should turn easily by hand if the play had been adjusted properly.

(7) Connect field coil and brush terminals.

(8) Insert magnetic switch and bolt down to lever housing.

Before inserting magnetic switch, push overrunning clutch to its furthest forward position with screwdriver to make assembly easier.

Before tightening down the mounting bolts, make sure that switch joint is hooked on properly to slot on top of lever.

(9) Install cover band.

This completes the assembly of the starter motor.



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## 7. TROUBLE SHOOTING AND REPAIRS

### (1) Trouble Shooting

| Symptom | Location of Trouble | Probable Cause | Method of Checking |
|---|---|---|---|
| Pinion does not jump out | Battery Circuit | Poor connection | Retighten |
| | Magnetic Switch | Broken connection at coil terminal | Refer text |
| | Shaft | Clutch slides hard | Turn by hand |
| Pinion returns too quickly | Magnetic Switch | Broken wire in holding coil | Refer text |
| Pinion does not return | Magnetic Switch | Short in holding coil or pull-in coil | Refer text |
| | | Main switch fused | Visual |
| Motor does not turn | Power Source | Discharged battery or defective circuit | Measure specific gravity and Voltage drop |
| | Field | Defective soldering or grounded | Refer text |
| | Armature | Rear shorted | Refer text |
| | | Grounded | Refer text |
| Low Cranking Torque | Power source | Discharged battery or defective circuit | Measure specific gravity and voltage |
| | Armature | Poor connection with commutator | Observe sparking |
| | Commutator | Burned or dirty | Visual |
| | Brushes | Worn | Visual |
| | Bushing | Lack of oil | Turn by hand |
| | Brake | Carbon or dirt on shoes | Turn by hand |
| Only armature turns | Overrunning clutch | Inadequate transmission of torque | Lock test |
| | | Defective meshing | Refer text |



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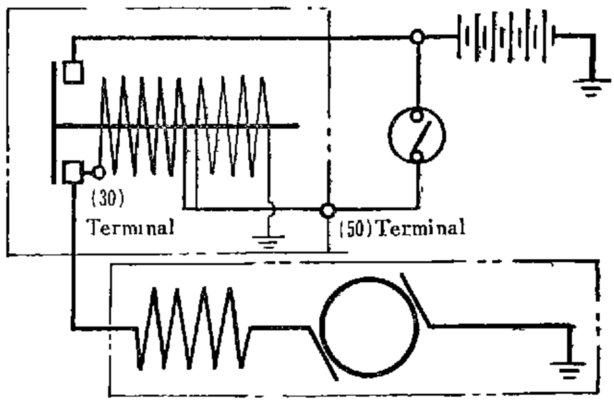
(2) **Testing and Repairing Magnetic Switch** (With switch removed from motor)




Wiring Diagram of Starter

Fluttering and other defects caused by magnetic switch not operating or not having adequate pull-in power due to low voltage are checked by making the following tests.

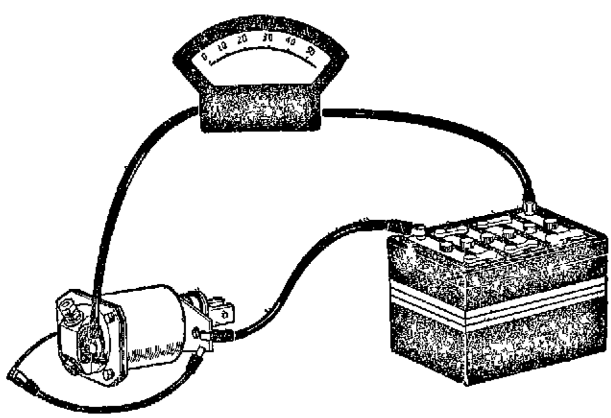
(a) Pull-in Test of Pull-in Coil

Impress specified voltage of 12 volts between terminals (30) and (50). If the magnetic switcl pulls in strongly, the pull-in coil can be considered to be satisfactory.

The current should be from 31 to 35 amperes.

(b) Holding Test of Holding Coil

Ground terminal (30) to switch body and impress specified voltage of 12 volts to terminal (50). If switch pulls in strongly and remains in this position after terminal (30) connection to ground is removed, the holding coil can be considered to be satisfactory.



If the plunger returns in this case, there is danger of fluttering taking place



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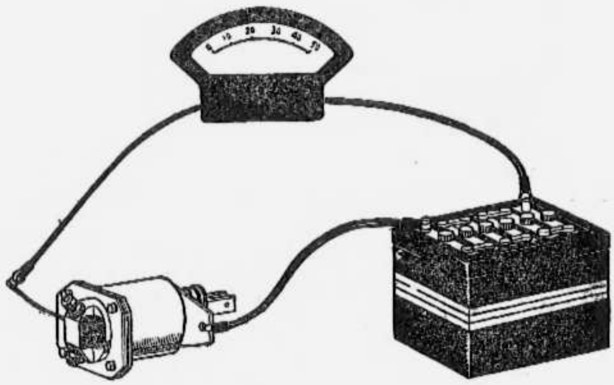
when the switch is operated.

(c) Return Test

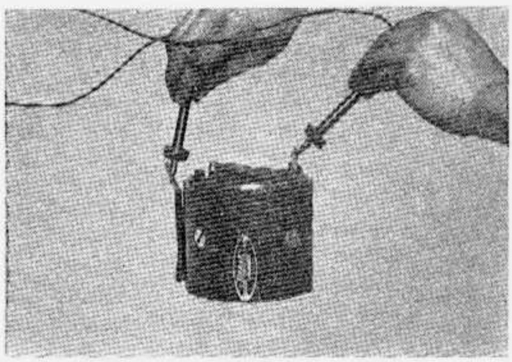
Impress specified voltage of 12 volts between terminal (30) and ground. The switch should not pull in. If switch pulls in this case, the overrunning clutch will not return to its former state after the key switch is turned off and engine will keep turning the overrunning clutch with dangers of causing large damages.



**(3) Checking and Repairing Field Coils**

Check resistance between end of field coil winding and yoke.

There should be no current flowing between these points.



If grounded, remove pole cores one at a time to make visual check to see which coil is grounded. Repair insulation on defective coil found.

**(4) Checking and Repairing Armature**

Test for rear short with growler.

The trouble is usually due at the soldered part of the commutator so that repairs can be made by resoldering.

Test for grounding by checking resistance between each commutator and armature core.



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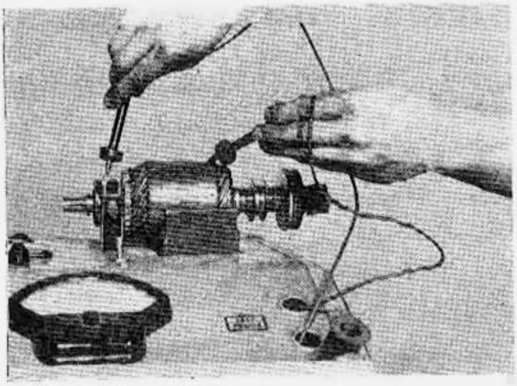


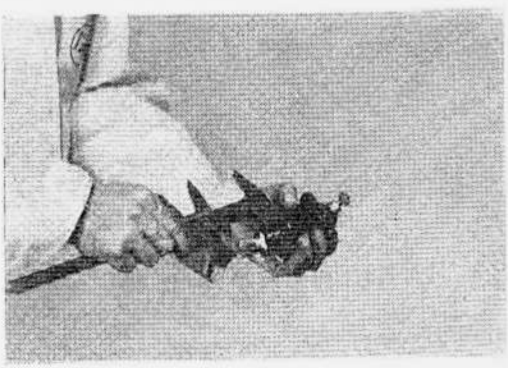
If found grounded, replace with new part.

Defective soldering between armature coil and commutator will cause poor rectification with considerable sparking. If commutator segments are found badly burned by this sparking, repair by soldering.

**(5) Defective Meshing and Its Repairs**

If pinion fails to mesh properly with ring gear, this is due to improper adjustment of pinion travel provided none of the gear teeth are damaged.

This pinion travel is correct if the length of moving stud on magnetic switch is from 46 to 47 mm (1.81″ to 1.85″).



To adjust this length, loosen locknut and turn stud bolt to suit.

If the clearance between the stop nut and pinion at the end of travel is from 2 to 4 mm (0.08″ to 0.16″), there is no need for further adjustment.

**(6) Worn Bushings**

If bushings are worn to give shaft more than 0.2 mm (0.008″) play, replace bushings.

**(7) Correcting Commutator**

If commutator is burned or dirty, dress down with sandpaper and wipe clean



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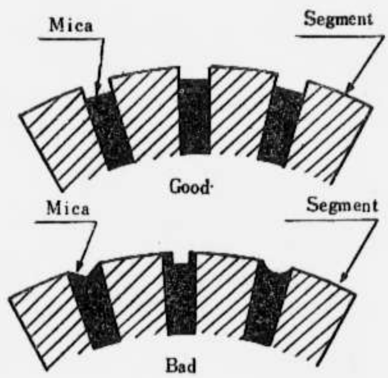
with gasoline.

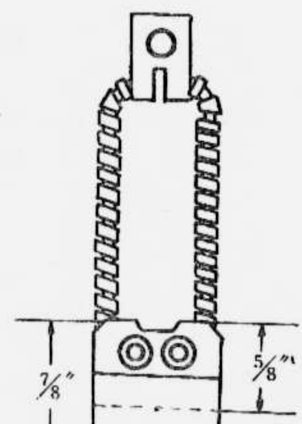
Machine commutator on lathe if surface is badly burned but if this makes the diameter less than 33 mm (1.30″), replace armature.

The surface of mica between the commutator segments should be undercut 0.5 to 0.8 mm (0.02″ to 0.03″) below the surface of the commutator.




## (8) Worn Brushes

If brushes are worn down to 5/8″ in height, replaces brushes




## (9) Weakened Brush Springs

If brush springs are weakened to show less than 25 oz. tension when used on new brushes, they should be replaced.



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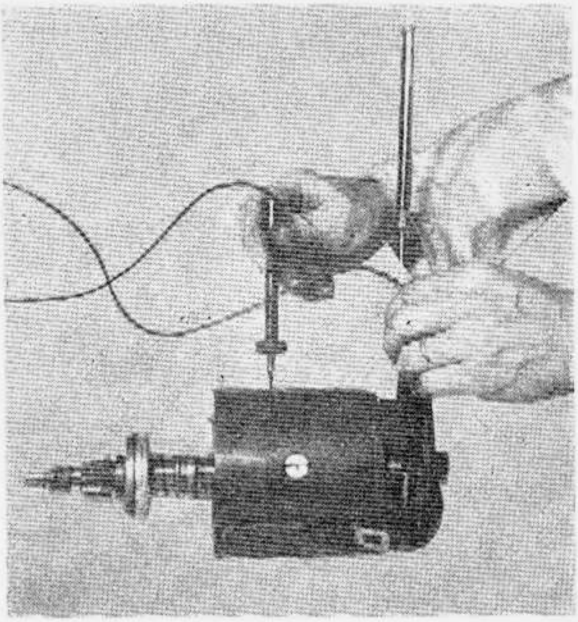

## 8. PRECAUTIONS ON HANDLING STARTER

(1) The centerline of the starter and that of the engine crankshaft must be perfectly parallel.
This makes it necessary to have the starter mounting nut thoroughly tight at all times.

(2) The cranking torque of the starter motor will depend largely on the condition of power source.
Check and service battery, all wiring connections, and other parts of the power source daily. Make sure that all connections are free from rust, paint, and corrosion and that they are completely tight.

(3) Running the starter for more than one minute continuously will impose a heavy drain on the battery and make starting much more difficult.
In starting, do not run starter for more than 15 seconds at a time and always rest a few seconds before attempting to restart.

(4) After the engine starts, turn off starter switch immediately.

(5) When disassembled, grease or oil sliding part of overrunning clutch, moving parts of magnetic switch, brake parts, and front and rear bushings.



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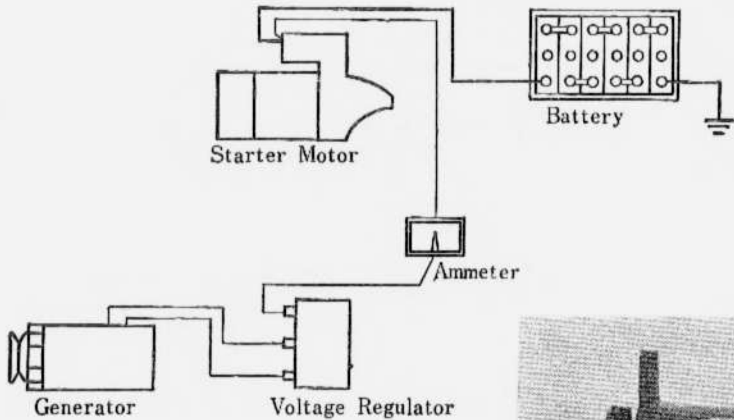
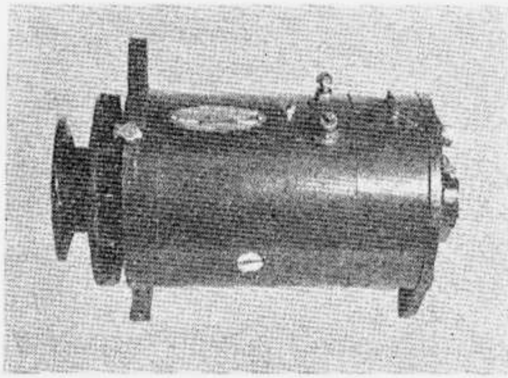
# GENERATOR



## 1. SPECIFICATIONS

| | |
|---|---|
| Model | Bosch Type |
| Part Number | FA 70 27000 |
| Type Winding | Shunt |
| Rating | Continuous |
| Direction of Rotation | Clockwise as viewed from pulley side |
| Method of Drive | V-belt |
| Output | 216 watts |
| Characteristics | |
| No-load Voltage | 13 volts |
| Speed | Less than 1000 rpm |
| Maximum Output Current | More than 18 amperes |
| Voltage | 14 volts |
| Speed | 2000 rpm |
| Motoring Current (A, F terminals shorted) | 8.5 to 10.5 amperes |
| Commutator Diameter | 4.6 mm (1.81″) |
| Brush Spring Tension | 650 gm (23 oz) |



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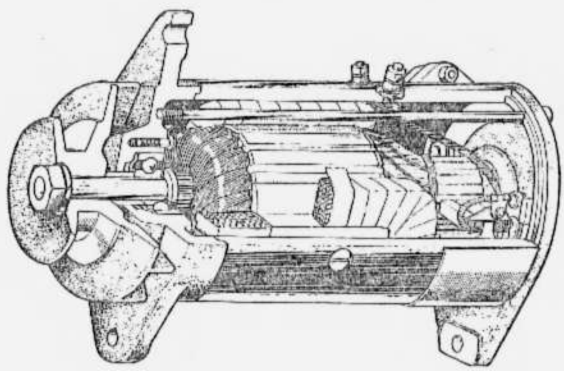
## 2. GENERATOR CONSTRUCTION

The armature is supported on both ends with ball bearings.

The field coils are supported by the pole cores and these pole cores are screwed on to the yoke with single screw respectively. The field coils are connected in series with one end connected to DF generator terminal and the other end connected to the negative brush.

The positive brush is connected to the D+terminal of generator.

The brush holders are riveted to the commutator end frame.

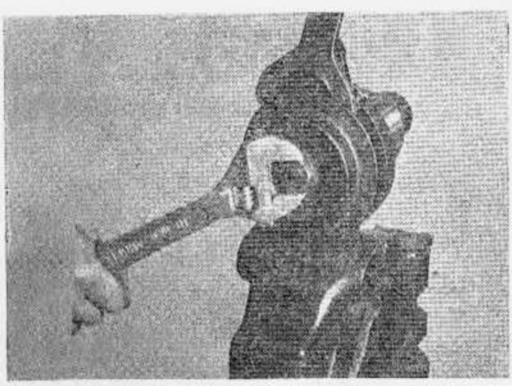


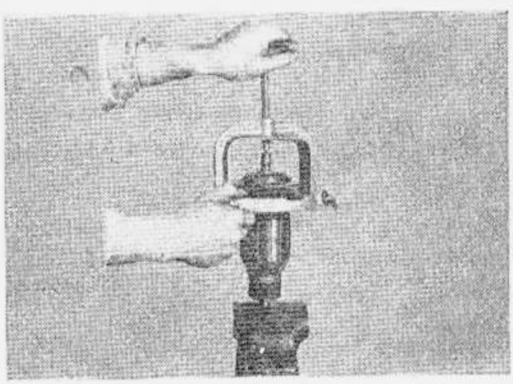
## 3. DISASSEMBLY AND REASSEMBLY OF GENERATOR

The generator is disassembled in the following order.

(1) Remove cover band and unloosen connection between field coil and DF terminal, and between brush and D−terminal.

(2) By removing the 2 through bolts, the generator can be disassembled into





pulley side end frame, armature, yoke complete, and commutator end frame. Practically all inspection and repairs to the generator can be carried out with the generator disassembled at this state.



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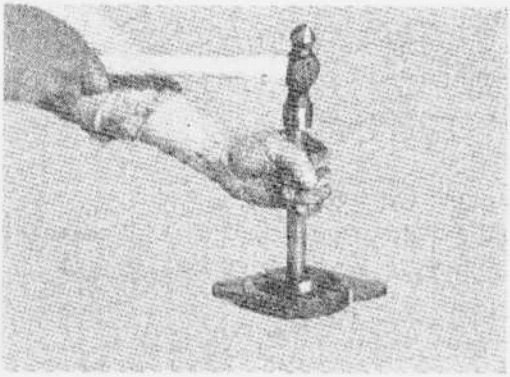
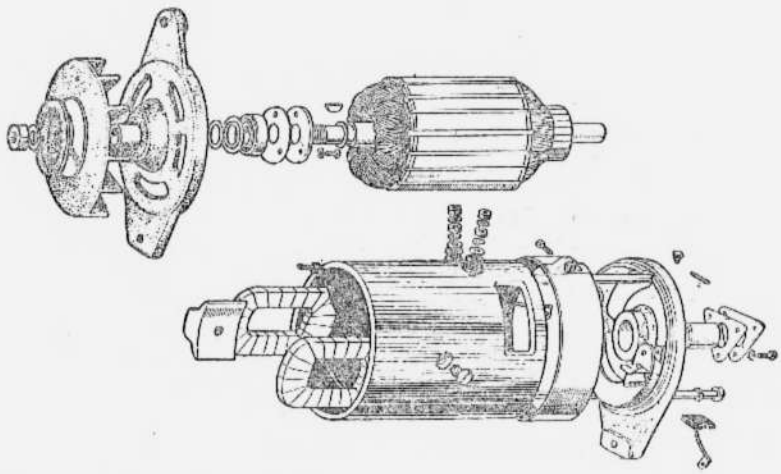
(3) Unscrew pulley lock nut and remove pulley from armature shaft with puller.
(4) Take out shaft key and supporting pulley side end frame, remove armature shaft by tapping it out lightly with a wooden mallet.
(5) To remove the ball bearing from pulley side end frame, first unhook snap ring with a screwdriver, then placing a spacer collar over the bearing, tap the bearing out lightly with a wooden mallet.



(6) Remove nuts from A and F terminals.
(7) Remove ground wire from field coil.
Remove field coils by unloosening their respective mounting pole core screws.
(8) The ball bearing on the commutator side can be removed easily as the bearing fit is not made so tight on this end.
This completes the disassembly of the generator.



To reassemble, follow the above procedure in reverse order. The following points should be observed during reassembly.
(1) Care should be taken to see when assembling the DF and D—terminals that



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they are properly insulated from the frame.

(2) Ball bearings should be washed clean and packed with fresh grease before installing.

(3) Pole cores should be thoroughly tightened into place.

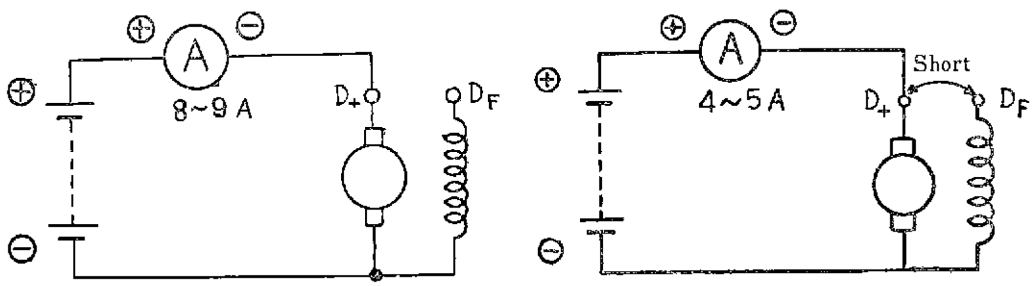
## 4. GENERATOR MOTORING TEST

The simplest method of checking the internal condition of the generator before disassembling is to give it a motoring test.

In this test, the condition of the generator is determined by using a fully charged battery and a 30-ampere ammeter, and noting the turning action and current of the generator.

(1) **Wiring Connections and Current**

Connect generator frame (unpainted part) to—terminal of battery,+terminal of battery to+terminal of ammeter, and—terminal of ammeter to generator D terminal and DF terminal.




If by the above connection, a current within 4 to 5 ampere flows as shown in the diagram and the generator turns smoothly, the generator can be considered to be in good condition.

Then by removing D+and DF terminal connection, the current should rise to 8 to 9 amperes.

(2) **If Generator is Defective**

If a large current flows through by the former connection, the probable causes are — the armature is too tight mechanically, short circuit at armature rear, grounded field coil, broken wiring, etc.

Then if the current returns to normal when D –and DF terminals are disconnected, the cause can be assumed to be in the field coil.

If however, a small current flows in the first case, the trouble can be assumed to be in poor contact between brushes and commutator or at other points where the current has difficulty in flowing. Before checking for cause, make certain that the battery is not at fault and that all connections in the circuit are in proper condition.



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## 5. TROUBLE SHOOTING GENERATOR

| Symptom | Location of Trouble | Probable Cause | Method of Checking |
|---|---|---|---|
| No Charging Shown | Brushes | Defective contact due to wear | Visual<br>Check dimension |
| | Brush springs | Brush floating due to weak or broken spring | Check spring tension |
| | Commutator | Poor contact with brushes due to burned surfaces | Visual |
| | | Short between segments | Refer text |
| | | Grounded | Refer text |
| | | Defective soldering to coil | Visual |
| | Armature coil | Short between wiring | Refer text |
| | | Grounded | Refer text |
| | Field Coils | Grounded | Refer text |
| | | Broken connection at terminal | Visual |
| | Terminals | Grounded | Refer text |
| | Brush holders | Positive side grounded | Refer text |
| | Wiring | Broken or grounded wiring between generator and regulator | Check with temporary wiring |
| | Regulator | Cutout relay does not close. Points burned | Refer Regulator |
| Inadequate Charging | Brushes | Poor contact due to wear | Check dimensions |
| | Brush springs | Poor brush contact due to weakened springs | Check spring tension |
| | Commutator | Burned, dirty, high mica | Visual |
| | | Defective soldering to coil | Visual |
| | Regulator | Burned points, Out of adjustment | Refer Regulator |
| No Output Regulation | Generator | D- or DF terminal lead wires shorted | Visual |
| | Regulator | Out of adjustment | Refer Regulator |
| | Wiring | Shorted wiring between generator and regulator | Check with temporary wiring |



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## 6. GENERATOR TESTING

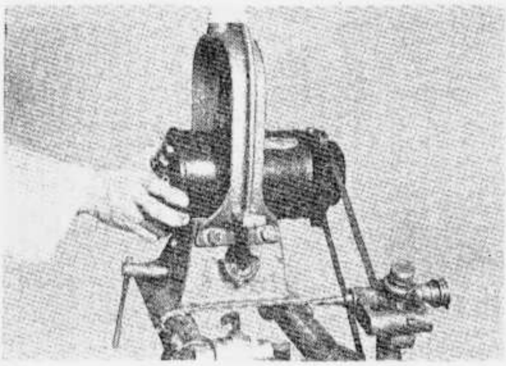
The condition of the generator performance is determined by testing with the generator tester.

The battery used must be in fully charged state.

### (1) Generator Output Test

Mount and run generator on tester and see if load current of 18 amperes at 14 to 14.8 volts can be obtained,

If these values cannot be obtained, the generator output can be considered inadequate making it necessary to disassemble and make necessary repairs.

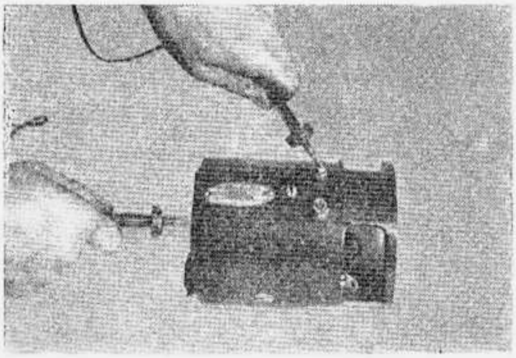


### (2) Generator Field Coil and Brush Holder Test

1. Field Coil Tests

a. Short Circuit Test

Place one test prod on F terminal and the other on generator yoke. If current flows, it indicates a short circuit in the coil and makes it necessary to repair the coil.





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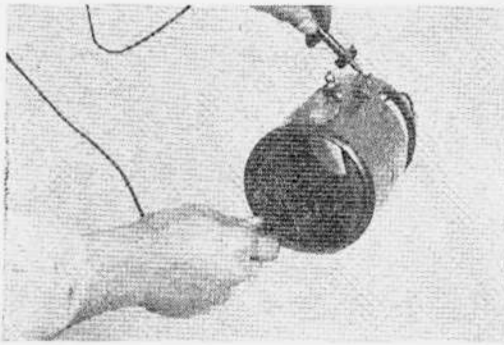
b. Open Circuit Test

Place one test prod on F terminal and the other on field coil lead. If current flows, the coils are in good condition but if current fails to flow, repair coil as there is a break in the windings.



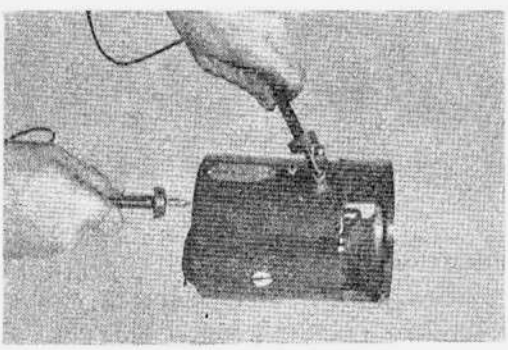
c. Field Current Test

Connect field lead wire of tester to generator F terminal and ground lead wire of tester to field coil lead. Impress 12 volts and check amount of current flowing through the coils. If this is within 2 amperes, the coils are satisfactory.

With the above tests, it is possibls to determine if the coils have excessive resistance or if there is a short ciruit or break in the coil windings.

2. Terminal Insulation Test

Place one test prod on A terminal and the other test prod on generator yoke. If current flows through tester, the condition is satisfactory. If current fails to flow, it indicates that the insulation between the A terminal and generator yoke is defective.



3. Brush Holder Insulation Test

Place one test prod on brush holder and the other test prod on generator



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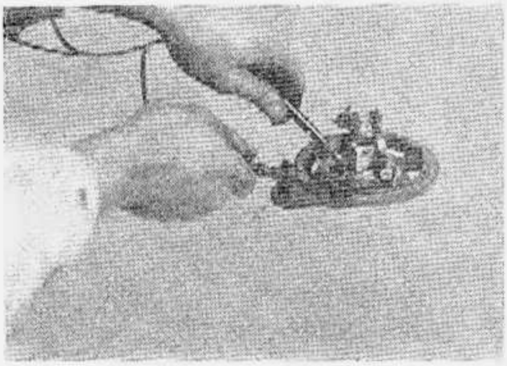
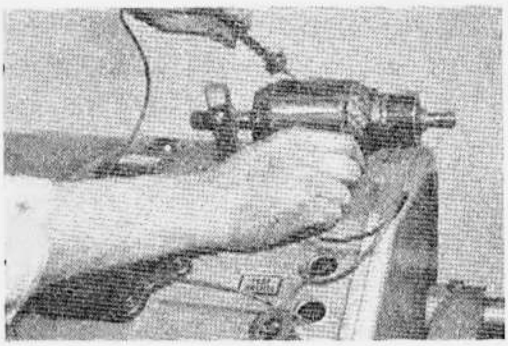
yoke. If current fails to flow through tester, the condition is satisfactory. If current flows, it indicates that the tested brush holder is grounded and should have the insulation repaired.

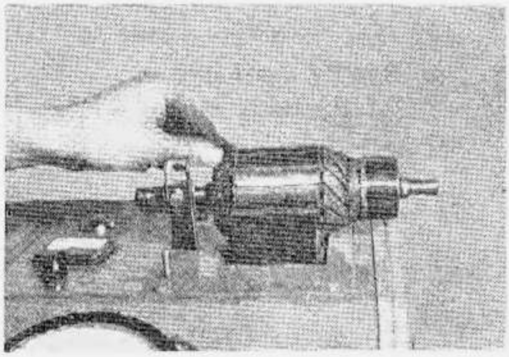


(3) **Armature Test**

a. Armature Ground Test

Place one test prod on armature core and the other test prod on commutator. The tester should not show any current flowing between these two points. If current flows, it is an indication that the armature is grounded.





b. Armature Short Circuit Test

Place armature on growler and holding a steel test bar against the armature, rotate the armature slowly. This steel test bar should not be attracted by the armature. If attracted, there is a short circuit in the armature.



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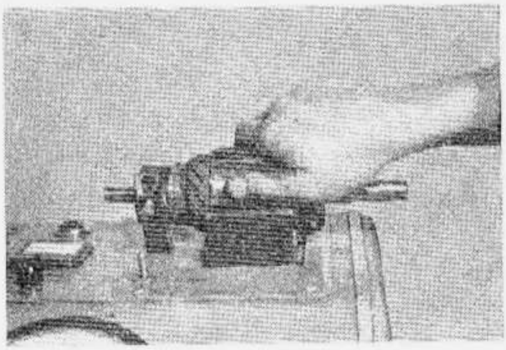
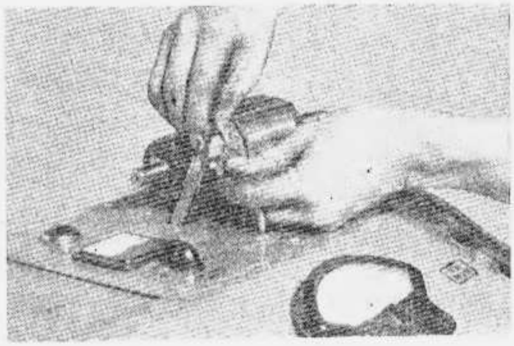
c. Armature Winding Test

The purpose of this test is to determine the amount of current flowing between two adjoining commutator segments and its armature winding, and is performed on the generator tester.

If the reading obtained shows considerable differences, the armature winding is defective.



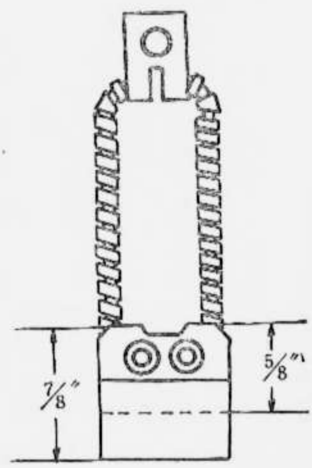


**(4) Reconditioning Commutator**

If the commutator shows slight burning or pitting, dress down smooth with fine sandpaper. If dirty with grease or oil, wash clean with gasoline.

However, if the commutator surface is badly pitted or burned, machine down on a lathe. The commutator can be used until machined down to 40 mm (1.57″) in diameter.

The mica in between the commutator segments should be 0.5 to 0.8 mm (0.02 to 0.03″) below the surface of the segments. The mica should always be undercut after commutator is machined.




**(5) Checking Brush Dimensions**

The brushes can be used until worn down to 15 mm (0.6″).

The brushes should move smoothly inside the brush holders. If found sticking, the cause is probably due to the brush holders being either bent or dirty in which case correct or clean.

**(6) Measuring Brush Spring Tension**

The brush spring tension is satisfactory if the force required to separate a new brush from commutator surface is more than 550 gm (20 oz) when



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measured with spring scales

**(7) Causes and Repairs of Generator Noises**

The probable causes of noises produced when generator is rotating are defective ball bearings, loose pole core, and bent shaft.

For noisy ball bearings, fill with ball bearing grease or replace.

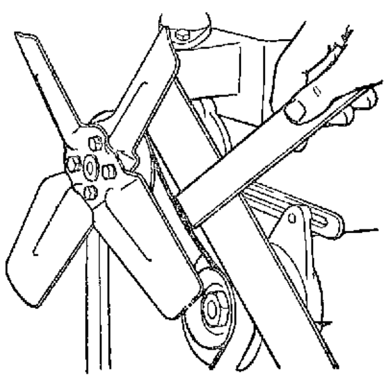
For loose pole cores, tighten down pole core screws securely.

Shafts when supported at bearing parts should not show more than 0.1 mm (0.004″) deflection at the core part.

## 7. PRECAUTIONS ON GENERATOR

(1) Generator drive belt should be checked frequently to see that it has the proper tension

Keep belt adjusted to have about 1/2″ slack.



(2) Lubricate armature shaft bearings with 2 to 3 drops of motor oil every 1,200 miles.

(3) Do not allow water to get into the generator with steam cleaner.

(4) Make constant check on generator bracket to cylinder block bolts, and all terminal connections to see that they are tight and also see that the wire harness covering is good condition



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# VOLTAGE REGULATOR

The voltage regulator is of the Bosch 2-contact type

## 1. VOLTAGE REOULATOR SPECIFICATIONS

| | |
|---|---|
| Model | Bosh 2-contact type |
| Part Number | RS 27700 |
| Cut-in Voltage | 12.5 volts |
| Countercurrent | 2 to 7.5 ameres |
| Regulating Voltage | 14.2 volts (1500 rpm)<br>14 to 14.8 volts (3000 rpm) |
| Current Limit | 18 amperes |
| Armature Gaps | |
| Voltage | 0.8 – 1.3 mm (0.031″ – 0.051″) |
| Current | 1.0 – 1.4 mm (0.039″ – 0.055″) |
| Relay | 0.8 – 1.3 mm (0.031″ – 0.051″) |
| Angle Gaps | |
| Voltage | 0.2 – 0.4 mm (0.008″ – 0.016″) |
| Current | 0.2 – 0.4 mm (0.008″ – 0.016″) |
| Relay | 0.4 – 0.8 mm (0.016″ – 0.031″) |
| Point Gaps | |
| Voltage | 0.2 – 0.4 mm (0.008″ – 0.016″) |
| Relay | 0.4 – 0.8 mm (0.016″ – 0.031″) |
| Contact Point Pressure | |
| Voltage | Not less than 180 grams (5.8 oz) |
| Current | Not less than 150 grams (4.8 oz) |
| Spring Presure | |
| Relay | Not less than 70 grams (2.2 oz) |

## 2. CONSTRUCTION AND OPERATION OF VOLTAGE REGULATOR

The Bosch 2-contact type voltage regulator is a three element type consisting of the voltage regulator, current limiter, and cutout relay units.



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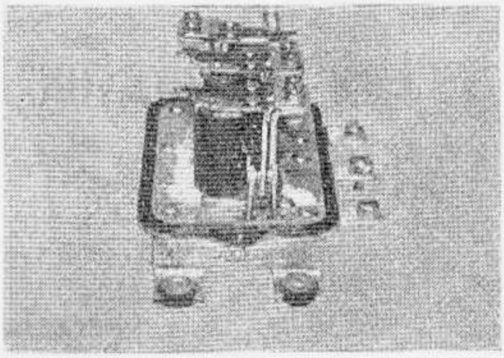
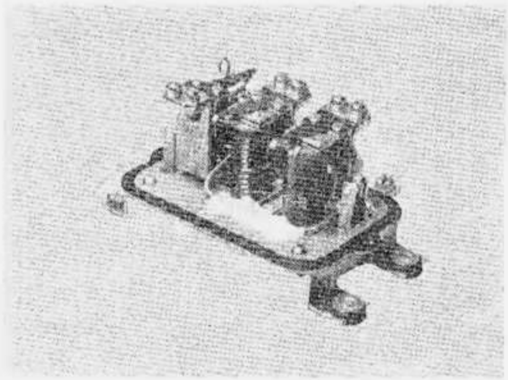


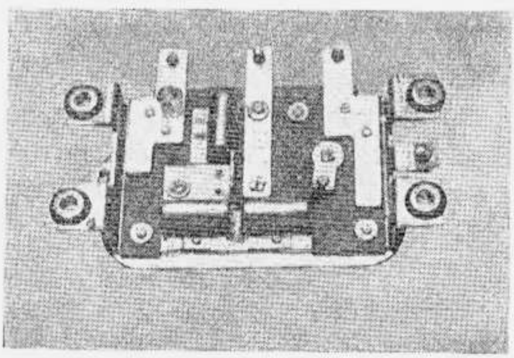
The advantages of the Bosch regulator are as follows:

(1) Regulator contacts are of the 2-contact type.

(2) Adjusting springs are of the flat plate type.



(3) Practically are parts arc riveted on.



(4) All contact points are of silver or tungsten.

(5) Adjusting resistances used are 10.5 ohms.



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(6) Screw end of F terminal is peened to make it non removable for preventing making wrong connection with A terminal

The operation of this regulator is as follows:

The internal wiring of the voltage regulator unit is as shown in the following diagram.

G .. . Generator

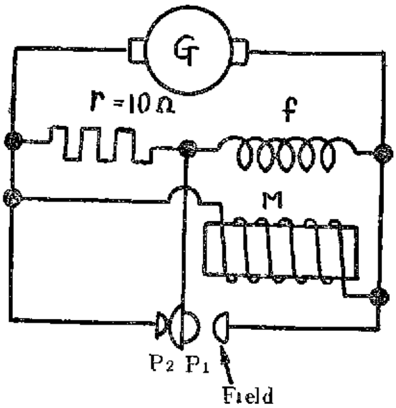
r .. . .. Resistance

M ........Armature Coil

f . . Field Coil

$P_1$. . .....High Speed Vibrating Points

$P_2$........ Low Speed Vibrating Points




When the generator begins to rotate to produce power, the current at first passes through point $P_2$ and flows through the field coil f with no current flowing through the resistance r. As the current through the field coil becomes larger, the generated current also becomes larger.

The generator terminal voltage is connected to act on the armature coil M so that as more current is generated, the armature coil M attracts point $P_2$ to pull open the contact.

When point $P_2$ opens, a restricted amount of current flows through resistance r into the field coil f but as the generated current becomes larger, the armature coil M becomes stronger and closes point $P_1$.

When point $P_1$ closes, the current instead of passing through the field coil f, flows through point $P_1$ to reduce the output of generator G.

The reduction in generator output lowers the voltage on armature coil to weaken its pulling force and allow point $P_1$ to open and point $P_2$ to close. The current then flows through point $P_2$ instead of through the resistance r to allow more current to flow through field coil f and increase generated current.

This process is continuously repeated to maintain the voltage at a constant value.

The relation between the generator speed and generated voltage is shown by the diagram below.



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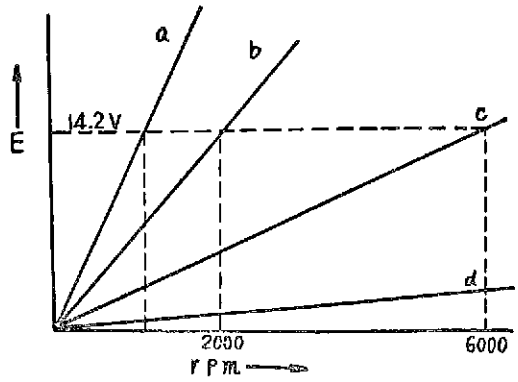
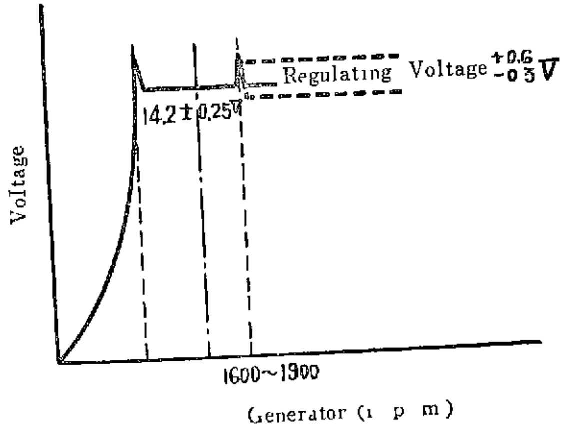



When the adjusting resistance r is zero, the voltage will rise rapidly as shown by curve a. Curve b shows the condition when the resistance r is equal to 10.5 ohms and curve c when resistance is 100 ohms At infinite resistance, that is, when the field coils are shorted, the voltage will rise as shown by curve d.

With 10.5 ohms, the voltage cannot be regulated to more than 2,000 rpm which makes it impractical but with 100 ohms, regulation can be carried out to 6,000 rpm which is a practical value.

Comparison of point sparking between use of 100 ohms and 10 5 ohms shows that the 10.5 ohms will give much less sparking.

In the Bosch type voltage regulator, these facts have been taken into consideration and the resistance made exceedingly small to decrease point burning offects of sparking and prolong the life of the contacts. The regulation range has been increased by shorting or cutting in resistance to regulate up to about 2,000 rpm and shorting the field coils above this speed to hold down the voltage. By this method, there may be a slight difference in voltage regulation at low and high speeds.



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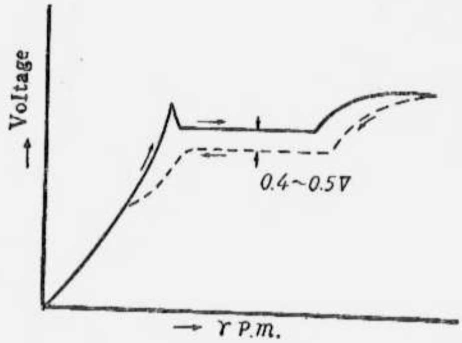
## 3. VOLTAGE REGULATOR CHARACTERISTICS

The characteristics of this Bosch regulator are as follows.

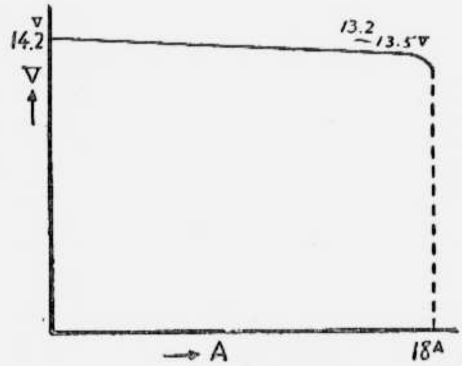
(1) **Hysteresis Effect** (No-load characteristic)

Voltage variation during voltage rise and voltage drop are as shown in the figure.




(2) **Drooping Voltage Characteristic**

When charging current flows through, the voltage tends to drop as shown in the figure.

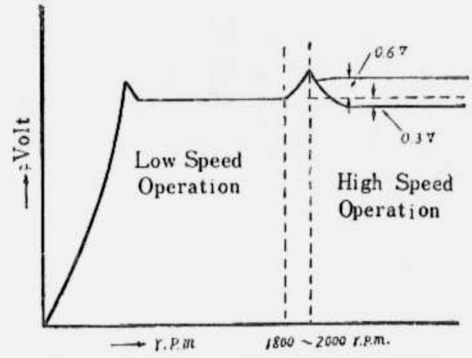



(3) **Point Characteristics** (At no-load)

As points are in two system, the variation in regulator voltage is as shown in the figure.

Low speed points operate at approximately generator speed of 900 to 1100 rpm.

High speed points operate at approximately generator speed of 1800 to 2000 rpm.



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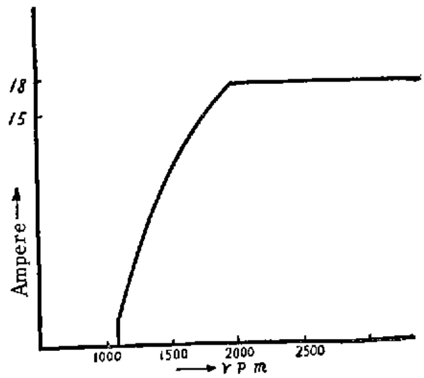
(4) **Charging Characteristics**

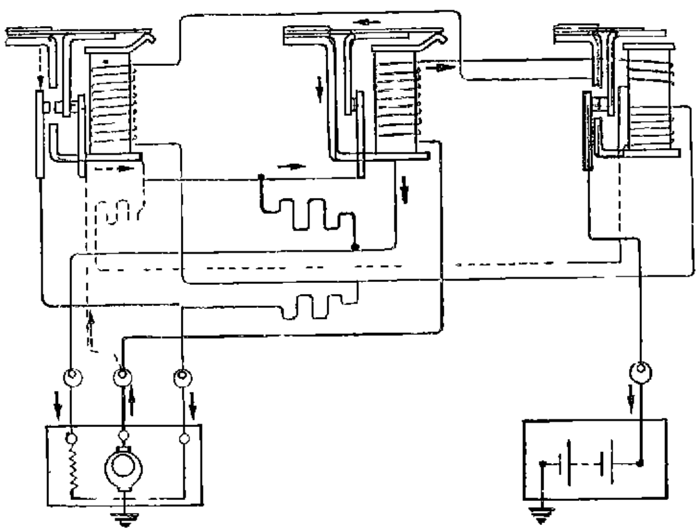
The generator operating together with this voltage regulator has an output of 216 watts, 18 amperes.

The charging characteristics is as shown in the figure.




## 4. ACTUAL OPERATION DIAGRAMS ON VOLTAGE REGULATOR

The following diagrams illustrates the operation of the voltage regulator under various conditions.



Operation of Regulator at Low Speed



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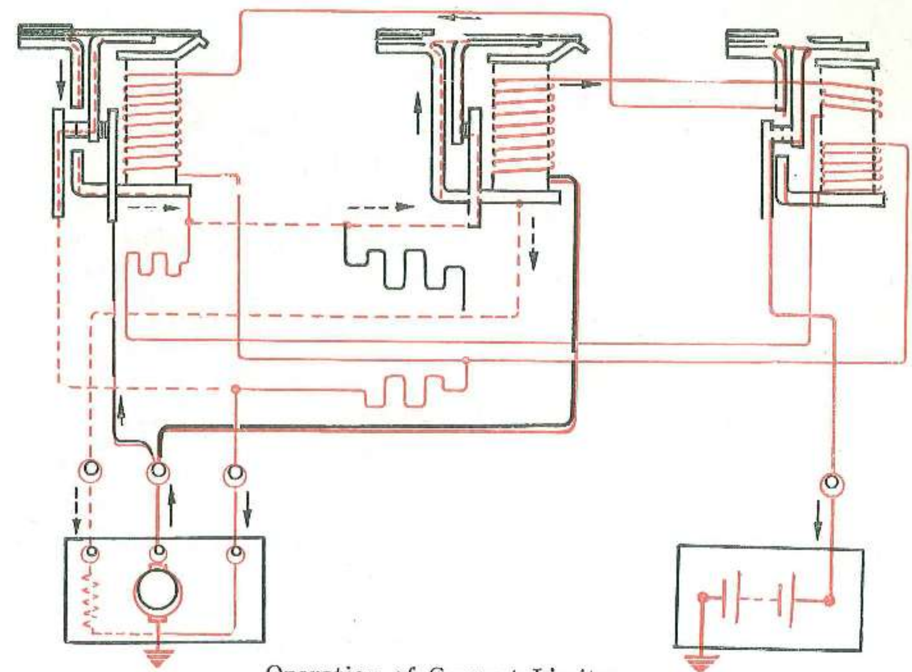
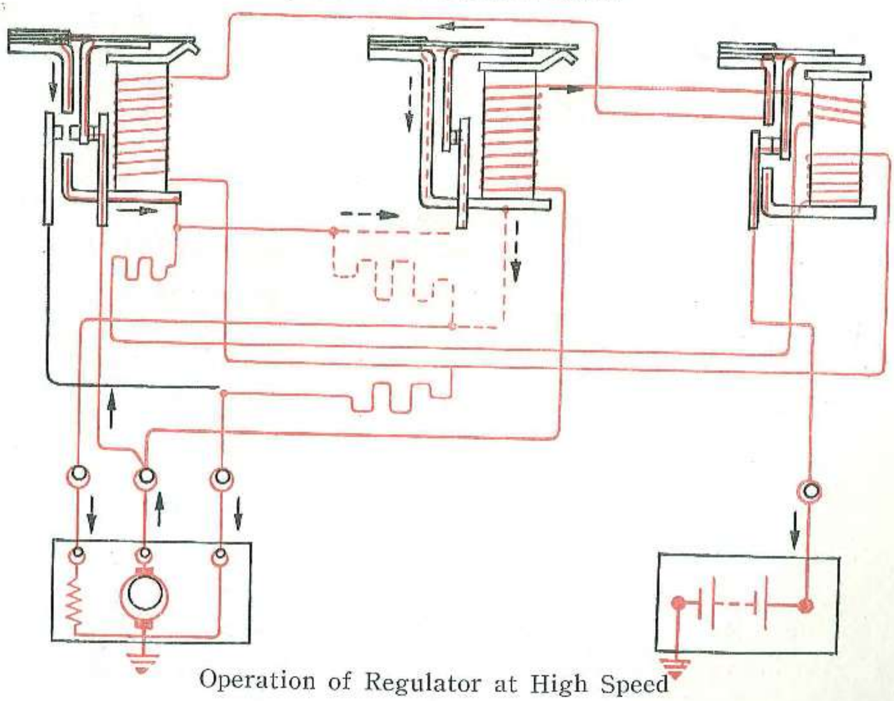


Operation of Current Limiter



Operation of Regulator at High Speed

## 5. VOLTAGE REGULATOR TESTING

The voltage regulator tester is used to check the action of the voltage regulator,



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current limiter, and cutout relay.

(1) **Testing Voltage Regulator**

The operating voltage of the voltage of the voltage regulator is determined with the tester. This should be between 13.95 and 14.45 volts if the regulator is in good working condition,

As previously described, the low speed contact points begin to operate from 900 to 1100 rpm and the high speed contact points from 1800 to 2000 rpm.

Also, for the same speed, there will be variations in voltages measured when voltage is rising and when voltage is falling due to hysteresis effect. Consequently, when reading voltages, always read that for rising voltage doing this by dropping the speed each time and raising it to the test value.

When adjusting voltages, check by adjusting it for low speed action and for high speed action and noting the difference.

(2) **Testing Current Limiter**

Test by running engine over 2000 rpm.

If the tester shows maximum current of 18 amperes, the current limiter is in good condition.

(3) **Testing Cutout Relay**

In the cutout relay, the cut-in and cut-out voltages together with the reverse current are determined with the tester.

a Cut-in Voltage

Raise engine speed gradually and read the voltage at the instant the cut-out relay points closes This voltage should be between 12 to 13 volts

Note: The cut-in voltage of the cutout relay should always be slightly less than the regulating voltage of the voltage regulator.

b. Cut-out Voltage

After the cutout relay points closes, lower engine speed and read the voltage at the instant the cutout points open. This voltage be approximately equal to the cut in voltage

In the cutout relay, it is only necessary to adjust the cut-in voltage and reverse current but this cut-out voltage is checked for reference.

c. Reverse Current

At the instant the cutout relay cuts out, the ammeter will deflect to the minus side. This amount is called countercurrent and should be from 2 to 7.5 amperes.

## 6 REGULATOR ADJUSTMENT METHODS

(1) Voltage Is Too Low At 1500 rpm Generator Speed

Cause is due to poor contacting at low speed contact points or flat springs



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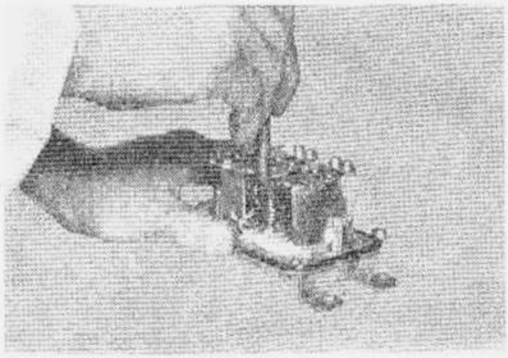
being out of adjustment.

First clean points carefully with chamois skin. If voltage is still low, increase spring tension slightly.



(2) Voltage Is Too High at 1500 rpm Generator Speed

Cause is due to spring being out of adjustment. Press down spring support slightly downward to correct.

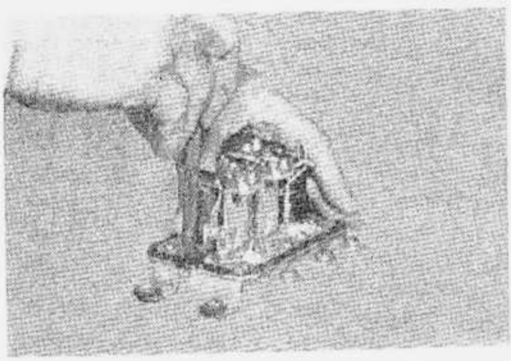
(3) Voltage Is Too Low At 3000 rpm Generator Speed

Try making point gap slightly smaller.

(4) Voltage Is Too High At 3000 rpm Generator Speed

Try making point gap slightly larger.

Or try cleaning high speed contact points carefully with chamois skin.



(5) Output Current Is Small

Cause is due to spring on current limiter being out of adjustment. Raise spring support slightly. Dress down current limiter points with sandpaper.

(6) Output Is Too Large

Cause is due to spring on current limiter being out of adjustment. Lower spring support slightly.

(7) Cut-in Speed Of Generator Is Too Large

Cause is due to defective contacting at voltage regulator low speed points



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or current limiter points.

Clean or dress points.

(8) Cut-in Voltage Is Too High (or Too Low)

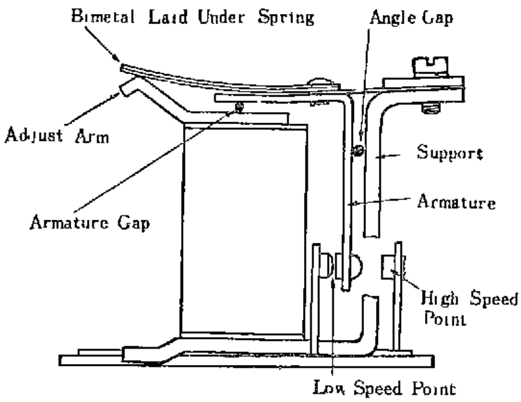
Adjust spring.

(9) Counter Current Is Too Large

Try making cutout point gap smaller.

The above are cases which do not require replacement of contact points. If the screws holding the armature points have been loosened to shift the armature points of if the armature points have been replaced, the gaps must be adjusted.

Adjustments are made as follows.



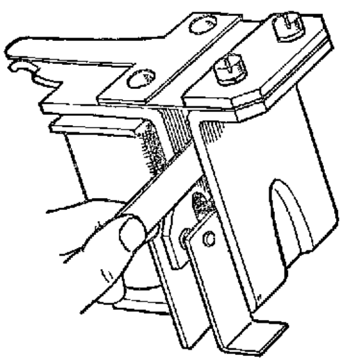

(1) Voltage Regulator Angle Gap

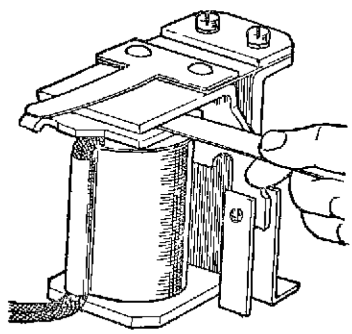
Insert 0.01″ thickness gauge into gap and tighten screws.

(2) Voltage Regulator Armature Gap

Insert 0.04″ thickness gauge into gap and bend point holder on high speed side until points contact.

Adjust to make armature gap 0.03″ to 0.04″ for the time being.







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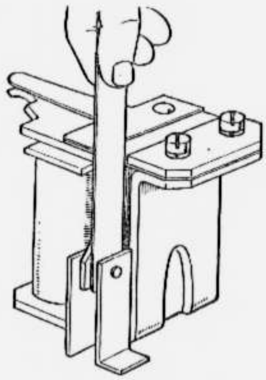
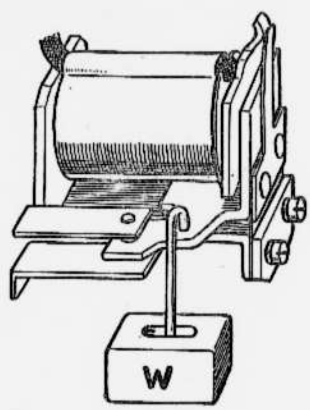
(3) Voltage Regulator Point Gap

Bend point holder on voltage regulator high speed side to make gap 0.01″.



(4) Voltage Regulator Contact Pressure

Hang a 180 gm (6.3 oz) weight on voltage regulator point. If the points fail to open under this weight, the contact pressure can be considered satisfactory




If the points open, bend the support part down slightly.

After the above gap adjustments have been completed, adjust spring to bring regulating voltage up to specified value.

If this specified value cannot be obtained, vary gap slightly by the following procedure.

(5) Armature Has Too Large A Vibration.

Make point gap smaller and armature gap larger.

Or clean points carefully with chamois skin.

(6) Voltage At High Speed Is Too High

Make point gap larger and armature gap smaller.



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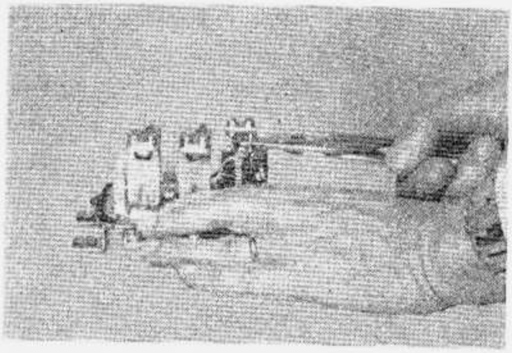
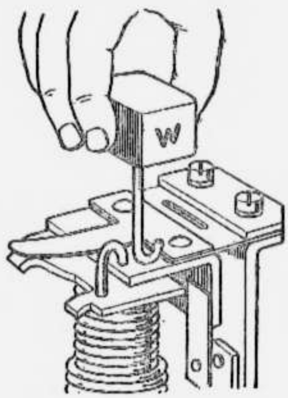
(7) Voltage At High Speed Is Too Low
Make point gap smaller and armature gap larger.

(8) If the points on the current limiter is replaced, adjust its angle gap and armature gap in the same manner as that for the voltage regulator.
The contact pressure in this case should be over 145 gms (5.1 oz).






(9) If the points on the cutout relay is replaced.
  (a) Adjust angle gap to 0.5 mm (0.020″)
  (b) Adjust armature gap to 1.0 mm (0.039″)
  (c) Adjust point gap to 0.5 mm (0.020″)
  (d) Measure spring pressure. The force required to open the contact between the armature and stopper should be more than 110 gm (3.9 oz).

## 7. TROUBLE SHOOTING

Outside of replacing points on this regulator, no other part can be repaired under normal conditions. Consequently, repairs consist only of making adjustments.

**Trouble Shooting Chart**

| Symptom | Location of Trouble | Probable Cause | Remedy |
|---|---|---|---|
| Fails to charge | Generator | Armature shaft, etc. | Refer text on Generator |
| | Wiring | Broken wire, grounding | Test with temporary wiring |
| | Regulator | Cutout relay does not close (Broken wire) | Replace assembly |
| | | Cutout relay does not close (Maladjustment) | Refer text on Adjustment |
| | | Defective cutout relay points | Same as above |



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| | | | |
|---|---|---|---|
| Charging inadequate | Generator | Poor brush contact, etc. | Refer text on Generator |
| | Regulator | Voltage regulation defective | Refer text on Adjustment |
| | | Current regulation defective | Same as above |
| | Others | Loose generator drive belt | Adjust belt tension |
| | | Poor wiring contact | Retighten terminals |
| Over-charging | Wiring | Short in A, F wiring | Test with temporary wiring |
| | | Defective regulator ground | Repair wiring |
| | Regulator | Voltage regulation defective | Refer text on Adjustment |
| | | Broken wire in voltage coil | Replace assembly |
| | Battery | Shorted plates | Repair |
| | | Specific gravity too low | Adjust |

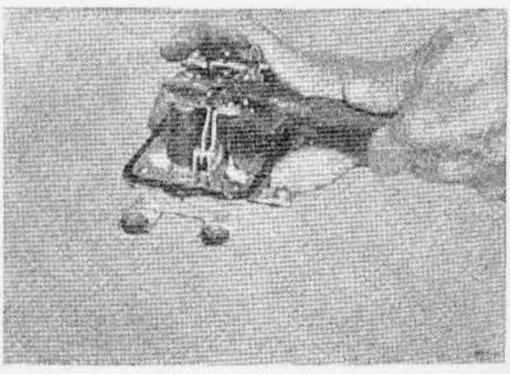
## 8. PRECAUTIONS ON HANDLING REGULATOR

(1) If regulator is believed to be at fault, check as soon as possible.

(2) Check all terminal connections frequently to see that they are tight.

(3) When adjusting regulator, do not meddle with any parts outside of cleaning points, adjusting point gap, and adjusting spring.
These should be sufficient to eliminate most troubles.

(4) Adjusting supports, as shown below, to vary contact pressure should specially be avoided.





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