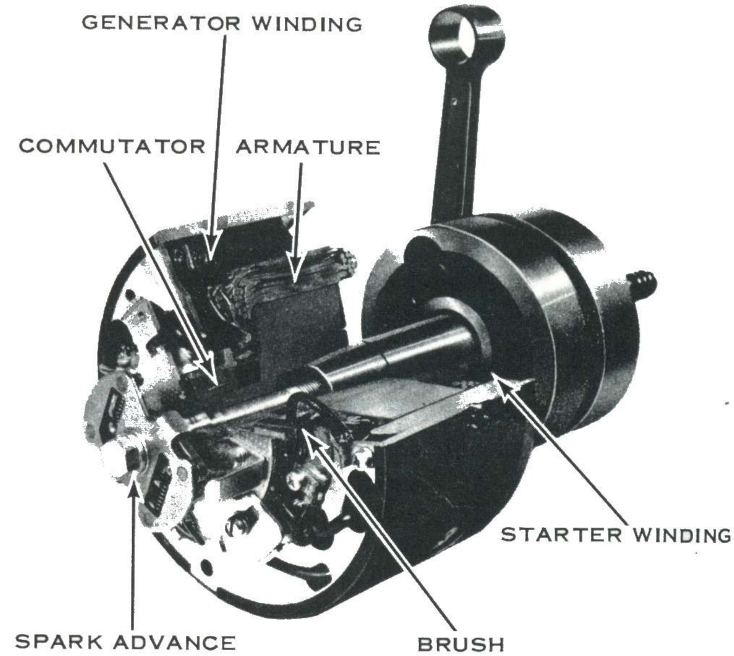
ELECTRICAL SYSTEM SERVICE

This chapter describes the construction, operation, and service procedures for the motorcycle's electrical equipment, including the generating circuit, electric starter, lighting and warning devices, switches, and ignition system. Servicing the DC generator-starter is covered by step-by-step illustrated instructions. Removal, inspection, and installation of the AC generator-magneto are explained with the aid of photographs, graphs, and illustrations. Inspecting for faulty ignition components is described in the last section of this chapter. Instructions on tuning the engine for best performance are given in Chapter 2.

Suzuki single-cylinder motorcycles use two different electrical systems: a combination DC generator-starter motor, used only on Model M15D, and an AC generator-magneto used on all other models. With either type, the electrical system converts a portion of the mechanical energy of the engine's crankshaft into electrical energy for the ignition system and for the other electrical components.

The kind of electricity furnished by each type of electrical system is the basis for differentiating between them. The DC generator-starter supplies direct current only to the battery, on which all the electrical components depend for operating power. The AC generator-magneto develops alternating current, part of which is converted to DC for charging the battery; the balance of the magneto's AC is supplied directly to the electrical components that do not need direct current from the battery—the ignition system and the night driving lights. A peculiarity of the AC generator-magneto type electrical system is that these components cannot function unless the engine is running.



Cutaway of the DC generator-starter with the armature mounted on the crankshaft. The spark advance mechanism is not used on U.S. models.

GENERATOR-STARTER

Model M15D

The DC generator system is similar to the typical automotive electrical system of a few years ago, in that it has a DC generator (which also serves as the starting motor) and a regulator to control the output. The 12-volt battery has a relatively large capacity (7 AH) to supply sufficient current to the starting motor under cold weather conditions.

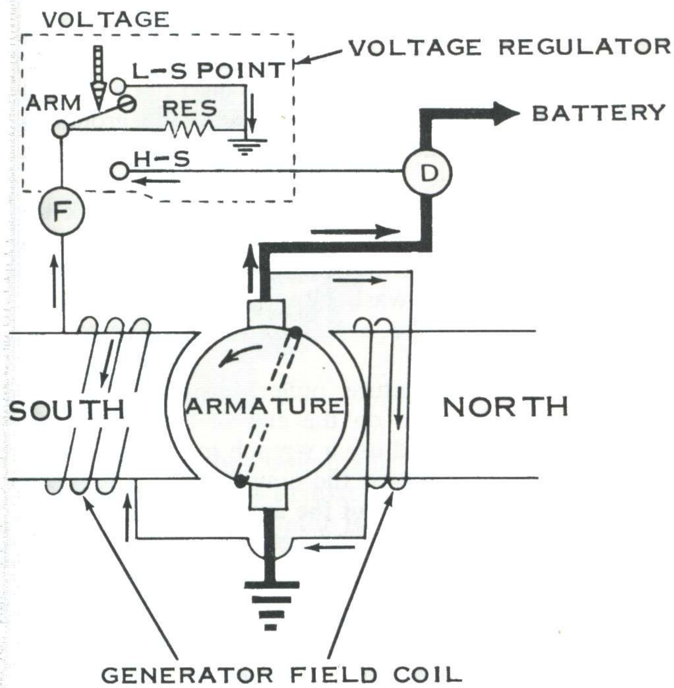
The generator is located inside of the left engine cover. There are two basic parts of the generator: the stator and the armature. The stator is fastened to the engine crankcase. The armature is attached to and turns with the crankshaft.

PRINCIPLE OF OPERATION

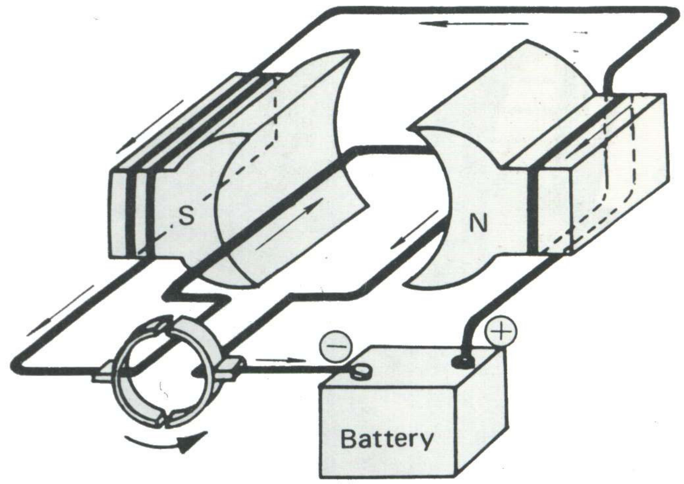
When a conductor is moved through a magnetic field, electricity is generated in the conductor. More electricity is generated as the strength of the magnetic field is increased, or as the conductor's speed is raised. In the DC generator, the magnetic field is developed in the stator coils and the electricity is produced in the rotating armature.

The stator has six laminated iron cores, called poles, fastened to its inner wall. Each core is wrapped with two different types of insulated wire: a fine wire with many turns and a heavy strap-type wire with comparatively few turns. Each core winding is connected in series with the other five core windings so that there are two continuous, separate stator windings. The iron cores become electromagnets when electric current is passed through either of the stator windings. The thin winding is used to excite and limit the magnetic field strength of the poles when the unit functions as a generator. The strap winding is used to develop an intense magnetic field for maximum torque when the unit functions as a starting motor.

The armature is made up of many separate loops of wire (conductors), insulated from the laminated core on which they are wound. The two ends of each individual loop are connected to opposite segments of the commutator. Two spring-loaded brushes, attached to the stator plate, pick up the electricity from the commutator as the armature is spun by the crankshaft. When each armature loop passes through the alternating magnetic fields of the stator, the generated elec-



Simplified diagram of the field winding used to magnetize the stator poles and thus control the output voltage when the unit functions as a generator. The amount of field current is controlled by the voltage regulator, which grounds the field wire for maximum output (L-S point) or short-circuits the field to stop generating capability (H-S point).



When the unit functions as a starting motor, the positive (+) terminal of the battery is connected to the thick field winding (marked "M"), which is connected in series with the armature through the brushes. Opposing magnetic forces in the stator poles and armature cause rotation of the armature and crankshaft.

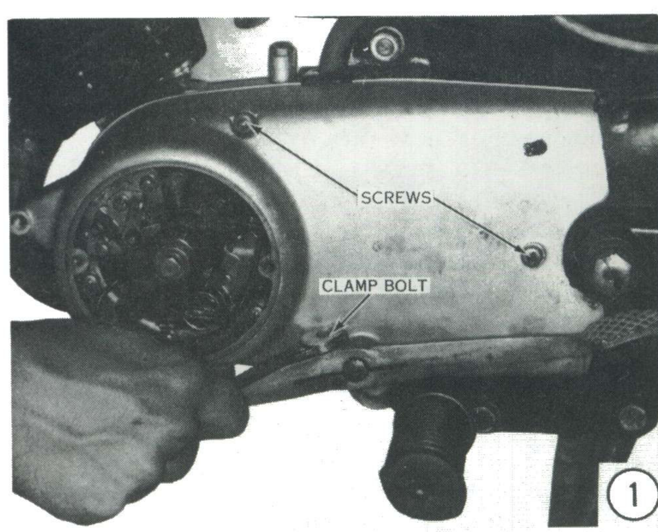
tricity is delivered to the brushes through the two commutator segments, which are the end terminals of the loop. Since the direction of the generated electricity reverses as the loop passes each of the poles, AC voltage is developed in the loop. Rotation of the commutator segments, with respect to the brushes, changes the AC into pulsating DC.

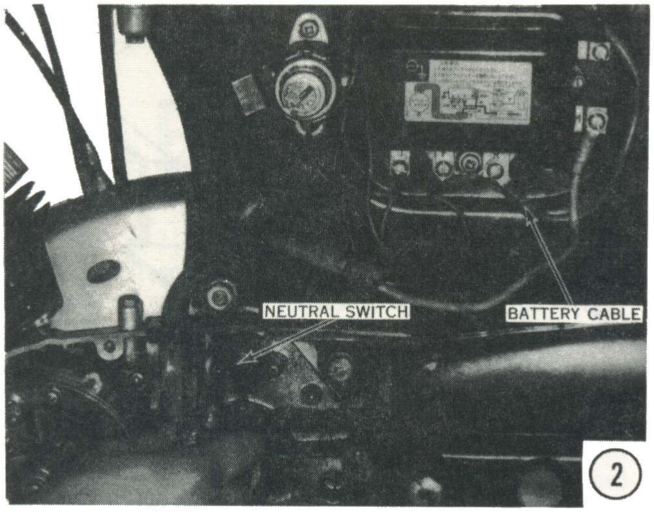
A wire from the insulated positive (+) brush (the generator's "D" terminal) carries this electricity to the regulator, which limits the voltage, and then it is delivered to the battery for charging and powering the motorcycle's electrical equipment. To obtain the electromagnetic field in the stator, one end of the stator field winding is connected to the positive (+) brush while the other end (the generator's "F" lead) is grounded through the voltage regulator. When the generator is first rotated, there is no field current in the stator winding so it is not an electromagnet. But residual magnetism in the iron cores furnishes enough field strength to initiate electrical generation in the armature loops. Some of the armature's output is routed back through the field stator winding to excite and increase the field strength in proportion to engine speed. The voltage regulator limits the generator output by controlling the strength of the stator field current. This is called a self-exciting type generator, because the armature output is used to magnetize the stator field poles.

When the generator functions as a starter motor, the strap-type motor winding in the stator is used. One end of the winding is connected to the positive (+) brush and the other end terminates in a thick wire (the generator's "M" lead), which is connected to the starter relay in the regulator case. When the starter button is pushed, a large current from the battery travels through the stator motor winding, setting up an intense electromagnetic field, and then enters the armature loops through the positive (+) brush, leaving through the grounded brush. The armature loops become electromagnetic also, but with identical magnetic polarity to the nearest stator poles. Because of the repelling force of the two same-polarity fields, the armature is twisted on its axis and cranks the engine.

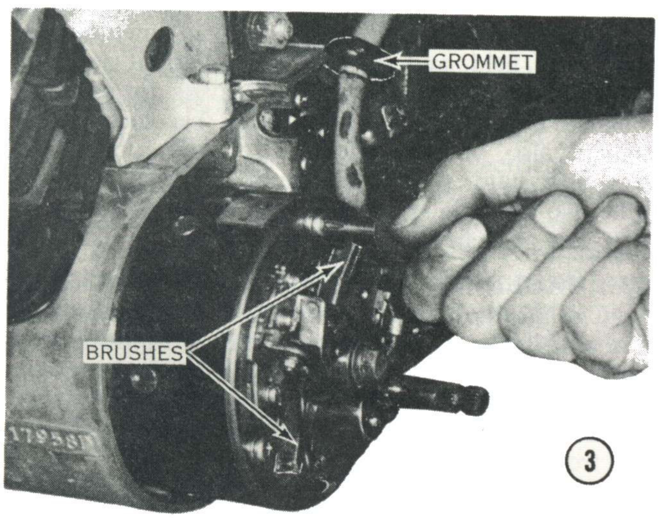
OVERHAULING THE GENERATOR-STARTER

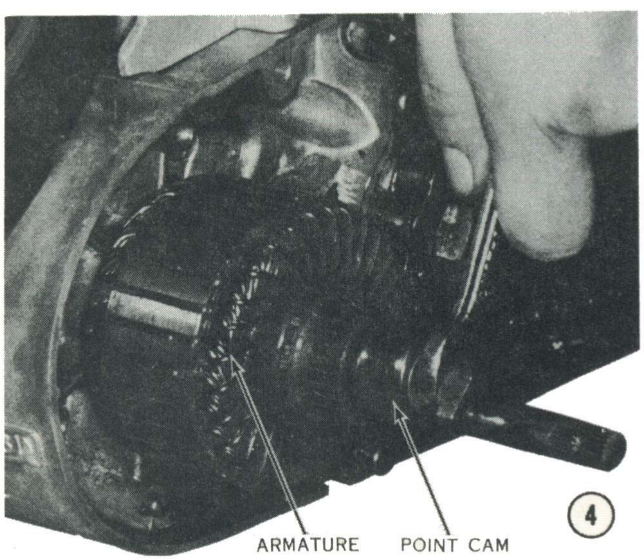
① Shift the transmission into fourth gear, take off the shift lever, loosen the three Phillips-headed screws with an impact screwdriver, and then remove the left engine cover. Loosen the small screw on the neutral switch terminal, and then pull the blue wire away from the switch.





② **CAUTION: Before working on the generator, disconnect the red cable from the battery's positive terminal to prevent accidental damage to the electrical equipment.** Take off the left frame cover, and then disconnect the following wires from the voltage regulator: yellow, red/green, and green. Separate the black ignition wire and the blue neutral switch wire from the frame wiring harness.





③ Pull up on the two brushes until the springs bear against their sides to hold them off the commutator. Use an impact screwdriver to take out the three screws, and then lift off the stator. Pull the grommets of the generator harness and the neutral wire from the crankcase slots.

④ With the transmission in fourth gear, lock the rear wheel by stepping on the brake pedal, and then use a wrench to loosen the armature bolt. Remove the bolt, lockwasher, flat washer, and ignition point cam from the armature. Use a pair of side cutters to pull the point cam key.

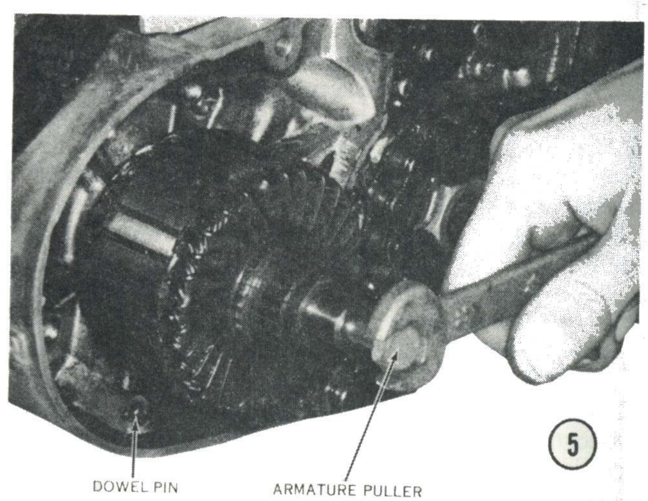
⑤ Turn the armature puller into the armature threads until it bottoms on the end of the crankshaft. Lock the rear wheel and use a wrench to turn the puller until the armature slips off the crankshaft. **CAUTION: Don't pry against the rear of the armature to remove it, or you will damage the windings.** Use a pair of side cutters to remove the Woodruff key from the crankshaft. **CAUTION: Don't lose the dowel pin which indexes the stator to the crankcase.**

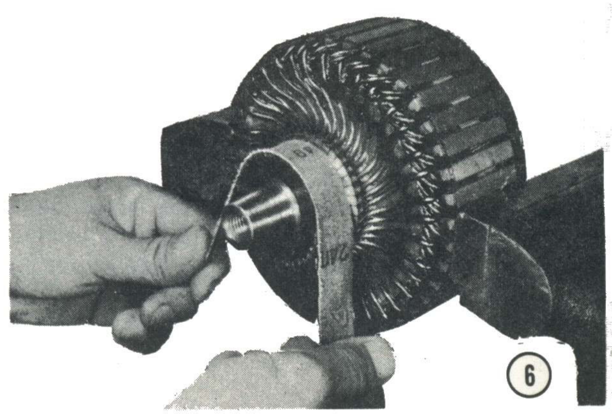
CLEANING AND INSPECTING

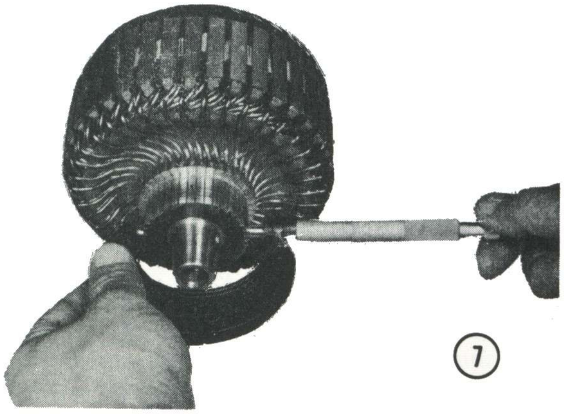
Wipe oil and dirt from the armature, stator, and brush holders with a dry cloth. **CAUTION: Never use compressed air or solvent to clean these parts, or you will damage the insulation.**

Armature

⑥ Clean oil from the commutator with a cloth saturated in alcohol. If the commutator is burned or corroded, polish it with #00 sandpaper. Wipe off all grit with a cloth to prevent rapid brush wear.







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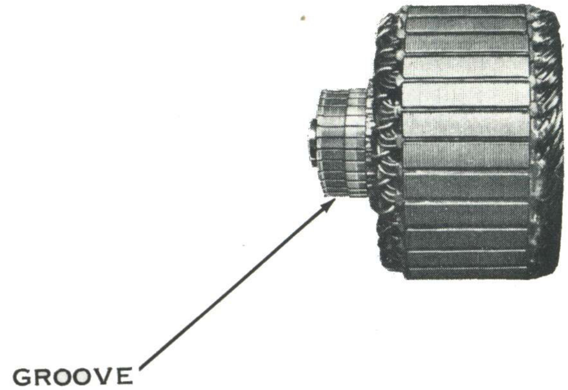

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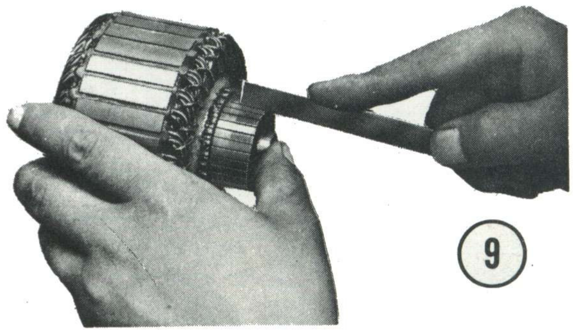
(7) Inspect the commutator for eccentricity, which can cause the brushes to float at high engine speeds.

(8) If the commutator is out of round or grooved from excessive wear, it should be trued on a lathe. **CAUTION: Don't remove more than 0.020" (0.040" on the diameter).** A new commutator has a diameter of 1.260". The armature should be replaced if the commutator diameter is less than 1.220".

(9) After turning the commutator, use a hacksaw blade to clean the undercuts between the commutator segments, which must be at least 0.020" deep. Polish the commutator to remove the burrs left by the hacksaw blade.

(10) Use an ohmmeter or self-powered continuity lamp to test the armature for grounded windings. Hold one test lead against the core and touch the other lead to the commutator. If the test lamp lights or the ohmmeter indicates low resistance, the windings are grounded and the armature must be replaced. Inspect the armature for open-circuited windings by looking at the soldered connections next to the commutator. An open circuit is indicated by melted solder on the stator poles which has spun off the overheated commutator. Use resin-core solder to repair loose connections. **CAUTION: Acid-core solder will cause corrosion and resistance connections in a short time.**

(11) To check for shorted windings, lay the armature in a growler, and then rotate it slowly while holding a hacksaw blade over the laminations. If one armature loop is shorted to another, the hacksaw blade will vibrate and the armature must be replaced.



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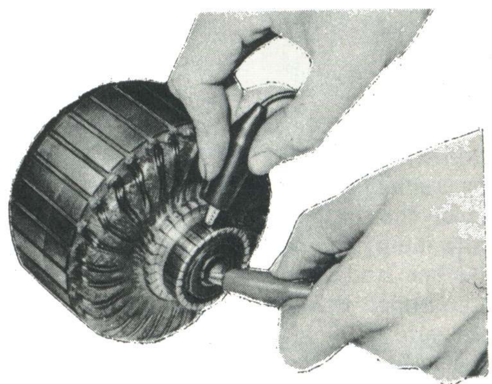

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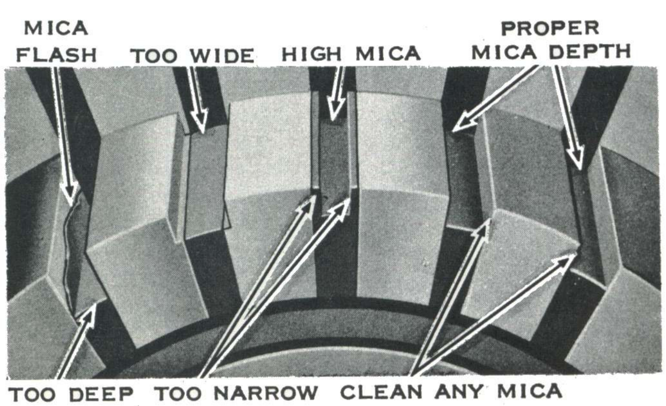
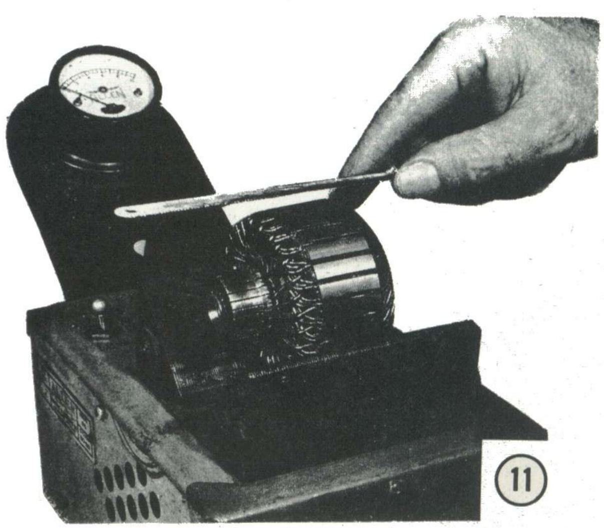


Some defects that interfere with proper brush-commutator contact. Mica flash will insulate the brushes from the armature as the commutator wears.



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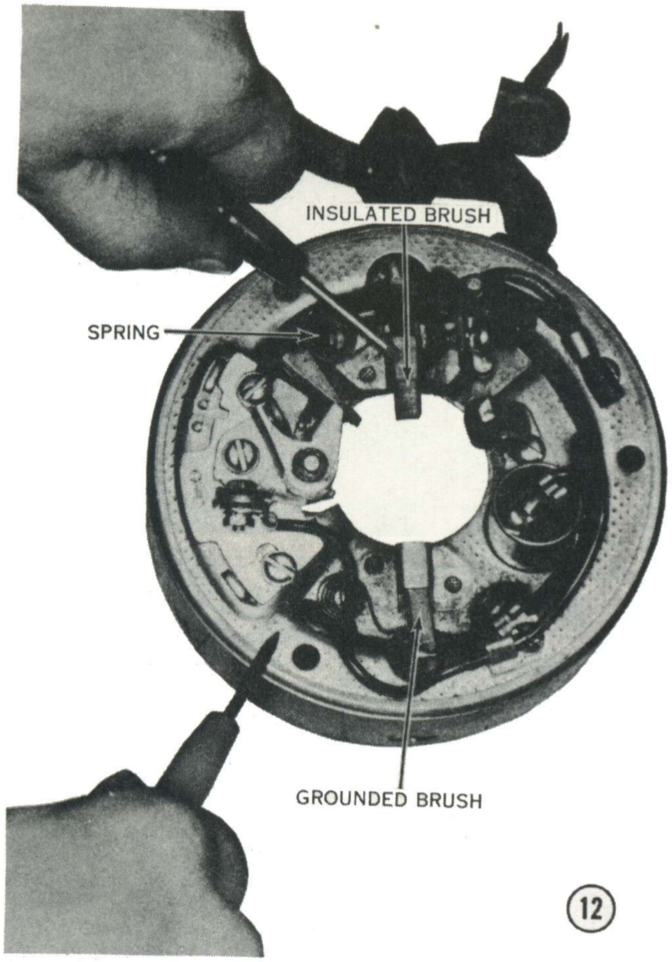

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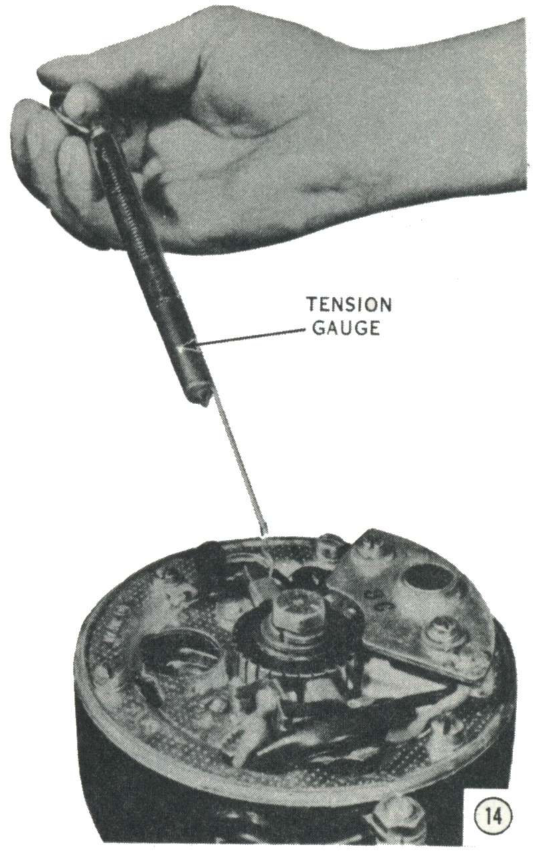

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BRUSH HOLDERS AND BRUSHES

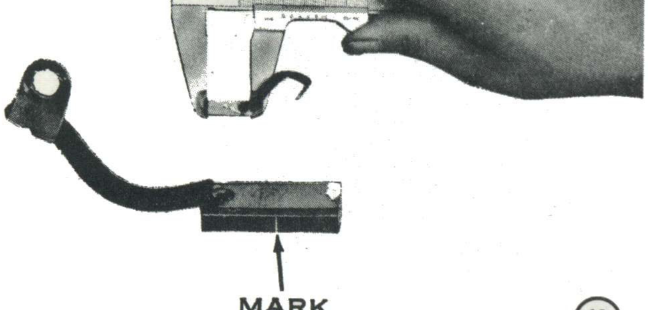
⑫ Check the brush holders to see if they are bent or loose on the stator, which causes misalignment and poor contact between the brushes and the commutator. Inspect the brush holders with a self-powered continuity lamp; connect one lead to the brush holder and the other lead to the stator. The lamp must light on the grounded brush and go out on the insulated brush. Make sure there is sufficient clearance between the insulated brush spring and surrounding metal parts to prevent a short circuit.

⑬ Unfasten the brush leads from their terminals, and then pull the brushes out of the stator for measuring. A new brush is 0.710″ long. Replace both brushes if one measures less than 0.470″ in length. When installing the brushes, check for a smooth, sliding fit in the brush holders. **CAUTION: If the brushes stick in the holders, intermittent contact with the commutator will result in arcing and burning of the commutator surface.** Insert the brush into its holder with the ramped side facing the spring, and then fasten the lead to the proper terminal.

⑭ To check the brush spring tension, position the armature inside the stator, and then lower the brushes onto the commutator. Use a gauge to measure the spring tension, which must be 16–22 oz, depending on the length of the brushes. New brush springs must be installed if the tension is less than 12 oz.

STATOR

⑮ Inspect the metal surfaces of the stator poles for scoring or scratching, which can be caused by a piece of metal wedging between the armature and stator, or by the armature rubbing against the stator poles. In the latter case, inspect the crankshaft for run-



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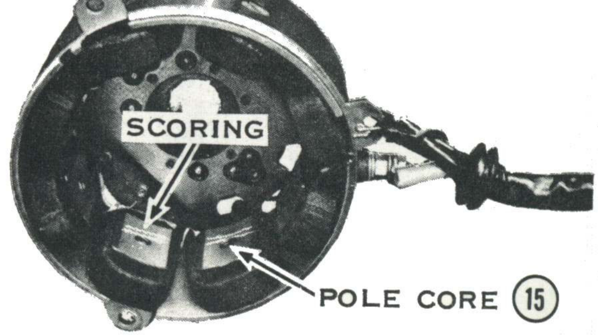

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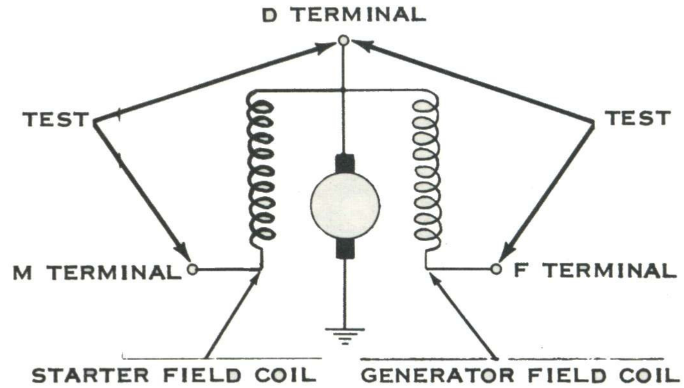
out and check the left main bearing for excessive wear by moving the end of the crankshaft up and down. Other possible causes are improper installation of the armature on the crankshaft or cocking of the stator on the engine—either of which can be caused by dirt.

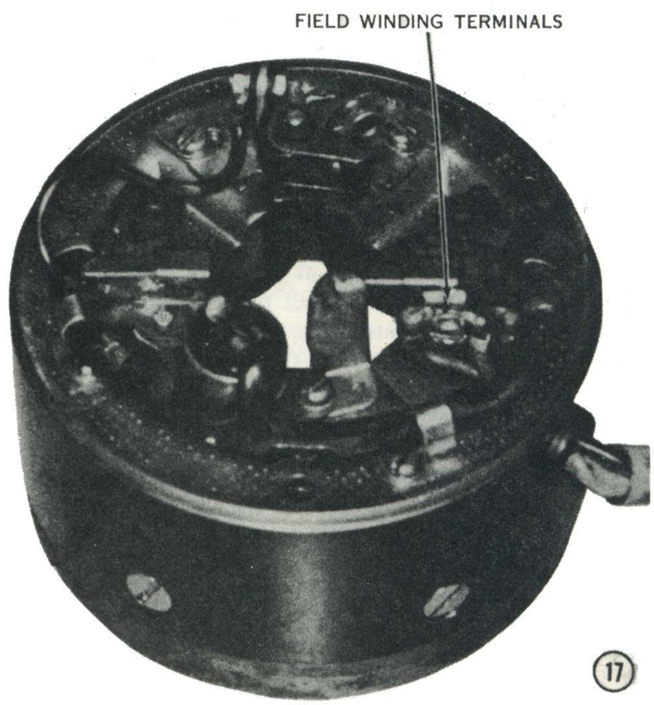
⑯ Use a self-powered continuity lamp or ohmmeter to check the stator's field windings for continuity. *NOTE: There are two windings in the field to be inspected: one for engine cranking (motor winding) and one for generating (field winding).* Test the motor winding by connecting one test lead to the red/green wire terminal and the other lead to the yellow wire terminal. Check the generator field winding by connecting one lead to the red/green wire and the other lead to the green wire. In either case, continuity must be indicated by the test lamp lighting brightly or the ohmmeter showing no resistance. If there is a break in the wiring, repair it with resin-core solder. **CAUTION: Never use acid-core solder, or corroded connections will develop.**

⑰ To check the stator winding insulation, unfasten the thin wire and the thick wire from the positive (+) brush terminal. Inspect the motor winding by connecting one test lead to the stator frame and the other to the yellow wire terminal. Then test the generator field winding by checking from the frame to the green wire terminal. There must not be any continuity, indicating that both windings are properly insulated from the frame. If there is continuity, disassemble the stator poles from the frame and look for a bare wire making contact with the frame or pole cores. To determine if there is leakage between the two windings, connect the test leads to the yellow wire and the green wire. If there is continuity, check for chafed insulation and contact where the wires loop between stator poles.

INSTALLING

⑱ Position the Woodruff key in the crankshaft keyway, and then push the armature onto the shaft while lining it up with the key. **CAUTION: Take special care to clean off flakes of metal from the tapered surfaces of the crankshaft and armature. Improper installation of the armature could cause it to loosen and strike the stator poles.** Insert the point cam key in the





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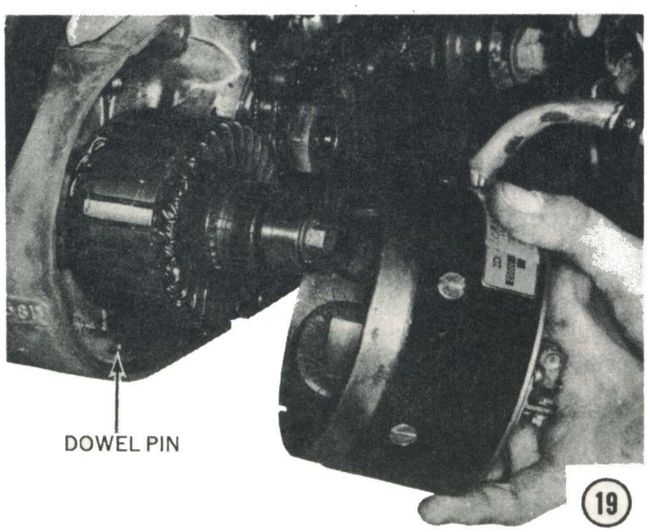

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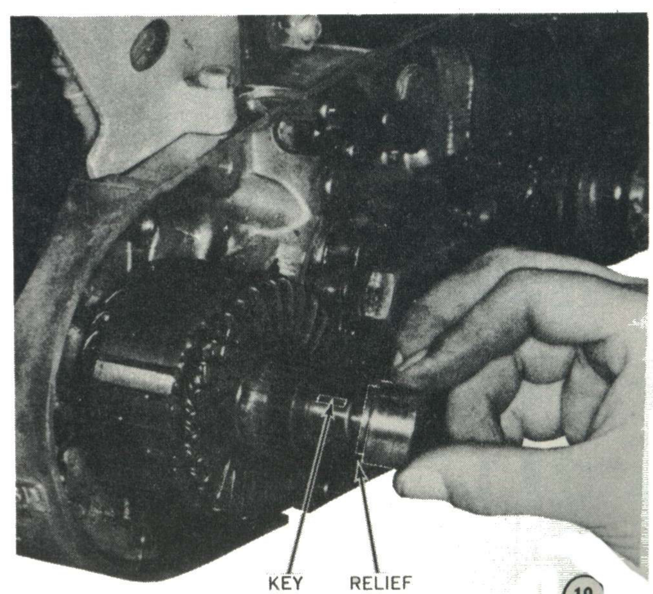

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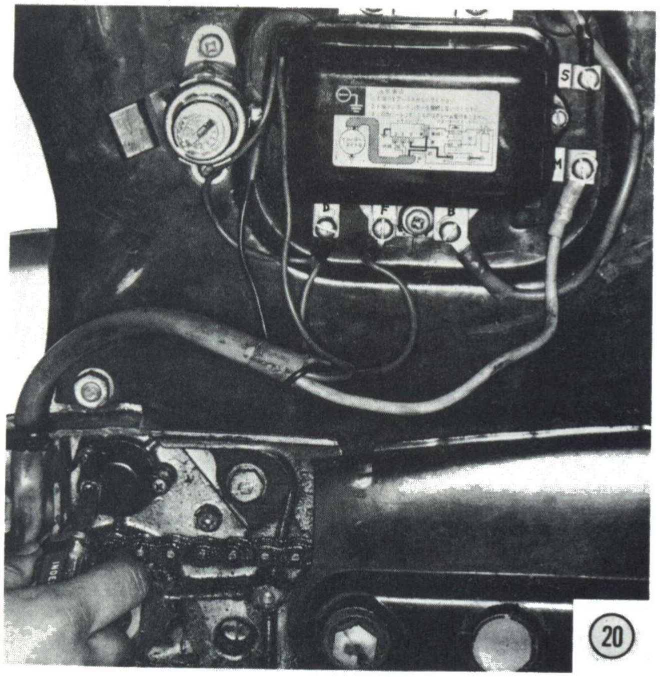
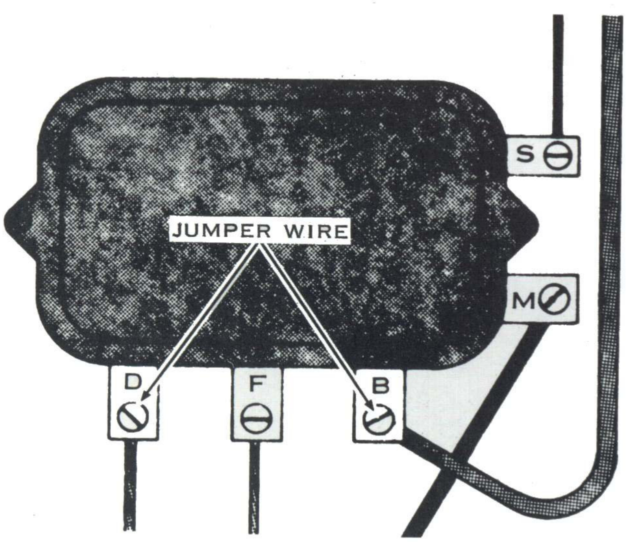


armature collar, index the point cam slot with the key, and then install it with the relief toward the armature, as shown. Secure the armature with the flat washer, lockwasher, and bolt. Tighten the bolt while applying the rear brake (transmission in fourth gear) to keep the crankshaft from turning.

⑲ Pull each brush out of its holder until the spring bears against the side of the brush to hold it out. Align the notch in the stator frame with the crankcase dowel pin, and then install the stator, taking care not to damage the brushes or the armature commutator. Secure the stator with the three long screws and lockwashers. Push the brushes down against the commutator.



To ensure correct generator polarity output, polarize the field winding by "flashing" a jumper wire between the regulator's "B" and "D" terminals. CAUTION: Remove the jumper wire as soon as there is a flash of electricity, or else the field winding may be damaged.

⑳ Route the generator wiring harness through the main switch bracket, and then make the following connections to the voltage regulator: yellow wire to the terminal marked "M", red/green wire to the "D" terminal, and the green wire to the "F" terminal. Connect the branching red/green wire from the "D" terminal to the matching wire from the frame wiring harness. *NOTE: This wire goes to the charge-indicator lamp.* Connect the black ignition wire and the blue neutral wire to the matching wires from the frame wiring harness. Fasten the red cable from the regulator to the battery's positive terminal. Slip the blue wire under the neutral switch terminal washer, and then tighten the screw. Push the two grommets into the notches in the crankcase. Install the left frame cover and the left engine cover, and then slide the shift lever onto the shift shaft and secure it with the clamp bolt and lockwasher.

POLARIZING THE STATOR POLES

The polarity of the electricity delivered by the generator is governed by the polarity of the residual magnetism in the stator field poles. If the magnetic polarity is reversed from improper handling, the generator will develop a positive ground, with negative polarity current being supplied to the regulator and battery. This causes severe arcing and burning of the regulator contacts. **CAUTION: Anytime the voltage regulator or the generator has been disconnected, polarize the stator poles before starting the engine.** To do this, momentarily connect a jumper wire between the regulator's "B" and "D" terminals. There will be a flash of electricity; this is normal. **CAUTION: Do not keep the jumper wire in contact with the terminals for more than two seconds, or damage to the stator windings could result. Don't touch the "F" terminal with the jumper, which will result in reversed generator polarity.**

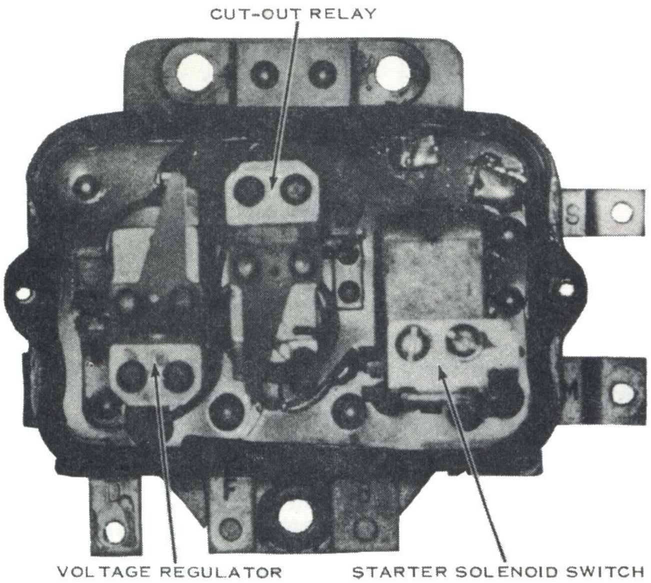
SEATING NEW BRUSHES

Whenever new brushes are installed or the commutator is resurfaced, wear in the brushes by applying a thin film of brush-seating paste to the commutator. *NOTE: This prevents the squealing noise and erratic generator performance which is characteristic of reduced commutator contact with new brushes.* There is no need to remove the paste as it soon disappears.

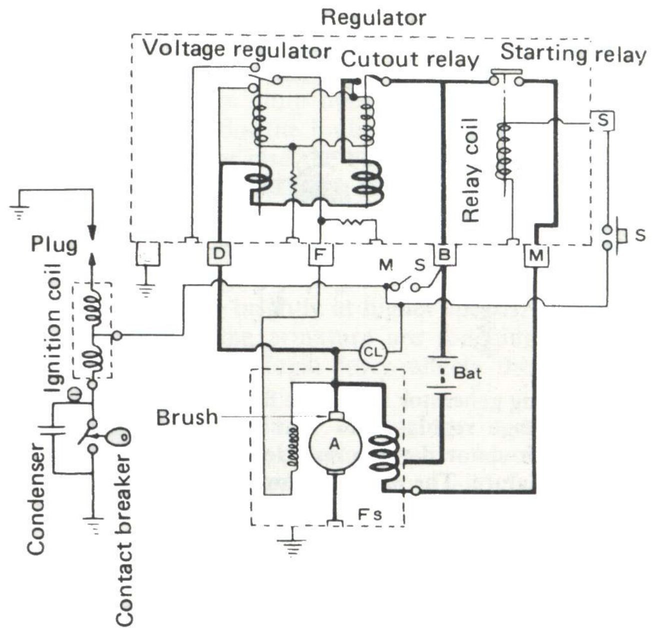
REGULATOR

The regulator governs the generator output to maintain the battery at an optimum level of charge. Removal of the cover exposes three individual units: the starter solenoid switch, the cut-out relay, and the voltage regulator. All three are electromagnetic switches that are counterbalanced by mechanical spring tension.

The starter solenoid switch is an ON/OFF-type switch that is used to pass current from the battery to the generator in the engine-cranking mode of operation. The switching is performed by a switch arm that is fastened to the relay frame by a spring steel hinge, which holds the arm away from the two contacts on the regulator base. These contacts are connected to the "B" (battery) and "M" (motor winding) terminals of the regulator. One end of the solenoid coil wire is connected to the "S" (switch) terminal of the regulator; the other end is grounded to the regulator base.



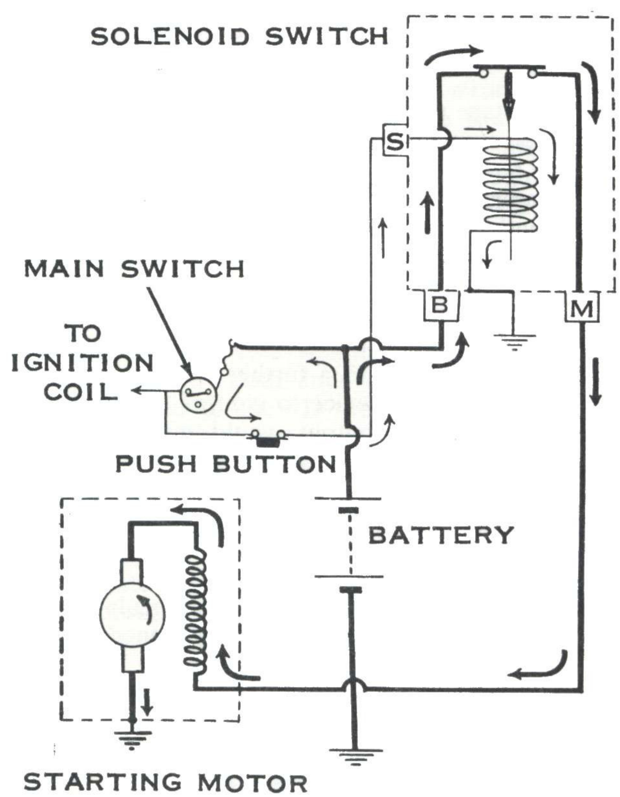
Voltage regulator with cover removed.



M · S	Main switch
S · S	Starter button or starter switch
C · L	Charge lamp
A	Armature
Fs	Starter Field coil

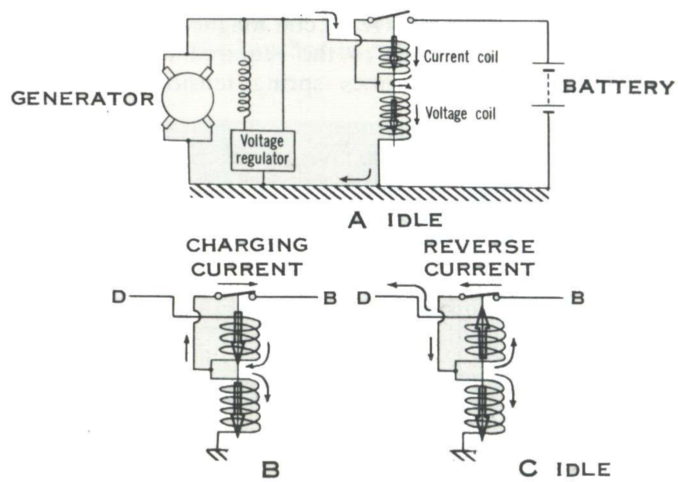
Schematic of the generator, starter, ignition, and regulator circuits for Model M15D.

When the starter button is pushed, battery current passes through the solenoid coil, setting up an electromagnetic field. The switch arm is pulled against the contacts, allowing the battery current to travel through the motor winding of the generator-starter to crank the engine.

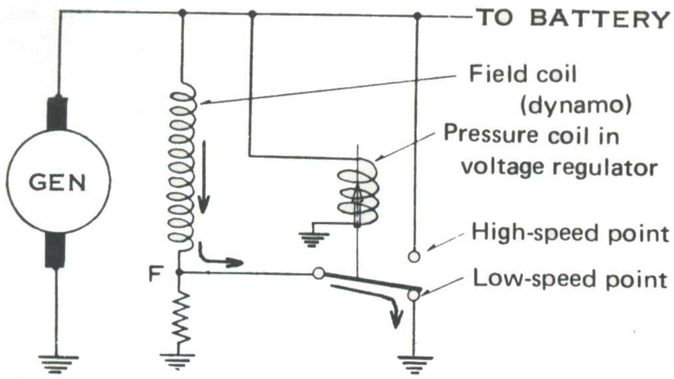


Pushing the starter button magnetizes the relay coil, which then attracts the switch arm against the solenoid contacts. Battery current flows across the contacts and through the starter winding and armature of the generator to make it function as a cranking motor.

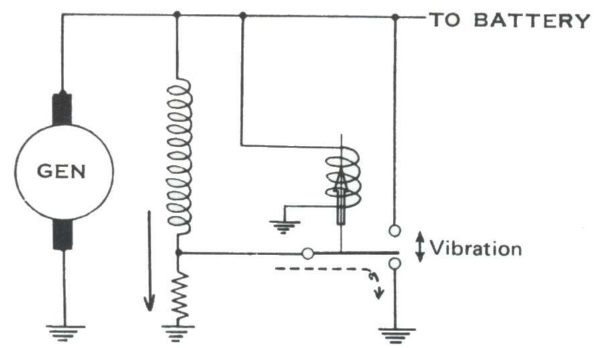
The cut-out relay is an ON/OFF-type switch that connects the generator to the battery whenever the generator is turning fast enough to develop usable out-



The cut-out relay in operation. As engine speed rises from idle, at A, generator current flowing through the current and voltage coils builds up to the required voltage level. At this point the coils' combined magnetic forces pull the switch arm closed so the generator can charge the battery, as at B. When engine speed drops back to idle, at C, generator voltage drops below the required level and the current reverses direction, flowing from the battery to the generator. The "backward" flow in the current coil sets up a magnetic field opposing that of the voltage coil, canceling most of the magnetic force acting on the switch arm. The beam spring lifts the switch arm to disconnect the battery from the generator, as at A.



At idling generator speed, the field winding is grounded by the voltage regulator so that strong electromagnetic forces in the stator develop sufficient voltage in the slow-turning armature. The arrows show the path and direction of the field current at slow generator speeds.

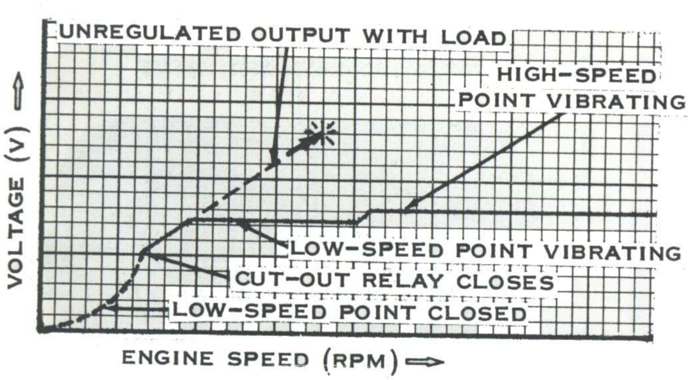


As generator speed rises from low rpm, increased generator voltage causes more current flow and a stronger magnetic force in the regulator coil, which pulls the switch arm away from the low-speed point. In this middle position, the field winding is still grounded through the adjusting resistor, which reduces field current and thus generator output. When generator speed is maintained in this range, the switch arm vibrates between the low-speed point and the middle "resistor" position to maintain a constant generator voltage level. Field current flow through the resistor (points open) is shown by the solid arrow, while current flow through the low-speed point (points closed) is shown by the broken arrow.

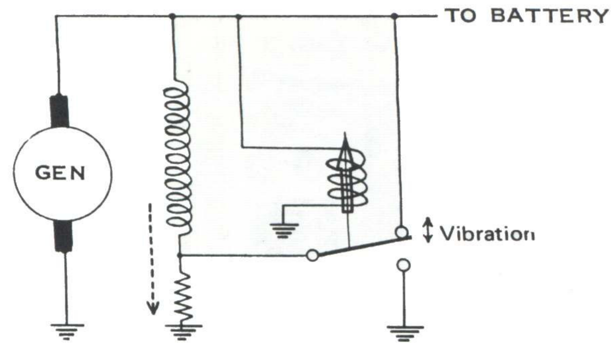
put with sufficient voltage to close the relay. The switch arm is connected to the regulator's "B" terminal, and it is held away from the base contact by the beam-type steel spring. The base contact and one end of the relay coil wire are connected to the regulator's "D" terminal to pick up generator output. The other end of the relay coil is grounded to the regulator base through a resistor. When the engine is idling or stopped, generator output drops below the relay's voltage setting, and the reduced magnetic force causes it to disconnect the generator-battery hookup by separating the switch arm from the base contact. This circuit-breaking action prevents a drain of reverse-flowing current from the battery to the génerator winding and armature, which would damage the generator and discharge the battery rapidly. As engine speed increases, generator output rises and strengthens the relay coil magnetic field. When generator voltage builds to the required level, the relay's magnetism overcomes spring tension and pulls the switch arm against the base contact to link the generator with the battery. *NOTE: The charge indicator lamp in the speedometer face is wired in parallel with the cut-out relay; one lead is connected to the battery and the other lead is fastened to the generator output wire (regulator "D" terminal).* When the relay closes (generator charging), the lamp goes out; when the relay opens, the lamp lights to indicate a no-charge condition.

The voltage regulator is a three-position, vibrating-contact type switch that controls the generator's output voltage by varying the strength of the magnetic field in the generator stator. To appreciate the voltage regulator's function, consider the generator's performance without any voltage control (field wire grounded): the generator develops more current as engine speed rises, proportionately increasing the current supplied to the stator field coils. This strengthens the stator's magnetic field, which leads to a further jump in generator output. Without some device to control the "snowballing" effect, generator output would multiply with a slight increase in engine speed and this would burn out all of the electrical equipment. So the voltage regulator's function is similar to that of a safety valve on an air compressor tank, limiting generator output voltage to a safe, constant level.

The switch arm is connected to the regulator's "F" (field winding) terminal, and it is positioned between two contact points on the regulator base. The upper contact is the low-speed point; it is fastened to the regulator base for a ground connection. The lower, insulated contact is the high-speed point; it is connected to the "D" terminal, along with one end of the relay coil wire, to pick up the generated voltage. The other end of the relay coil is grounded to the regulator base through a resistor. With the engine stopped or at idle-to-medium engine speeds, relay magnetic strength is not



Graph showing the regulator's progressive phases of operation in terms of engine speed. The broken line at idle represents generator voltage building up to a usable level. The closing of the cut-out relay connects the load of the battery, ignition, and lights to the generator, which reduces the rate of voltage rise. Vibration of the voltage regulator switch arm maintains generator voltage at a constant level. The broken line at the top represents uncontrolled generator output from a grounded field winding; the asterisk shows the point at which bulb filaments burn out from the excessive current.



At higher generator speeds, still-higher current flowing through the voltage coil causes sufficient magnetic force to pull the switch arm against the high-speed point. This short-circuits the field winding, both ends of which are now connected to the positive (+) brush of the generator. Without the electromagnetic field in the stator, generator output stops abruptly, until voltage drops below the required level. Then the voltage coil weakens enough to let the switch arm move back to the middle "resistor" position, and generator output climbs up to the cut-off level again. The broken arrow shows field current flow with the points open, and there is no current flow with the points closed.

strong enough to influence the switch arm, which is held against the low-speed point by the beam-type steel spring. In this position, the negative (−) end of the stator field winding is grounded through the switch arm to the low-speed point to energize the field winding fully. Thus the armature develops sufficient voltage at low speeds because of the strong electromagnetic field.

As speed increases, generated voltage reaches 15V, where the relay coil becomes strong enough to pull the switch arm away from the low-speed point to break the ground connection. In this middle position, the field winding is still grounded through a resistor connected to the regulator "F" terminal. The resistor reduces the field current, weakening the electromagnetic field in the stator to control the generator output at the specified voltage.

At high engine speeds, generated voltage climbs to 16V, and the relay coil pulls the switch arm against the high-speed point. Both ends of the field winding are then connected to the "D" terminal of the regulator, effectively shorting out the field circuit and stopping current flow through the field winding. Without the electromagnetic field, the generator puts out only the slight voltage which the residual magnetism in the poles can develop in the armature. In operation, the switch arm vibrates many times each second between the middle position and the two stationary points to limit the generator output to 15.4–16.6 volts.

TROUBLESHOOTING WITH THE CHARGE-INDICATOR LAMP

The charge-indicator lamp can be very useful in finding the cause of charging problems. The lamp is lit anytime there is a difference in voltage between the battery and the generator. The following charge lamp indications will help you find the fault in the generating system:

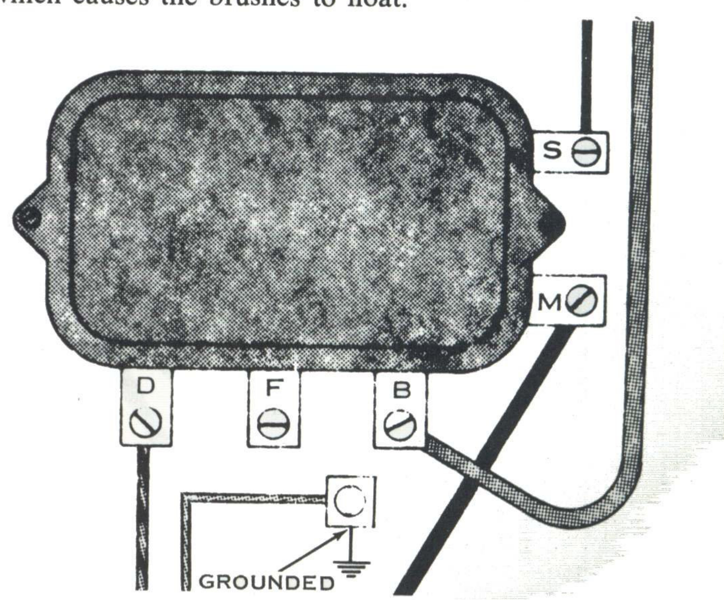
If the charge lamp is lit while the engine is idling and goes out as the throttle is opened slightly, the generator is working properly.

If the charge lamp does not light when the main switch is turned on, the bulb or fuse is burned out, the battery is dead, or else the cut-out relay is stuck in the closed position. **CAUTION: If the cut-out relay is stuck, disconnect the battery immediately to prevent a heavy discharge and possible damage to the generator.**

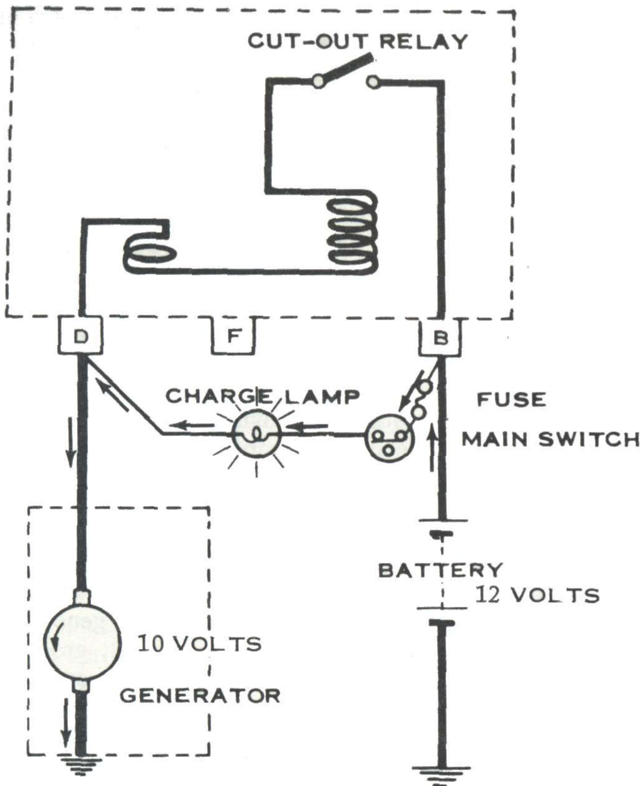
If the charge lamp goes out at medium engine speeds, but burns brightly at higher speeds, one or more of the loops in the armature are touching each other (shorting) as centrifugal force affects them at higher RPMs.

If the charge lamp is brightly lit at all engine speeds, the generator or regulator is at fault. To isolate the trouble, disconnect the green lead from the regulator "F" terminal and ground the lead with the engine running slightly faster than idle. If the lamp stays lit, the generator is at fault. *NOTE: If the electric starter cranks the engine normally, the brushes and the armature commutator are OK.* Check the generator field winding for broken wires (short-circuit), grounding near the brush end of the winding, or a layer short between the starter winding and the generator winding. If the lamp goes out now, the regulator is defective. Remove the cover and check for bending of the switch arm or beam spring of the voltage regulator, which would result in an excessively low voltage limitation. *NOTE: If the switch arm is welded to the high-speed point, replace the regulator.*

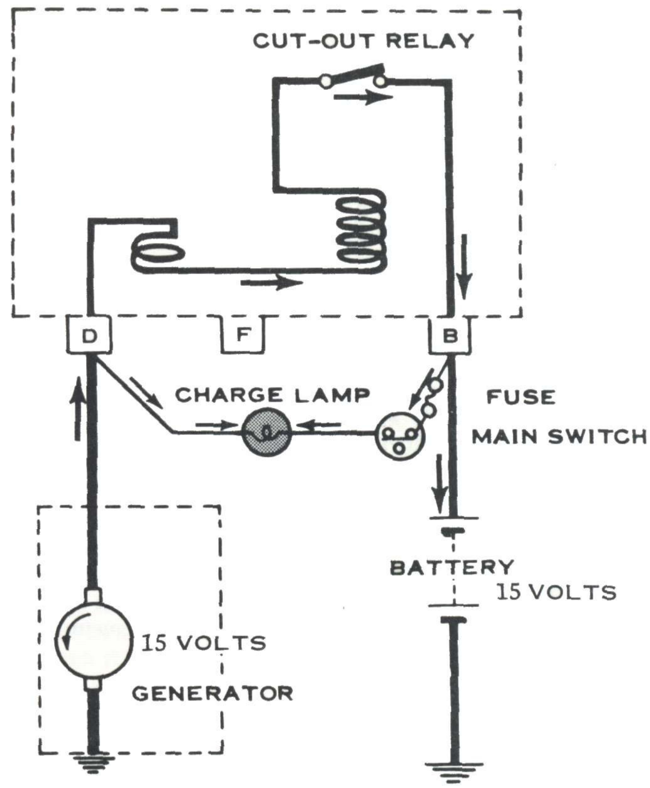
If the charge lamp glows dimly at high engine speeds, check the generator by pushing the brushes against the commutator with your fingers. If the lamp now goes out, the trouble is weak brush springs, worn or sticking brushes, or an out-of-round commutator, which causes the brushes to float.



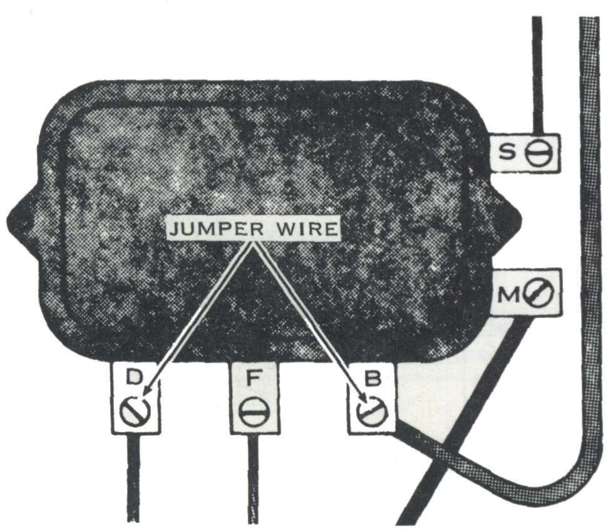
To isolate the cause of no battery charging current, as shown by a brightly lit charge-indicator lamp, remove the wire from the regulator "F" terminal and ground it with the engine running slightly faster than idle. The fault is in the regulator if the lamp goes out. Inspect the generator if the lamp stays lit.



Circuit for the charge-indicator lamp. One side of the lamp is connected to the generator output terminal (D) while the other side is wired to the battery positive (+) terminal (B) through the main switch. Anytime there is a difference in voltage between the generator and battery, such as with the engine idling, the charge lamp is illuminated by current flowing through its filament from the higher potential to the lower one.



The charge lamp goes out when battery and generator voltages are the same, such as when the cut-out relay closes. There is no current flowing through the bulb, because the voltage at both terminals is equal, as shown by the arrows.



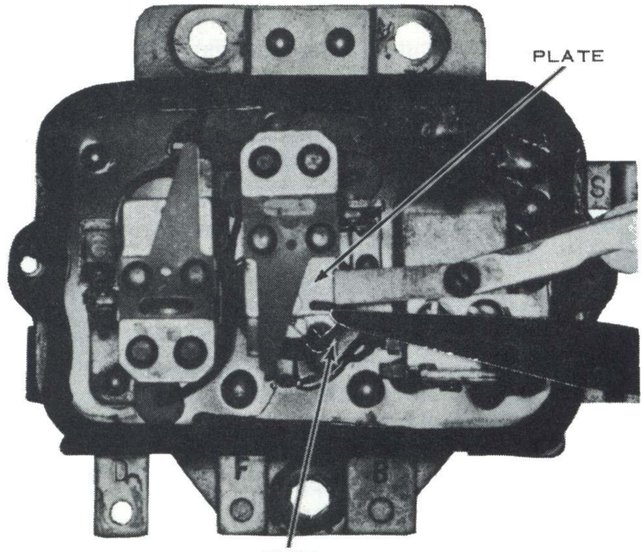
A dimly-lit charge lamp at all speeds could point to a defective cut-out relay; bypass the relay by connecting a jumper wire to the regulator's "B" and "D" terminals and then varying engine speed. If the lamp is now dark, inspect the cut-out relay as described in the text. CAUTION: Don't let the engine idle or stop running with the jumper wire connected, as this could damage the generator and discharge the battery.

If the charge lamp stays on until the engine warms up and then goes out, check for a poor ground connection between the engine and frame. *NOTE: On M15Ds before Engine No. M10-299534D, with rubber engine mounts, inspect the engine ground lead fastened to the top rear of the crankcase and inside the frame.* To do this, it is necessary to remove the top two engine mount bolts and tilt the engine forward. Later units have metal engine mounts, and the crankcase is grounded directly to the frame.

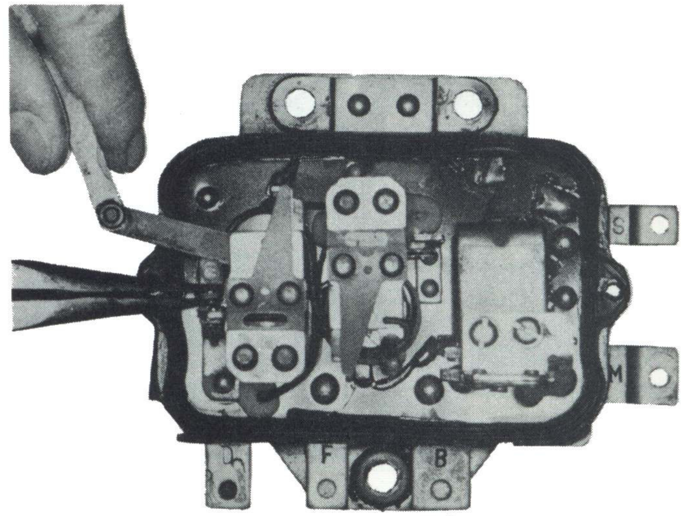
If the charge lamp burns brighter as engine speed increases, and then goes out with a flash, there is a bad connection between the generator and regulator. Clean the mounting areas of the regulator, generator, and crankcase; clean and tighten the terminals.

If the charge lamp lights when the main switch is turned on, but stays out when the engine drops back to idle, either the engine idle speed is too high or the cut-out relay is adjusted for too low a cut-out voltage, which can burn the relay contacts. Take off the regulator cover and make sure the relay beam spring is not bent, and then adjust the cut-out voltage level.

If the charge lamp is dimly lit at all engine speeds, connect a jumper wire between the regulator's "B" and "D" terminals, and then open the throttle. If the light now goes out, the trouble is in the cut-out relay. If the lamp still glows dimly, check for corroded or loose connections at the battery cables. *NOTE: To determine the fault in the cut-out relay, remove the*



Inspect the cut-out relay air gap by inserting a 0.045″ feeler gauge between the relay core and the hinged plate. Adjust as required by bending the copper stop wire.



Use a 0.040″ feeler gauge to check the voltage regulator air gap, as shown here. The gap adjustment is made by bending the low-speed point support.

jumper wire and take off the regulator cover. Look at the cut-out relay contacts to see if they are pitted or oxidized, and also make sure the switch arm is not bent or it won't make complete contact with the base point.

TESTING THE REGULATOR CIRCUITS

To test the regulator circuits, take off the cover by removing the two screws, and then disconnect all the wires from the terminals. Connect one lead of an ohmmeter or a self-powered continuity test lamp to the field terminal ("F") and the other lead to the regulator's grounding lug. The ohmmeter should show low resistance (less than 1 ohm) or the lamp should light brightly. Now separate the switch arm from the low-speed point of the regulator unit; the ohmmeter should indicate 7 ohms or the lamp should dim slightly.

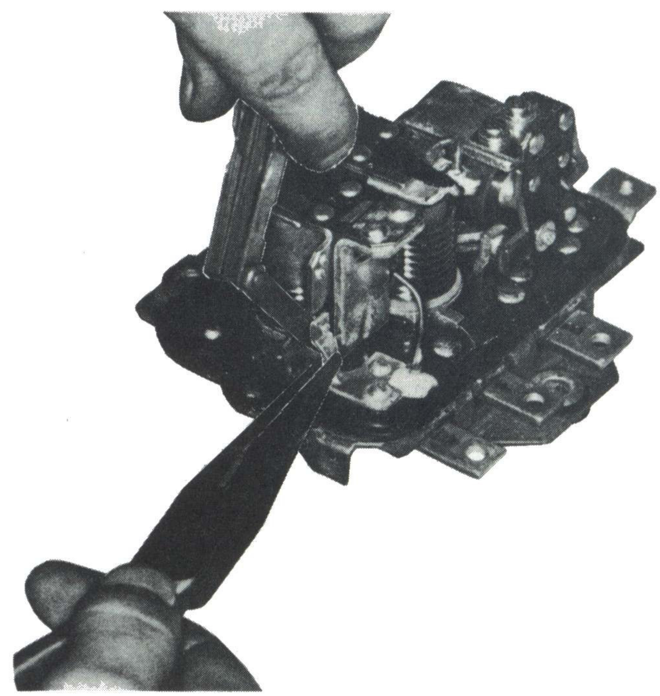
Move the one test lead from the ground lug to the regulator's generator output terminal ("D"). There should be 30–40 ohms resistance between the "F" and "D" terminals until you push the switch arm down so that it touches the high-speed point. Then the ohmmeter should indicate less than 1 ohm or the test lamp should brighten.

To test the cut-out relay, connect one test lead to the battery terminal ("B") and one lead to the "D" terminal. Hold the relay contacts closed, and the ohmmeter should indicate less than 1 ohm (test lamp brightly lit). Release the switch arm, and the ohmmeter needle should show maximum resistance—infinity (test lamp goes out).

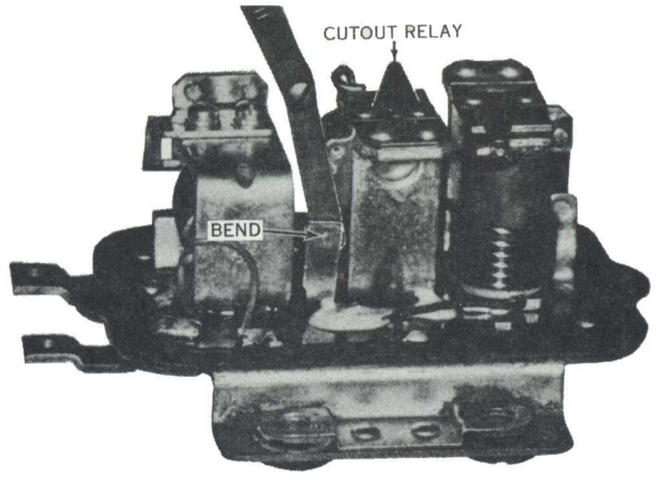
CLEANING AND SETTING THE REGULATOR CONTACT POINTS

Each of the units in the regulator depends on clean contact point surfaces for reliable operation. With use, these points become pitted or oxidized so that starting and generating performance are affected adversely. To clean the points, first disconnect the battery's red cable. Clean the contact points with #00 silicon-carbide paper. **CAUTION: Don't use sandpaper or emery cloth.** Remove any residual grit with a strip of lintless paper (business card) soaked in trichloroethylene, drawing the paper between the point surfaces. *NOTE: The starter solenoid switch has extremely hard contacts, which require a riffler or spoon file to clean the point surfaces properly.*

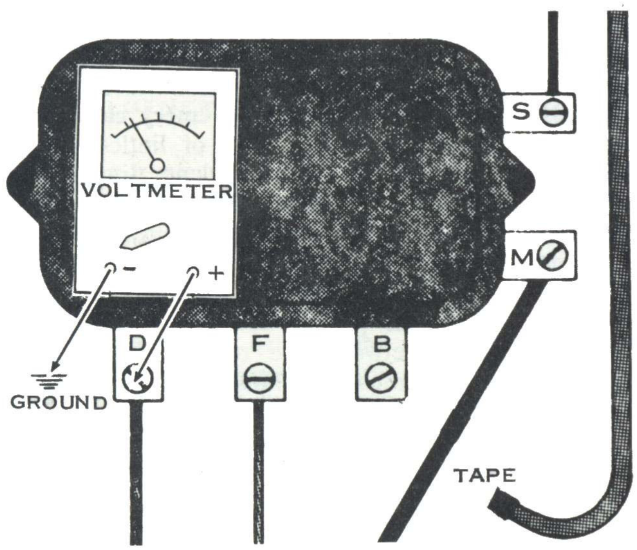
After cleaning the points, use a feeler gauge to check the air gap between the relay core and the hinged plate, which must be 0.045″ on the cut-out relay and 0.040″ on the voltage regulator. Adjust the



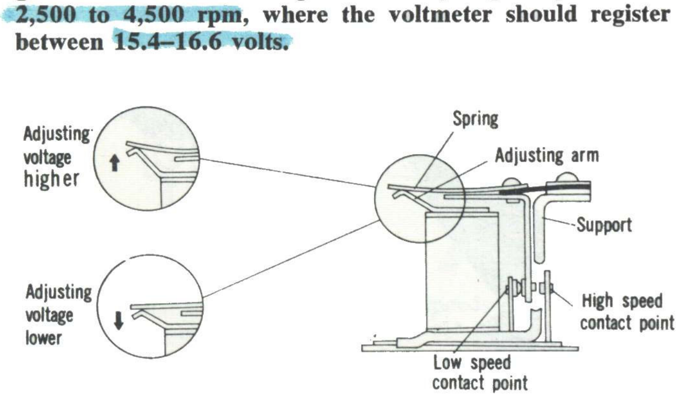
Inspect the voltage regulator point gap by inserting a 0.012″ feeler gauge between the switch arm contact and the high-speed point. Bend the high-speed point support to obtain the specified point gap.



Use a 0.032″ feeler gauge to check the cut-out relay point gap; bend the base point support if an adjustment is required.



To check the no-load voltage setting before adjusting the voltage regulator, disconnect the red wire from the regulator "B" terminal. CAUTION: Wrap tape around the red wire terminal to prevent an accidental short circuit. **Connect the red (+) lead of a DC voltmeter (0–25V) to the "D" terminal and the black (−) lead to a frame or engine ground. Kickstart the engine and vary engine speed from 2,500 to 4,500 rpm, where the voltmeter should register between 15.4–16.6 volts.**



Adjusting the voltage regulator is accomplished by bending the beam spring stop. CAUTION: Don't bend the beam spring itself, which will ruin the regulator with consequent generator and battery difficulties.

voltage regulator air gap by bending the low-speed point support. The cut-out relay air gap is adjusted by bending the copper stop wire on the hinged plate. Then check the point gap between the switch arm and the high-speed point of the voltage regulator, which must be 0.008–0.016″. Adjust by bending the high-speed point support. The cut-out relay point gap must be 0.028–0.035″; bend the base point support to adjust the gap.

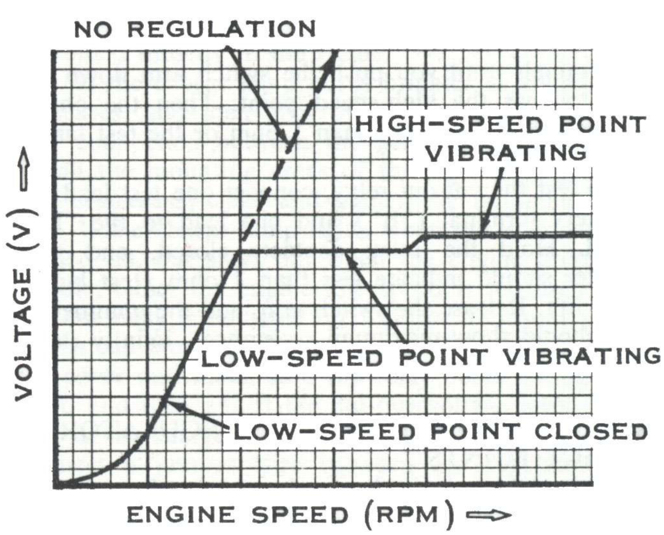
ADJUSTING THE REGULATOR

Inspection of the voltage regulator setting is necessary whenever the battery loses its charge during use (low voltage regulator setting) or when the battery water must be refilled frequently (high voltage regulator setting). Remove the regulator cover and disconnect the red wire from the "B" terminal. Connect the red (+) lead of a DC voltmeter (0–25V) to the "D" terminal and the black (−) lead to ground.

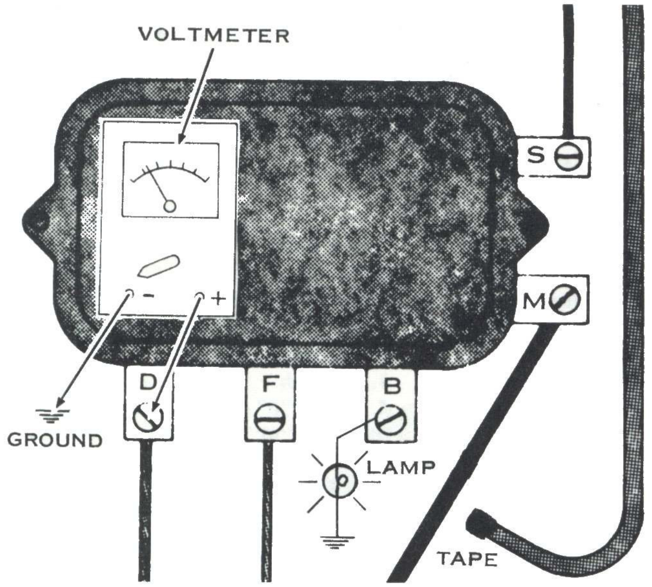
Kickstart the engine, because the electric starter has been disconnected. **CAUTION: Don't rev the engine and don't run this test for more than 30 seconds, or you could burn out the regulator and generator.** The voltmeter should register between 15.4–16.6 volts when engine speed is varied from 2,500–4,500 rpm. You will note a slight jump in voltage as engine speed is increased past 4,000 rpm, which is caused by the voltage regulator shifting from the low-speed point to the high-speed point. If this increases the voltage reading by more than one volt, check and adjust the regulator air gap.

Adjust the voltage regulator setting by bending the beam spring stop. Bending the stop upward increases the spring tension and raises the regulated voltage level.

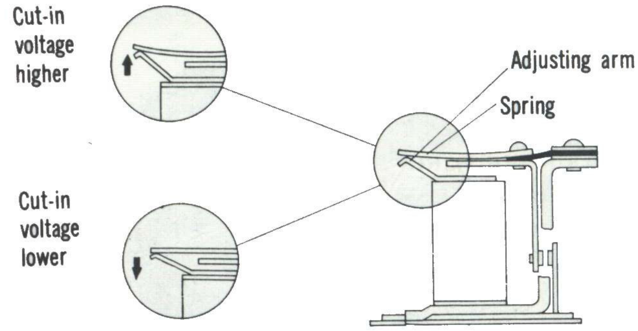
Using the same voltmeter hookup as before, check the cut-out relay voltage setting. If necessary, lower the engine's idle speed to permit the cut-out points to open. Slowly open the throttle and note the voltmeter



Graph showing the no-load voltage characteristics of the regulator in terms of engine speed. The "snowballing" effect of a grounded field wire is shown by the broken line.



To check the cut-out relay voltage setting, use the voltmeter connections shown here. It is possible to listen for (or to watch) the cut-out relay closing to find out the cut-in voltage from the meter, but a more accurate method is to connect a test lamp to the regulator "B" terminal and ground. When the lamp lights, the voltmeter must indicate 12.0–13.5 volts.

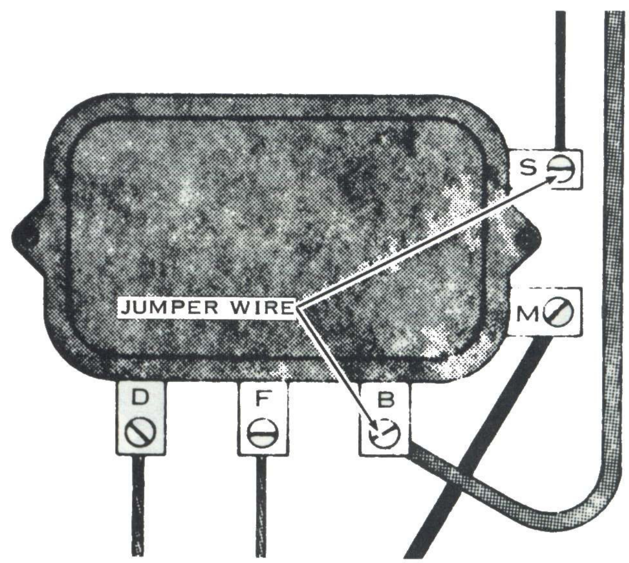


Bend the spring stop to adjust the cut-out relay cut-in voltage setting. CAUTION: Don't bend the beam spring itself, as this leads to insufficient battery charging or damage to the battery and generator.

reading when the cut-out relay pulls the switch arm against the base point, which should be 12.0–13.5 volts. Adjust the cut-out relay setting by increasing the spring tension to raise the cut-in voltage, if necessary.

STARTER OPERATION

When the generator is energized as a starter, it becomes an electric motor to crank the engine. When the electric-start pushbutton is depressed, it energizes the solenoid inside the regulator box, which then connects the battery directly to the generator motor winding ("M") and the armature so that a crankshaft-turning torque of almost 5 ft-lb is developed.



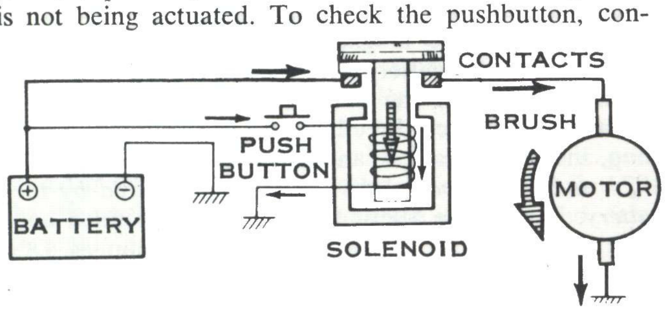
To check for trouble in the pushbutton switch and associated wiring, connect a jumper wire as shown here. If the solenoid clicks now, inspect the pushbutton and wiring for defects. If there is still no sound, check the solenoid and its wiring as described in the text.

TROUBLESHOOTING THE STARTER

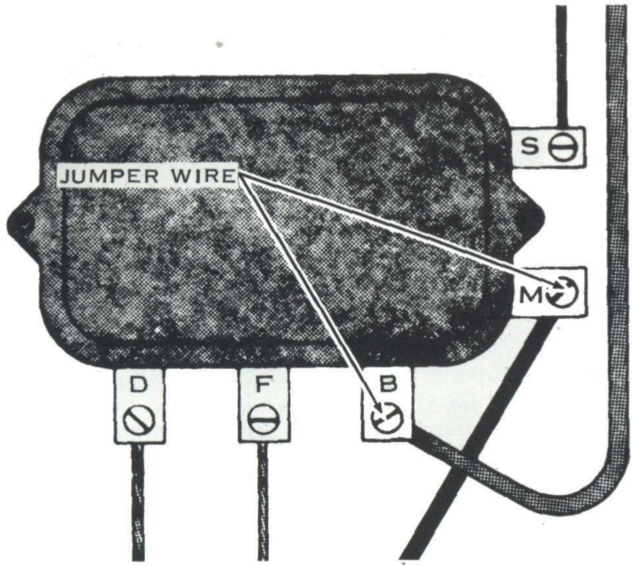
There are four parts of the starter system: the pushbutton switch, solenoid switch, starting motor (generator), and battery. The following suggestions will help you to locate the trouble.

If there is no audible click when the starter button is depressed, the starter solenoid in the regulator is not being actuated. To check the pushbutton, connect a jumper wire to the regulator's "B" terminal and momentarily touch it to the regulator's "S" terminal. If the solenoid now clicks, the pushbutton is defective, or the wires from the battery to the main switch, main switch to the pushbutton, or pushbutton to the "S" terminal are broken (open circuited). If the solenoid still does not click, inspect the battery terminals for corrosion or loose connections. Check the battery voltage with the starter button depressed; it must be more than 8 volts. To check the solenoid relay coil, connect an ohmmeter to the "S" terminal and ground lug of the regulator; resistance must be 4–7 ohms.

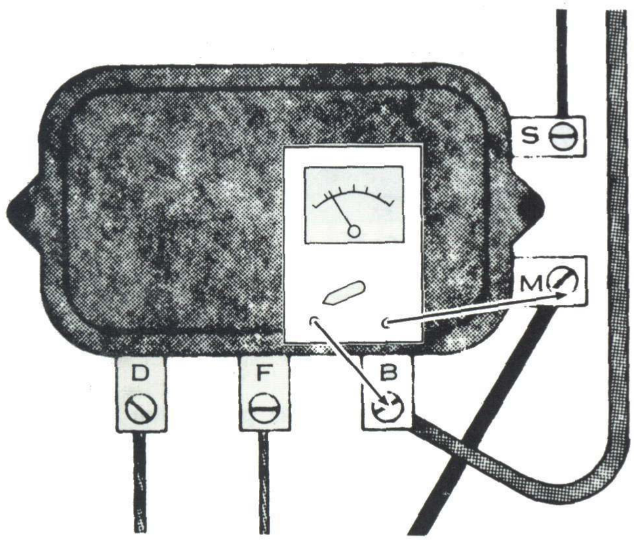
If the solenoid clicks when the button is depressed, but the crankshaft doesn't turn, connect a heavy jumper wire to the regulator "B" terminal and touch it to the "M" terminal. If the motor now cranks the engine, the solenoid contacts are dirty. If the starter motor still doesn't work, check the battery connections. If this doesn't help, overhaul the generator-starter motor.



This simple schematic shows the parts of the electric-starter system to be checked.



To bypass the solenoid, connect a thick-gauge jumper wire as shown here. CAUTION: A thin jumper wire may overheat from the heavy current and burn your fingers. **Refer to the text for the test conclusions.**



Slow engine cranking may be caused by excessive resistance in the solenoid contacts. Connect a DC voltmeter (0–12V) as shown here to find the voltage drop, which must be less than 0.5 volt with the starter operating.

Check the brushes, armature, and field motor winding as previously described in the generator section.

If the solenoid clicks, but the crankshaft doesn't turn and the charge lamp dims considerably, check the battery voltage with the starter button depressed. If it is less than 8 volts, the battery is discharged or the terminals are loose and corroded. If it is more than 8 volts, the battery is OK. Turn off the main switch, lift the brushes from the commutator, and then check for continuity between ground and the yellow "M" wire and also between ground and the red/green "D" wire. If there is no ground, then the armature has a layer short circuit or it is grounded; replace it.

MODEL M15D ELECTRICAL SPECIFICATIONS

Generator Data		
Manufacturer:	Nippon Denso	
Marking:	20000-020	
Rated Output:	80 Watt	
No. of Poles:	6	
Brushes		
Number	2	
Length (Std):	0.710 Inch	
(Min):	0.410 Inch	
Air Gap	0.014-0.018 Inch	
Commutator		
Std Diameter:	1.260 Inch	
Min Diameter:	1.240 Inch	
Stator Winding	4.2 Ohm "F" Generator	
Resistance:	0.2 Ohm "M" Starter	
Starter Speed:	1200 Rpm	
Starter Torque:	4.69 Ft-Lb	
Regulator Data		
Manufacturer:	Nippon Denso	
Marking:	26000-036	
Regulated Voltage:	15.4-16.6 (No Load)	
Cut-In Voltage:	12.0-13.5	
	Air Gap	Point Gap
Voltage Regulator:	0.040"	0.012"
Cut-Out Relay:	0.045"	0.032"
Starter Relay:	0.160"	0.120"

If the engine cranks slowly (less than 1,000 rpm), check the battery voltage as described above. If the battery is OK, inspect the starter solenoid contacts by connecting the leads of a DC voltmeter (0–12V) to the "M" and "B" terminals of the regulator to find the voltage drop, which must be less than 0.5 volt with the button depressed. If it is within specifications, measure the starter motor current draw by separating the yellow lead from the regulator "M" terminal and connecting an ammeter (0–100A) in series with the yellow wire to the terminal. With the button depressed, starter current draw must be 15–80 amps. If it is less, look for poor contact between the brushes and the commutator. If it is more, there is a layer short in the armature or a ground in the armature or field motor winding. *NOTE: Don't overlook the possibility of mechanical interference in the engine which may prevent it from turning freely, such as contact between the armature and stator poles, seized piston, or frozen crankshaft bearings.*