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AUTOMOTIVE DIESEL MAINTENANCE 2. UNIT XV, UNDERSTANDING DC GENERATOR PRINCIPLES (PART II).
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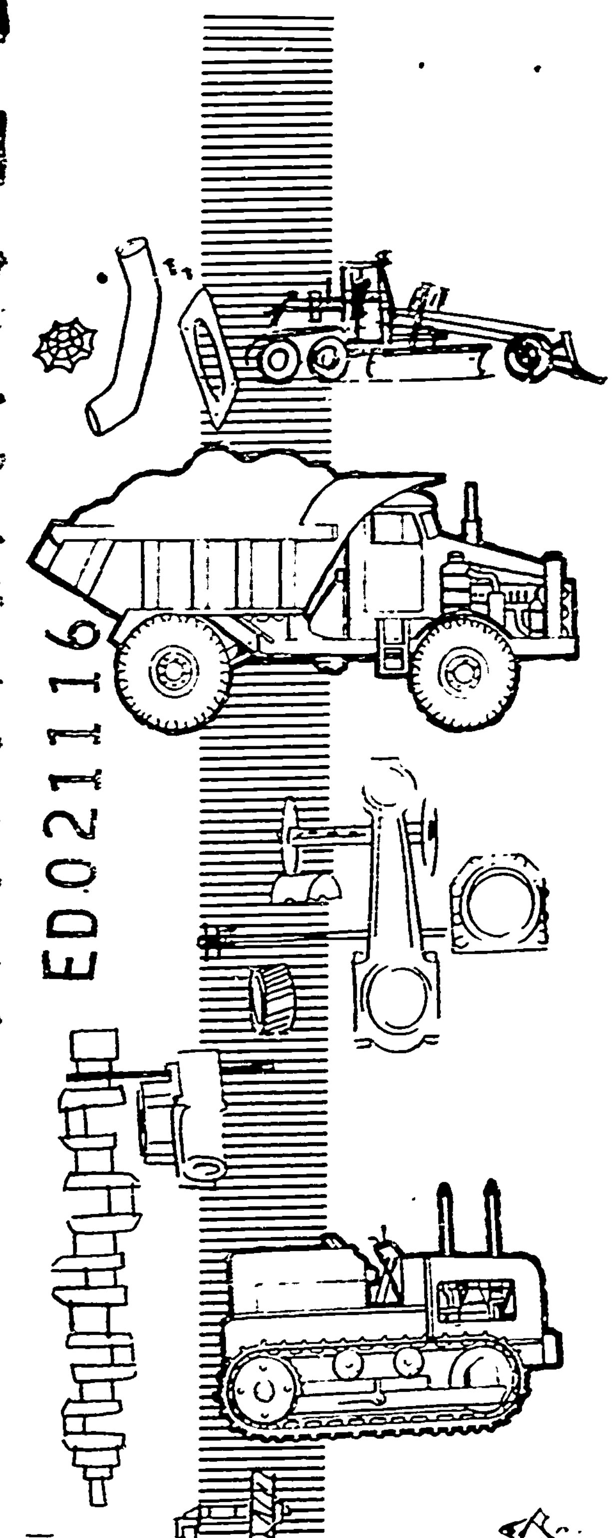
THIS MODULE OF A 25-MODULE COURSE IS DESIGNED TO DEVELOP AN UNDERSTANDING OF MAINTENANCE PROCEDURES FOR DIRECT CURRENT GENERATORS USED ON DIESEL POWERED EQUIPMENT. TOPICS ARE SPECIAL GENERATOR CIRCUITS, GENERATOR TESTING, AND GENERATOR POLARITY. THE MODULE CONSISTS OF A SELF-INSTRUCTIONAL PROGRAMED TRAINING FILM "DC GENERATORS II--GENERATOR TESTING PROCEDURES" AND OTHER MATERIALS. SEE VT 005 685 FOR FURTHER INFORMATION. MODULES IN THIS SERIES ARE AVAILABLE AS VT 005 685 - VT 005 709. MODULES FOR "AUTOMOTIVE DIESEL MAINTENANCE 1" ARE AVAILABLE AS VT 005 655 - VT 005 684. THE 2-YEAR PROGRAM OUTLINE FOR "AUTOMOTIVE DIESEL MAINTENANCE 1 AND 2" IS AVAILABLE AS VT 006 006. THE TEXT MATERIAL, PROGRAMED TRAINING FILM, AND THE ELECTRONIC TUTOR MAY BE RENTED (FOR $1.75 PER WEEK) OR PURCHASED FROM THE HUMAN ENGINEERING INSTITUTE, HEADQUARTERS AND DEVELOPMENT CENTER, 2341 CARNEGIE AVENUE, CLEVELAND, OHIO 44115. (HC)

STUDY AND READING MATERIALS



AUTOMOTIVE DIESEL 2 MAINTENANCE

UNDERSTANDING DC GENERATOR PRINCIPLES (PART II)

UNIT XV

SECTION A SPECIAL GENERATOR CIRCUITS

SECTION B GENERATOR TESTING

SECTION C GENERATOR POLARITY

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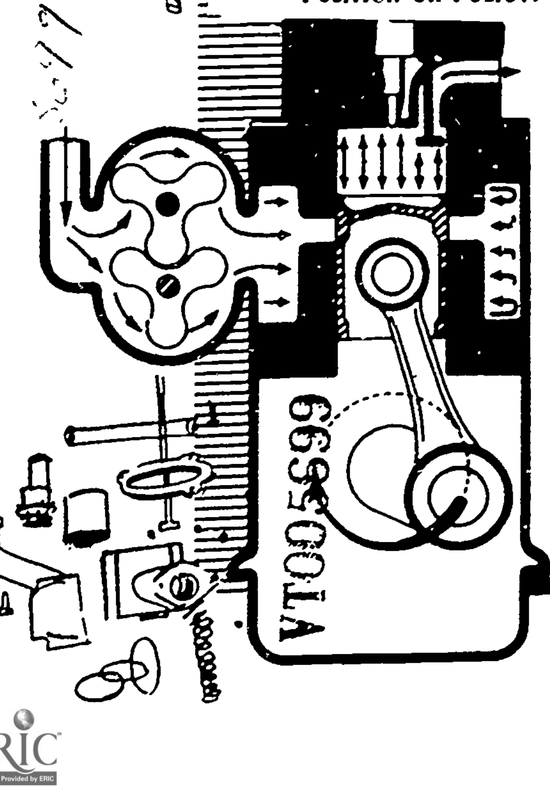
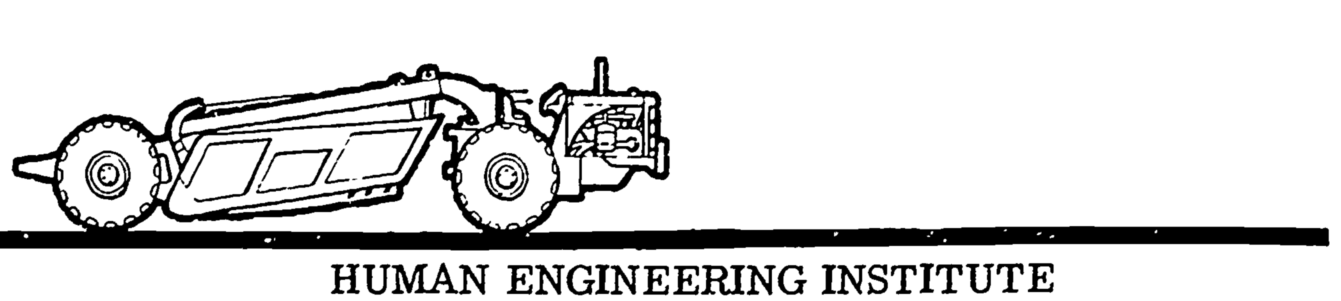




HUMAN ENGINEERING INSTITUTE

The information covered thus far has been concerned with the shunt type generator. Its principles of operation and method of developing voltage have been explored. Other types of special generators have been designed for specific applications. However, the basic principles of operation are the same as for the shunt generator, with only slight variations or additions made to this basic generator design. Examples of generators of other designs are the Third Brush, Interpole, Bucking Field, and Split Field types.

SECTION A -- SPECIAL GENERATOR CIRCUITS

THIRD BRUSH GENERATOR -- The Third Brush type generator uses three brushes instead of two. As an internal means of controlling maximum current output of the generator, the field circuit is connected so that the current fed to the field coil windings is taken off the commutator by the third brush. The two main brushes are located at the neutral points on the commutator where there is maximum voltage. The third brush is placed in an intermediate position between the two brushes. Consequently, it picks up less than maximum available voltage.

On most units the position of the third brush can be adjusted and set in various positions relative to the main brushes. See Figure 1. Moving the third brush toward the adjacent main brush increases the voltage across the field circuit, and current through the field windings is thereby increased. Increasing the field current increases the strength of the magnetic field and results in a higher generator output. Moving the third brush away from the adjacent main brush reduces the voltage across the field circuit, and current through the field windings is decreased. Reduced field current decreases the strength of the magnetic field resulting in a lower generator output.

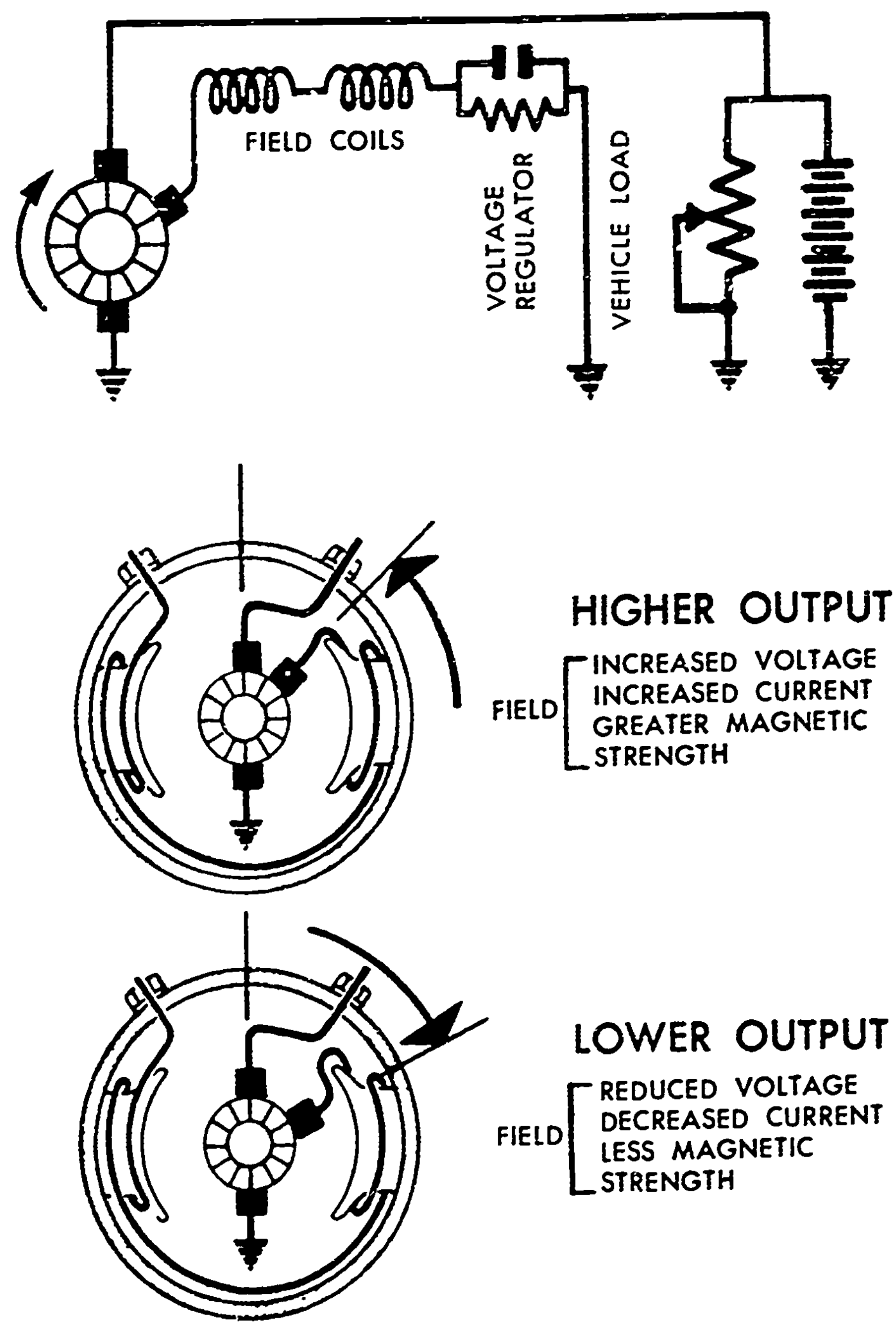


Fig. 1 Three brush generator

Although not in use on present day automobiles, the third brush generator still has widespread use on farm machinery and other off-highway equipment. The shunt generator has replaced the third brush generator for automotive applications. It reaches its peak specified output at lower speeds than the third brush generator and can maintain this output throughout the generator speed range.

INTERPOLE GENERATORS -- In the section covering neutral position, we learned that the magnetic field is distorted when current flows through the armature conductors. When there are a great number of conductors or there is high current flow, the distortion of the normal magnetic field becomes great. It should be remembered that the mechanical neutral position is half way between the pole shoes. There is a point where the armature conductor, connected to the brushes through the commutator, usually has zero current flow, since the voltage that has been developed is changing from one direction to the other. However, with a distorted magnetic field the conductor is still generating voltage at this point and there is a flow of current when the conductor is shorted by the brushes. This causes arcing at the brushes, which results in short brush life.

To obtain both long brush life and good commutation without serious arcing, it is essential that the armature coil does not cut lines of force during commutation. It is possible to neutralize the magnetic force of the armature coils by installing an interpole. See Figure 2. The interpole is a narrow piece mounted on the generator frame between the two regulator poles. It

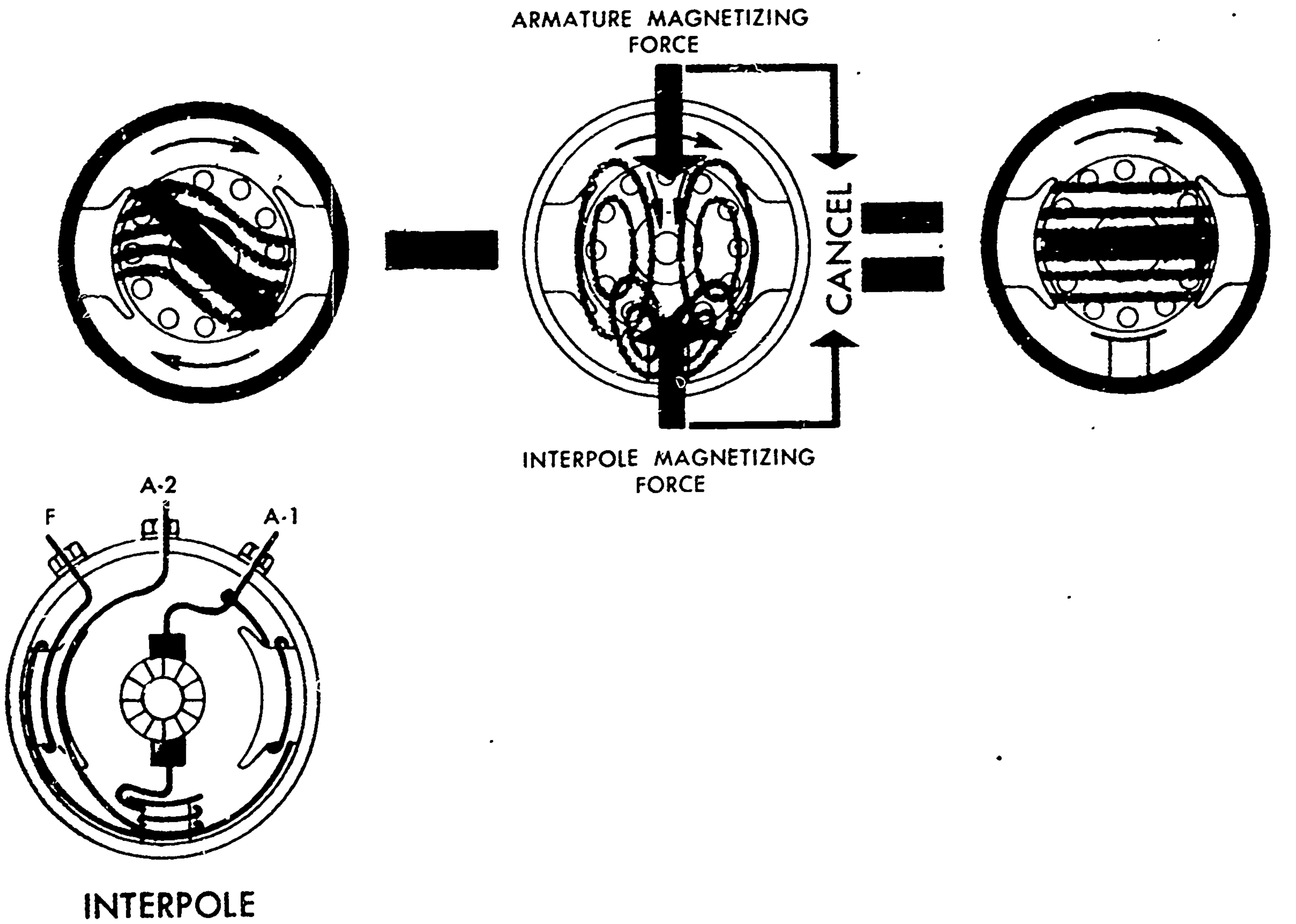


Fig. 2 Interpole generator

is wound with heavy bar copper since all the armature current goes through this winding. The number of turns in the interpole coil is calculated to produce enough ampere turns in the opposite direction to offset the magnetic field created by the current flow through the armature. Since the amount of current flowing through the armature and the interpole coil is always the same, the right amount of correction is always present to nullify the armature reaction and to allow the normal magnetic field between the poles to remain in a straight line.

Because no field distortion occurs after the magnetic force -- created by the current flow through the armature -- is equalized in the generator using interpoles, it is necessary that the brushes be located exactly on the mechanical neutral position rather than in an advanced position as is found practical on non-interpole generators. On certain installations where high speed and high current loads are important factors, the installation of an interpole type generator may increase brush life as much as two to eight times over similar generators without interpoles.

BUCKING FIELD GENERATORS -- Some generators have additional turns of wire on the armature to develop the voltage necessary to obtain a current for the load circuit at very low operating speeds. Also where higher system voltage is used, such as on 32 volt marine applications, more armature turns are required to produce higher voltage at as low a speed as possible. When there is a wide range of operating speeds for such generators, voltage regulation at the higher speeds becomes a very important problem.

As stated earlier, the voltage produced in a generator depends upon the strength of the magnetic field, the number of armature conductors cutting through the field, and the speed of armature rotation. When there is a large number of conductors and the speed is great, only a very weak field is needed to produce the required voltage, particularly when only a low current output is required by the load circuit.

When such a generator operates at very high speeds, it is possible to produce more than the required voltage even with a normally regulated field coil circuit. The residual magnetism of the pole shoes and the generator frame supply sufficient magnetic field strength to produce voltage, but this voltage cannot be controlled. Even though the voltage winding of the regulator opens the contact points and inserts a resistance in the field coil circuit, voltage will continue to climb.

Controlling voltage on this type of generator is made possible by use of a bucking field coil. This is a shunt coil of high resistance, wound on one pole piece and connected directly across the brushes on the armature. The winding is connected in a reverse direction to the normal field winding and has an opposing magnetic effect to it. See Figure 3. At low speeds, when the normal field current is large, the opposing effect of the bucking field is not great in proportion to the main field. At higher speeds, when current in the regular or main field circuit is reduced by the voltage regulator, the opposing effect of the bucking field is greater than the residual magnetic field, and practically all of the magnetic lines of force are cancelled.

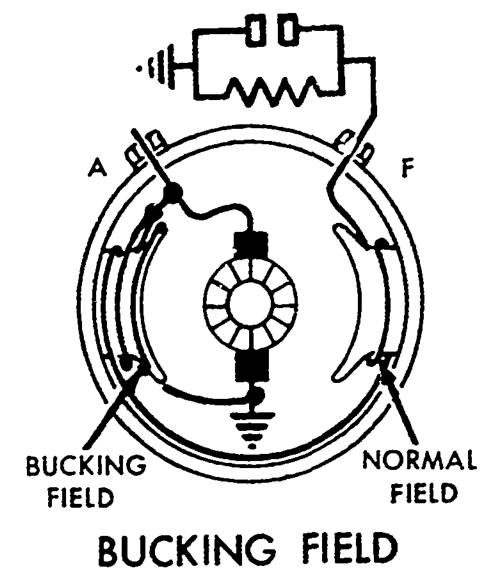


Fig. 3 Bucking field generator

With no magnetic field for the armature conductors to cut through, the generator voltage will immediately drop. Thus, the current flow through the main field coils can be controlled by the regulator, the effects of residual magnetism can be controlled by the bucking field and normal generator voltage can be maintained. The function of the bucking field is, therefore, an aid to regulation.

SPLIT FIELD GENERATORS -- The limited field coil current that can be handled by the vibrating contact points is a disadvantage on some applications. Either at engine idle or low driving speeds, the armature does not turn at sufficient speed to cut through enough magnetic lines of force to develop sufficient voltage to provide current for the load circuit. Under these conditions, current for all vehicle loads is supplied by the battery. If prolonged periods of idling and slow driving speeds prevail, the battery soon becomes discharged. Therefore, it is necessary on such applications to provide a means of generating sufficient voltage at low engine speeds to supply current for the load circuit.

The split field generator was designed for this purpose. See Figure 4. As the name implies, it has two field circuits within the generator. By increasing the magnetic field strength with an added field coil circuit, the voltage necessary to provide current for the load circuit and for charging the battery can be reached at much lower speed. Thus, current for the load circuit and charging the battery can be obtained at engine idle speeds, preventing battery discharge.

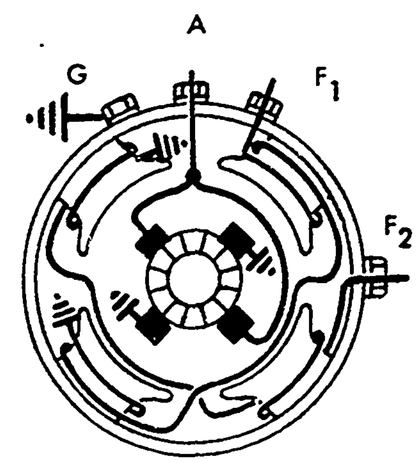


Fig. 4 Split field generator

The stronger field necessary for developing voltage at low speed is accomplished by splitting the field circuit into two separate circuits, each controlled by its own voltage and current regulator. Each set of field coils is designed for maximum allowable field current. The split field type generator has approximately double the field strength of a generator having only one field. This type of generator is successfully used on applications such as city buses and other vehicles, where long periods of engine idling and slow operating speeds require the use of such a generator to prevent repeated battery run-down.

SECTION B -- GENERATOR TESTING

Regardless of its design, no piece of equipment will last forever. It is subject to malfunctions and disorders. The generator is no exception, and tests are required to locate the troubles when they occur.

Basic malfunctions can be classified into four groups: short circuits, open circuits, grounded circuits and circuits with abnormally high resistance.

A short circuit is any undesired connection that permits the current to bypass part of the electrical unit. It can be thought of as an unwanted copper-to-copper connection in the generator, since copper is the material used for the conductor that carries the current. An open circuit is any undesired break in the circuit containing current flow, thus causing extremely high resistance. Normally no current will flow in an open circuit. A grounded circuit is an undesired connection that bypasses part or all of the electrical unit from the insulated side to the ground side of the circuit. It can be thought of as an unwanted copper-to-iron connection in the generator. A circuit with abnormally high resistance is, as the name implies, one containing resistance of a nature that increases the total resistance on the circuit. Poor or loose connections, corroded connections, and frayed or damaged wires are examples of conditions causing high resistance. See Figures 5 and 6.

The following information is devoted to testing the generator and its component parts.

If a generator is tested for electrical output and is found to be lacking, a further check is required to see which of the component parts is causing the difficulty.

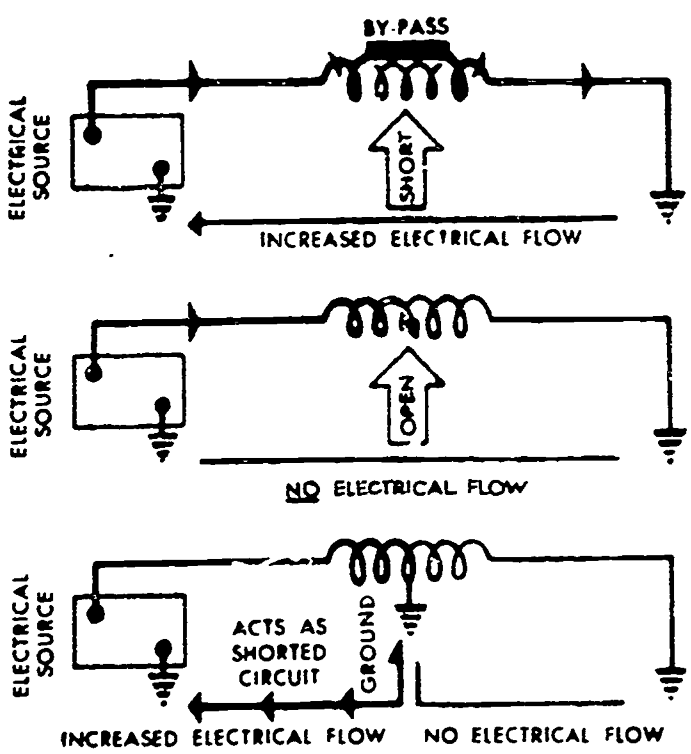


Fig. 5 Shorts, opens and grounds

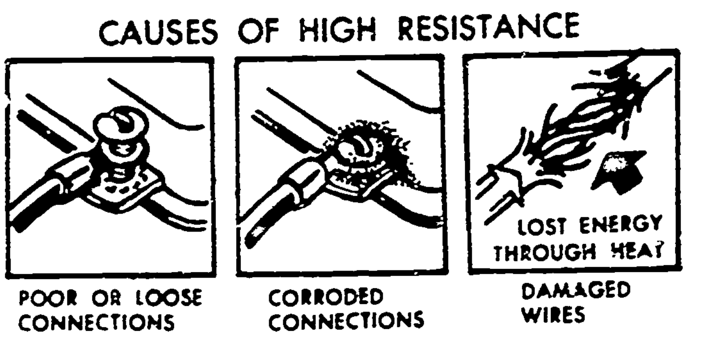


Fig. 6 High resistance connections

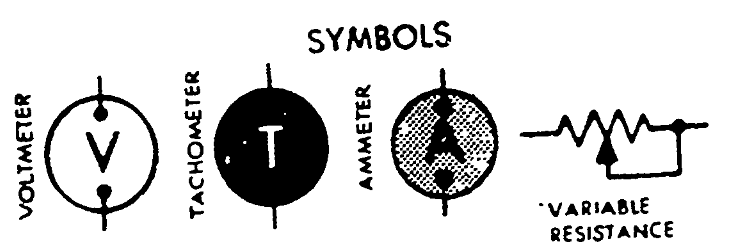


Fig. 7 Meter symbols

Published specifications for generators are available. Review of these specifications will reveal that each generator model is listed with such information as type "A" or type "B" circuit, the direction of rotation and cold output specifications. Cold output data as listed in the specifications apply to generators at a temperature of 80 degrees F and with the brushes well seated on the commutator bars.

Variations in temperature or brush seating may cause deviations of as much as 100 rpm or more from rated speeds. Any inaccuracies in test meters or other test equipment will, of course, also give false information regarding the generator.

To conduct a generator output test, some means must be provided for driving the generator. It is also necessary to have a voltmeter, an ammeter, a tachometer and a variable resistance unit capable of safely handling the voltage and current involved. An "AVR" machine may be used for generator output testing. It includes a voltmeter, an ammeter and a variable resistance unit all in a single test unit. See Figure 7 for symbols.

PROCEDURE FOR TESTING GENERATOR OUTPUT -- The following procedure should be followed when checking the output of a generator:

The generator, meters and resistance should be hooked up as shown in Figure 8. An "A" circuit generator has the (F) terminal grounded by a jumper lead to complete the field circuit. A "B" circuit generator has the (F) terminal connected to the (A) terminal by a jumper lead to complete the field circuit.

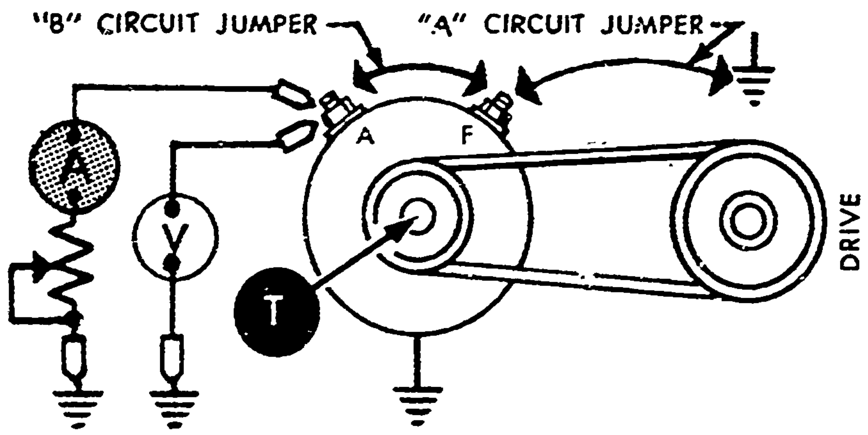


Fig. 8 Test meter connections

Drive the generator at a speed slightly below the rated specifications, using a tachometer to measure the speed of rotation. Adjust the variable resistance unit to a value that will cause the generator voltage to be that which is specified. Increasing the resistance in the load circuit will increase generator voltage, whereas decreasing the resistance in the load circuit will decrease generator voltage. Measure the voltage by attaching the voltmeter in the position shown in Figure 8. Increase generator speed until the current flow of the circuit is that which is specified. Measure the current flow with the ammeter attached in the position shown. Recheck the voltage reading to make sure that it is the same as specified.

Adjust the variable resistance and speed, as required, to obtain the specified voltage and current. The speed of rotation needed to produce the required voltage and current should be that which is specified, providing the limits of temperature and brush seating are correct. If voltage and current are obtained at a slower speed than that specified, it indicates that the generator is in good electrical condition. Voltage and current obtained at a higher speed than that specified, indicates that the generator is in poor or unsatisfactory electrical condition.

COMPONENT PART	POSSIBLE FAULT
ARMATURE	Open circuited windings Short circuited windings Grounded windings Dirty commutator
FIELD COILS	Short circuits High resistance connections Open circuits Ground circuits
BRUSHES	High resistance connections Off neutral position (If adjustable type brushes)
MECHANICAL PROBLEMS	Tight bearings Pole being rubbed by armature

Fig. 9 Troubleshooting check list

The problem then is to determine which of the components is not functioning properly and which one is preventing full generator output at its rated speed. The chart in Figure 9 lists the possible disorders. A check of each part will be necessary, to determine which component or combination of components, is defective.

No output from the generator is often caused by a grounded armature circuit. This can occur either in the circuit within the generator or in the circuit outside the generator. Extremely low resistance in any circuit connecting the insulated brush of the generator to the ground brush will be responsible for lack of output from the generator.

A very low voltage reading from the generator whose voltage will not increase with speed of rotation is often caused by an open field circuit. A reading of from two to four volts is indicative of this condition. With no field circuit to build up the magnetic strength of the generator, the only voltage that can be obtained is the result of the residual magnetism. An open field circuit can occur either within the generator itself or outside of the generator in its external circuit.

ARMATURE TESTING -- As mentioned before, some possible electrical failures of an armature can be caused by: open circuited windings, short circuited windings, grounded windings, and a dirty commutator. It is necessary to determine which is at fault.

An armature winding with an open circuit will cause severe arcing between the brush and the commutator. Since all the loops of the armature are connected in series, an open circuit in one winding reduces the current paths in the armature by one-half in a two brush generator. This means the brushes are breaking the circuit twice for every revolution of the armature. Arcing causes burning of the commutator bars and brushes. Since the current paths within the armature are cut in half, the effective loops on the armature can develop only half as much voltage at any given speed when compared to an armature that is in good electrical condition. A generator output test will show that under this condition, approximately twice the rated speed is required to obtain specified current and voltage.

An open circuited armature is easily identified by visual inspection of the commutator bars. The trailing edge of the bar attached to the open circuit winding will be badly burned. See Figure 10. Severe arcing of the generator can easily be seen during operation. Some test equipment manufacturers provide an armature testing machine called a growler. Some growlers include an attachment used to locate the open circuit in the armature. Replacement or re-winding of an armature with an open circuit is required for proper generator repair.

A short circuited armature will cause a decrease in generator output at any speed. An output test will disclose that specified current and voltage are obtained at higher than rated speed.

A short circuited armature has one or more loops touching each other in a copper-to-copper connection. This could occur either within the windings themselves or at the commutator bars. Since the loops touch, they form a complete circuit. The voltage developed in the closed loops will cause current to flow only in the closed loop circuit and not in the external load circuit. The more loops that are shorted out, the higher the speed required to develop specified voltage and current. A very badly shorted armature will never develop specified voltage and current in the safe speed range. Extended use of a short circuited armature can cause high internal heat.

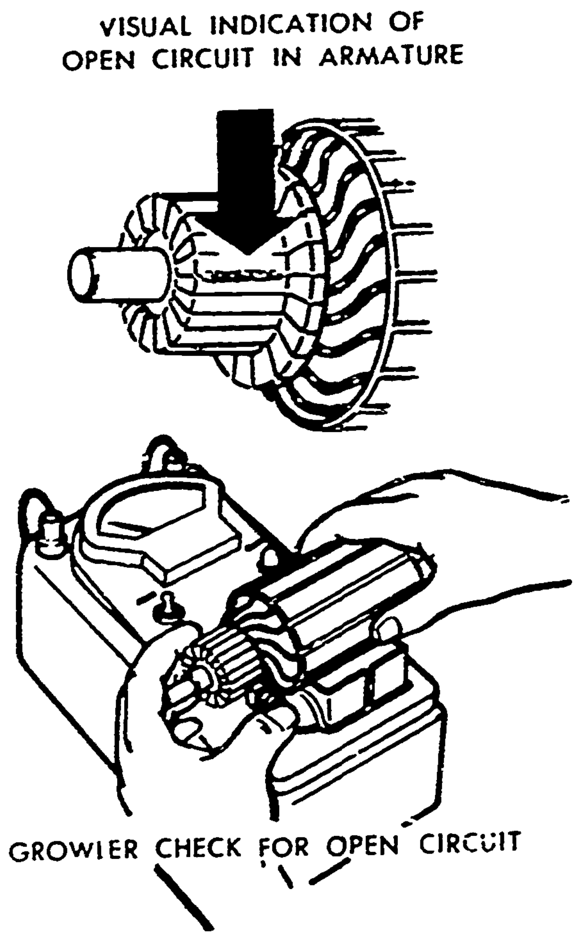


Fig. 10 Visual inspection and tests

An armature with shorted armature windings is identified by a growler check. The armature is placed in the oscillating magnetic field of the growler as shown in Figure 11. The moving field cuts across the loops of the armature. Voltage is developed causing current flow in the completed or shorted circuit. This current produces a magnetic field that attracts and releases, many times per second, a hacksaw blade that is held above the conductor carrying the current. If the armature is shorted, the hacksaw blade vibrates on the area of the short circuit. Replacement or rewinding of the short circuited armature is required for proper generator repair.

An armature with a grounded circuit will cause decreased generator output at any speed. A generator output test will disclose that specified current and voltage can be obtained only at a higher than rated speed. A grounded armature has its windings touching some portion of the ground circuit, or a copper-to-iron connection. This means that the normally insulated side of the loop is connected to the ground or return side of the winding. The

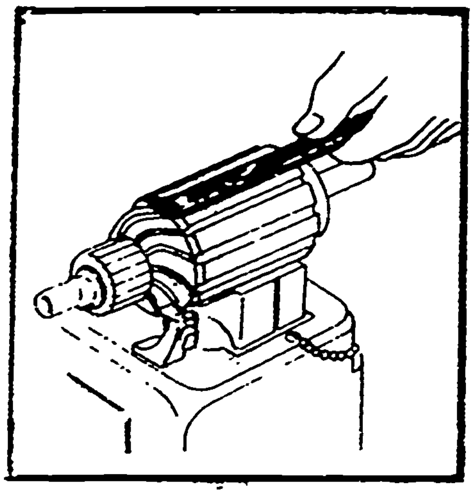


Fig. 11 Growler check for short circuit

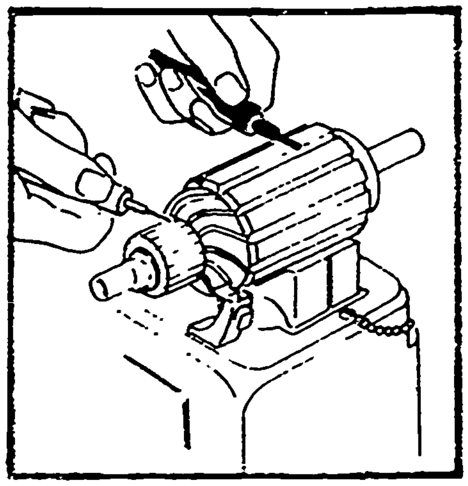


Fig. 12 Test lamp check for grounds

grounded portion of the circuit now bypasses the external load circuit and--since the ground connection has low resistance--the generator voltage build-up will be very small. The smaller the resistance in the undesired ground connection, the smaller the voltage developed.

An armature with a grounded circuit is identified by test lamp, as shown in Figure 12. If one prod of a test lamp is placed on a copper portion of the armature and the other prod is placed on the iron portion of the armature, the test lamp will light if the armature is grounded. If the armature is not grounded, the test lamp will not light.

A dirty or oxidized commutator can cause conditions that appear as if the armature were shorted or grounded. Oil, grease or dirt packed between the commutator bars can provide a path for current flow, thereby shorting the armature loops of the armature. A heavy corrosion or film on the commutator bars can successfully insulate the commutator from the brushes, preventing the generator from building up voltage. Any corrosion on the bars acts as resistance and results in developing high generator voltage. Such conditions can easily be identified by visual inspection.

For proper armature repair under these conditions, the commutator should be turned on a lathe to clean off all corrosion and light resistance films. Care should be taken after turning the commutator to undercut the mica insulators between the commutator bars to a depth equal to the width of the mica. Since the mica insulators are harder than the copper commutator bars, they do not wear as fast. Therefore, mica insulators higher than the commutator bars will cause rapid brush wear, bouncing brushes and arcing. Such conditions can easily be identified by visual inspection of the commutator.

FIELD COIL TESTING -- Failure of the field coil circuit can be caused by either an open field circuit, a grounded field circuit, short circuited field coils, or a field circuit with a high resistance. Any of these conditions has a definite adverse effect upon generator output and must be eliminated to obtain proper generator operation. Current cannot flow if there is an open circuit in the field coil winding. Therefore the magnetic field between the pole shoes can not be strengthened, and residual magnetism provides the only magnetic field. Consequently, voltage developed under these conditions will be insufficient to close the cut-out relay points and complete the charging circuit to the battery.

A test lamp connected to either end of the field coils will reveal a break or open in the field coil circuit. Illustrations for testing both "A" and "B" circuit generators are shown in Figure 13. A lighted test lamp indicates a continuous circuit but does not indicate a shorted circuit.

A grounded field circuit has different effects upon generator output, depending upon where it is grounded. Consider all circuits as starting at the insulated brush of the generator. If the field is grounded before the field coils, there will be little or no flow of current in the field coils, and generator voltage will not build up. In this condition, the armature circuit would also be grounded since the field wire is connected to the armature circuit. See Figure 14.

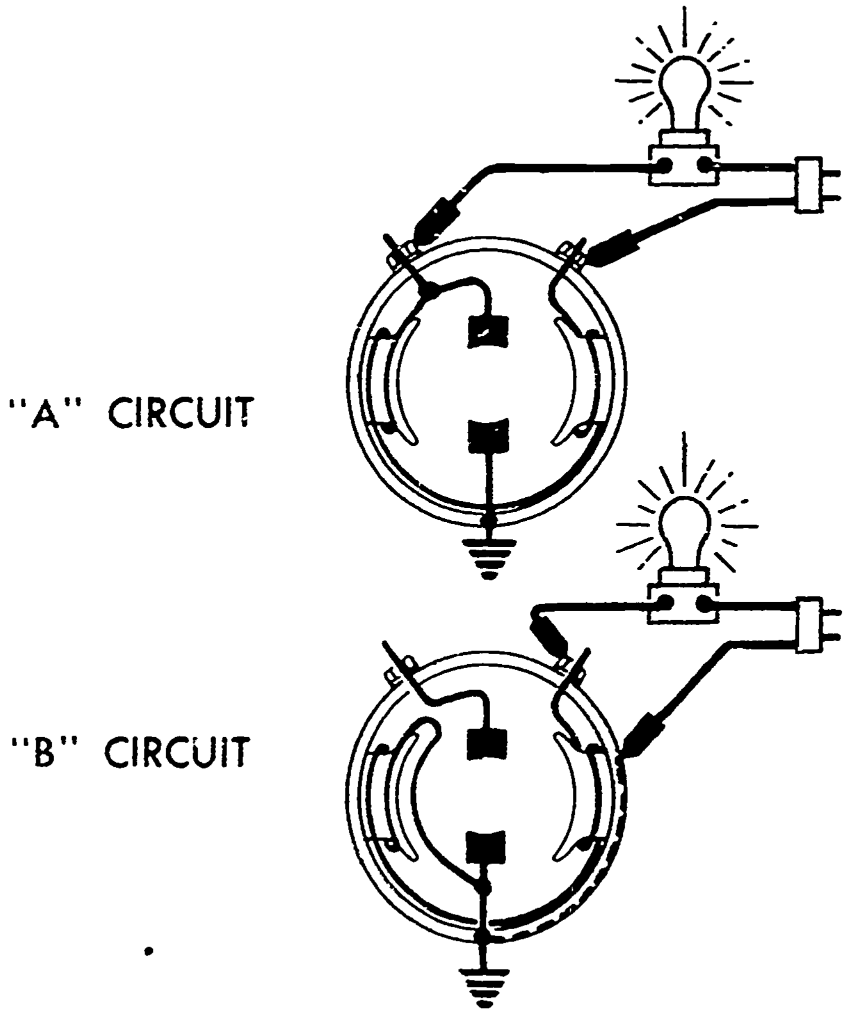


Fig. 13 Checking fields with test lamp

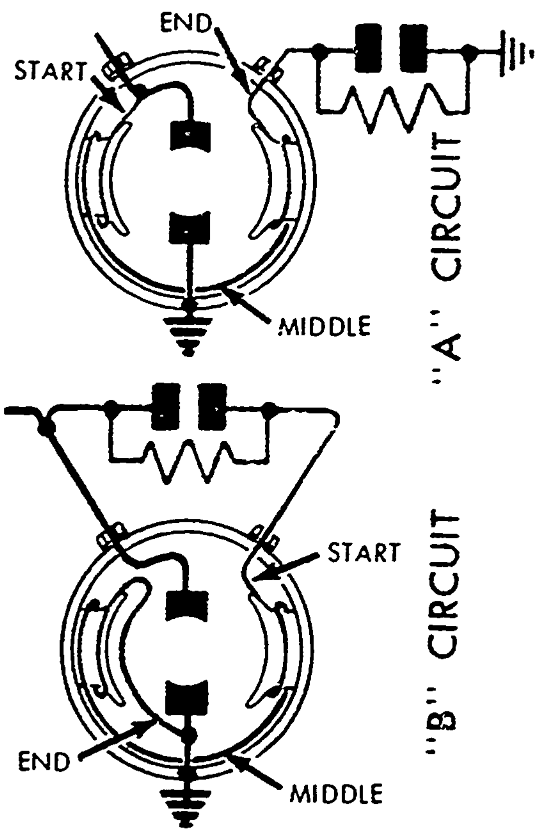


Fig. 14 Circuit testing

If the field coils are grounded at a middle or half-way point, the effect will depend on whether it is an "A" or "B" circuit generator. A generator with an "A" type circuit will build up in voltage as in normal operation. Less resistance in the field coils will permit more current to flow, and the ampere-turn ratio of the field circuit will remain approximately the same. The ground would bypass the circuit through the regulating points and the regulating resistance, and neither current nor voltage control can be obtained over the generator.

A generator with a "B" type circuit will also build up in voltage as in normal operation with its field circuit grounded at the middle or half-way point. The decreased resistance of the field coils will allow more current to flow, and the ampere-turn ratio in the field circuit will remain approximately the same. There will be a circuit through the regulating points and regulating resistance. Therefore, current and voltage control can be maintained. The increased current flow in the field circuit will, however, cause burning and oxidation of the regulator points. This will cause the resistance of the points to become very high, and the field circuit will eventually become an open circuit.

If the field coils are grounded at the end of the field coil windings, the effect on the generator will again depend on whether it is an "A" circuit or "B" circuit generator. An "A" circuit generator will have its field circuit grounded before the regulator and no current or voltage control can be obtained. A "B" circuit generator will have its field circuit grounded in the normal place and operation will be normal.

A test lamp is used to determine if the field circuit is grounded. All intended ground connections of the field coil circuit must be disconnected. Illustrations for both "A" and "B" type generators are shown in Figure 15. The lamp will light if the field circuit is grounded but will not light if the field circuit is not grounded.

A short circuited field coil has little or no effect on the generator output. The resistance of the field circuit is decreased by the number of turns shorted out of the circuit, which allows more current flow in the field circuit and the ampere-turn ratio of the circuit remains approximately the same.

Test specifications for generators are published by manufacturers. Included in the specifications is information on the field current draw. Most published information is based on the field coil temperature of 80 degrees F.

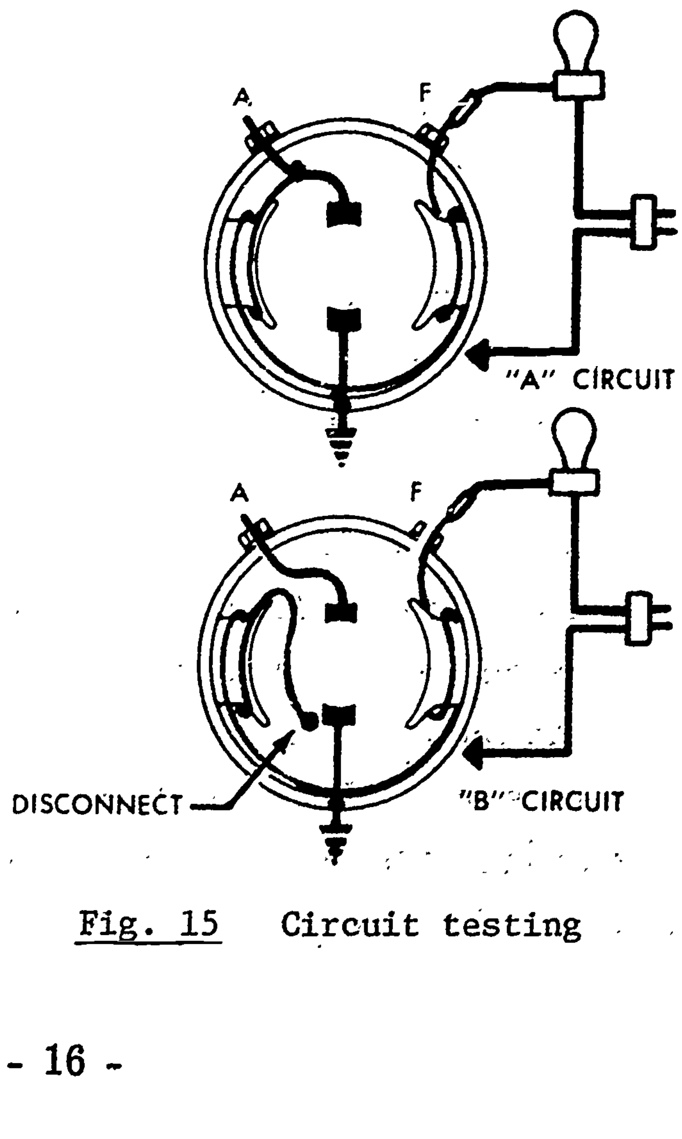


Fig. 15 Circuit testing

Any deviation from this temperature will alter the results of the test.

The illustration in Figure 16 shows the proper hook-up to measure current flow in the field coils when a specified voltage is applied. Specified voltage is obtained by adjusting the variable resistor until the reading of the voltmeter, in the position shown, is correct. Current flow through the coil is measured by an ammeter and should agree with published specifications. Any deviation in current from the specifications indicates a defect in the field circuit.

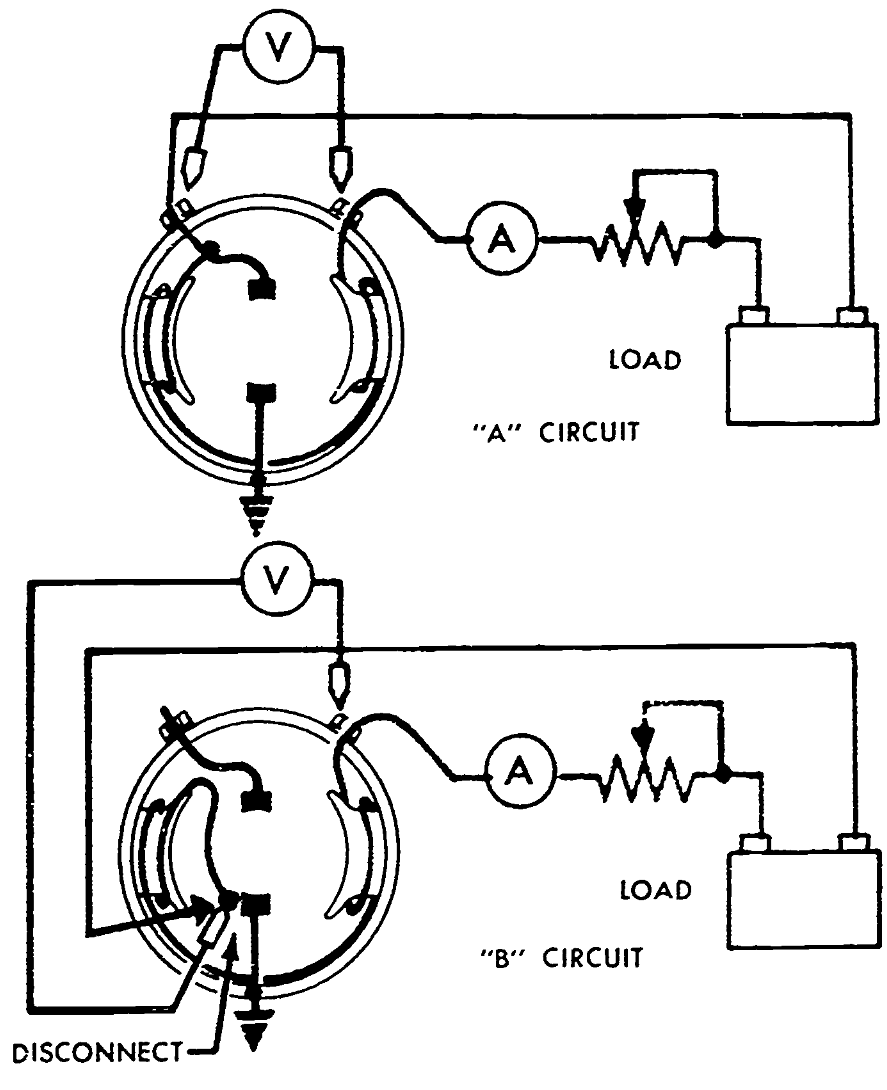


Fig. 16 Testing field current draw

A current draw of more than that specified indicates the resistance of the circuit is too low and that some of the turns of the coil are shorted (touching each other). Repair or replacement of the field coils involved is required for proper generator operation.

A current draw less than that specified indicates the resistance of the circuit is too high and a bad (loose) connection or damaged wire is in the circuit. High resistance in the field circuit decreases the field coil current and, thereby decreases the strength of the magnetic field between the pole pieces. The decrease of magnetic strength within the generator will require a higher speed of rotation to develop the rated voltage and current from the generator.

BRUSHES AND BRUSH HOLDERS -- The brush is a small but very important part of the generator and does not always receive the attention it requires for good generator operation. All brushes are by no means alike. They cannot be used indiscriminately, although they may have the same physical dimensions. Brushes are selected for each type of generator after tests are conducted under the most severe operating conditions to determine their length of life. Most high output generators use electrographitic brushes which have high electrical and thermal conductivity. They can withstand high loads and high temperatures. The process under which they are manufactured makes them hard and very tough.

In heavy duty applications there are two extremes of operation: a high output at high speeds and a low output at low speeds. Each condition requires a brush with a different composition. A brush with a third composition is made to take care of the average operation. These brushes are designated as hard, soft, and medium. Different system voltages may require brushes with other compositions. Most brushes used with high output generators have leads called pigtails packed or tamped into the brush with silver-plated copper flakes to form a low resistance connection.

One factor common to all brushes is the sliding friction between them and the bars of the commutator. Normal current flow causes enough oxidation to maintain a copper oxide film, which has little friction. See Figure 17. At no load or current flow, the brushes may abrade or rub away this film and bring on a high friction condition which causes brush chatter, heat and wear.

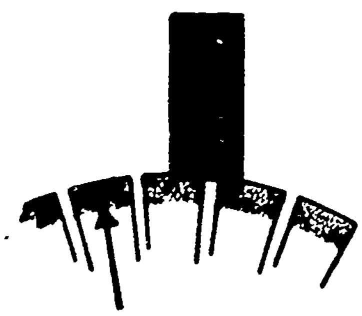


Fig. 17 Brush and commutator bars

Under conditions of operation where extremely low current is generated, insufficient copper oxide is produced between the brush and the commutator for an adequate film, and there is a tendency for the brushes to chatter (vibrate up and down). Under such conditions, the brush leads may loosen in the brush, forming a high resistance connection, causing the current to pass through the brush surface area and brush holder instead of the pigtails.

If this condition exists, corrosion and etching takes place between the brush and holder, which unless corrected, will eventually prevent good brush contact with the commutator and may cause a burned brush, brush holder, or brush holder arm.

When replacing brushes due to this condition, the brush holder should be replaced, as well as the brush arm. When replacing worn brushes, the brush holder guides must be polished to allow free movement of the brush.

A brush arm stop is provided to protect the commutator bars from being scored by the brush arm when the brush is worn away. The **brush** arm stop also prevents the brush arm from applying pressure on the brush when it becomes too short for satisfactory service. The brush should not be allowed to wear down until the brush arm touches the stop. See Figure 18.

Test specifications contain information on the proper spring tension applied to the brush arm. A check of the tension should be made during all generator repair to assure proper generator efficiency and long brush life. Brush arm tension should be measured at a point as close to the middle of the brush as possible. Weak spring tension will cause the brushes to bounce at high speeds, which will result in arcing and poor commutation. Strong spring tension will cause excessive friction between the brush and the commutator, and short brush life will result. See Figure 19.

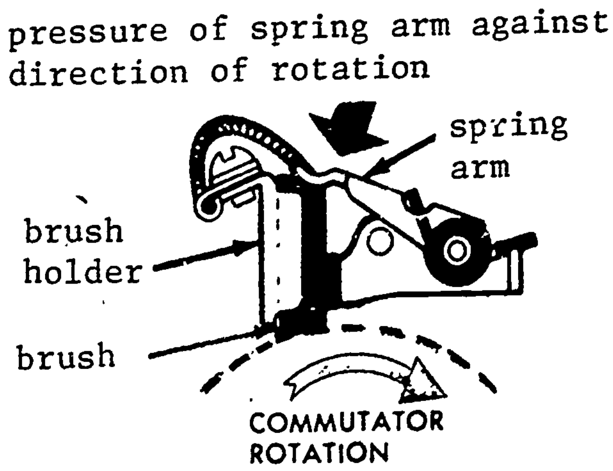


Fig. 18 Brush holder details

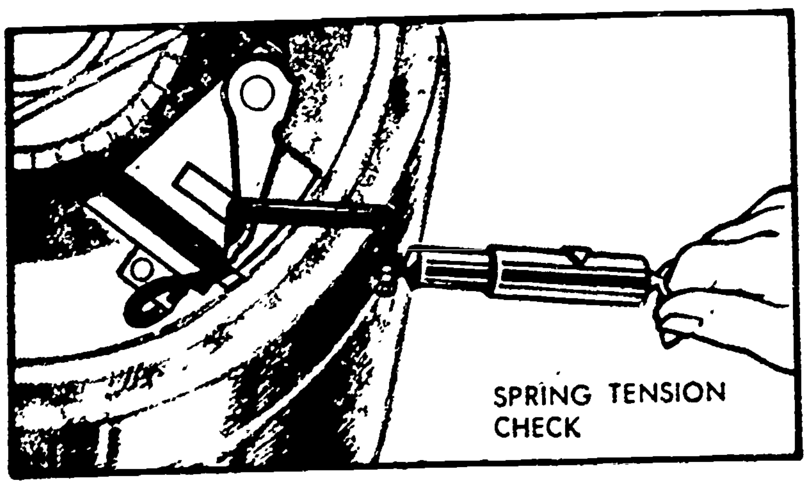


Fig. 19 Spring tension check

Generator testing should include an electrical check of the brush holders and frame. A test lamp placed across the grounded brush holder and the frame should light. If it does not, the brush holder is insulated from the frame and all circuits are open. A test lamp placed across the insulated brush holder and frame should not light. If it does, the brush holder is grounded to the frame and all circuits will be grounded at this point. See Figure 20.

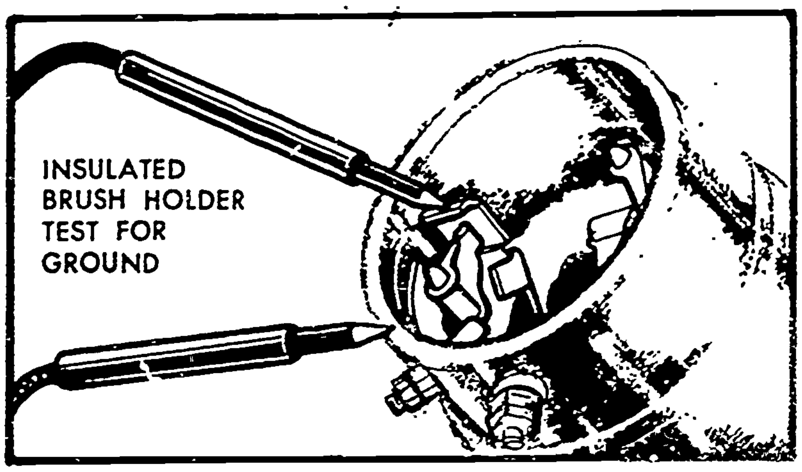


Fig. 20 Testing for grounds

Maximum current output at high speeds causes a commutation problem of heat, which greatly increases wear of the brushes. Similarly, extremely short brush life results from friction when a generator is operated at low or zero current output. Lubricating ingredients are built into some brushes where low output predominates. Where low and high output operation predominates, laminated brushes are sometimes used.

If the brushes are worn down to less than half their original length, they should be replaced. New brushes can be seated to make good contact with the commutator by holding a brush seating stone on the commutator with the generator in operation or by applying brush seating compound to the commutator. Blow away all dust after the seating operation.

When replacing brushes, be sure that the brush seat is obtained across the thickness of the brush,front to back. A 25% contact area is satisfactory. However, a seat of the same area across the heel or toe of the brush would not be satisfactory. Heel or toe seating of a brush changes the neutral position, and will result in excessive arcing. See Figure 21.

NEUTRAL POSITIONING OF BRUSHES --Many of the higher output shunt generators have adjustable brush plates which can be shifted to obtain the proper brush locations with respect to the neutral point. Proper adjustment is necessary to obtain best commutation and therefore maximum brush and commutator life. The neutral point refers to a particular relationship among the poles, armature windings and brushes. When the relationship of these parts is correct, minimum arcing and best commutation will be obtained. Whenever new brushes, armature or poles are installed, or whenever a generator has been disassembled, the brush position must be checked and adjusted as follows:

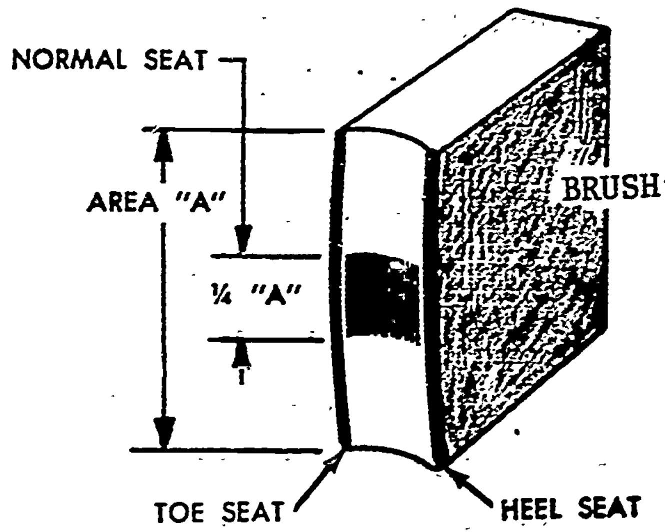


Fig. 21 Brush seat details

With the generator assembled and the brush ring attaching screws just tight enough to hold the brush ring in place in the commutator end frame, connect a battery between the generator (A) terminal and ground (or between (A1) and (A2) terminals on insulated units) and note the tendency for the armature to rotate. The generator should be on a test bench, with the armature free to rotate and without any connection to the generator field terminal. The voltage to use in making this check is the minimum amount of voltage which will cause the armature to rotate when it is free to turn. This voltage may be obtained by connecting a variable resistance into the circuit from the battery.

The neutral point is found by shifting the brushes into the position at which there is no tendency for the armature to rotate in either direction. If the generator has interpoles, the brush setting must be exactly on the neutral point. Generators without interpoles must have their brushes shifted ahead 1/4 (one quarter) commutator bar width in the direction of armature rotation so that the armature will tend to rotate very slowly in the direction of normal drive rotation. After the brush position is found, the brush plate locking or attaching screws should be tightened securely.

DISASSEMBLY AND MECHANICAL PROBLEMS -- Generator disassembly can be accomplished first by removing the thru-bolts, or end frame attaching bolts, and then separating the two end frame assemblies from the field frame. On some models, it is necessary to detach leads from the brush holders before the commutator end frame can be removed. Also, on some generators, the commutator end frame retainer plate, and the cotter pin and nut on the shaft, must be removed before the end frame can be separated from the field frame.

When removing bearings from the armature shaft or end frame, care should be taken to avoid damage to the balls and raceways. If the bearing is a press fit over the shaft, use bearing pullers against the inner race only. If the inner race is inaccessible, and it is necessary to pull against the outer race, the balls will be loaded and may be damaged. Similarly, when removing a bearing whose outer race is a press fit into the end frame, use an arbor press against the outer race to avoid loading the balls.

After bearing removal, wash in a clean solvent, and carefully inspect for worn surfaces, looseness, broken separators, a cracked ring or race, and a rough or catchy feeling. Always replace any bearing if its condition is doubtful.

IMPORTANT -- Refer to the section in manufacturers specifications entitled "MAINTENANCE" for proper lubrication procedures.

When remounting bearings, use an arbor press, and press firmly and evenly against the proper race to avoid loading the balls. If the mounting surfaces are clean, and the bearing is started properly and it is not cocked or mis-aligned, it can be mounted without undue pressure.

Grease and oil seals should be replaced after appreciable mileage or operating hours, or if the seal is worn or damaged in any way. The reassembly procedure, for the most part, is the reverse of disassembly. Care should be taken to avoid damage to grease seals and oil seals during reassembly, and the brushes should be checked after reassembly to make sure they are free in their holders and the brush-arms move freely.

The interior of the generator should be thoroughly cleaned to allow the maximum amount of air circulation for ventilation and cooling. Many cases of burned up generators have resulted from dirt being packed inside the generator, restricting the flow of air.

Oil inside the generator is highly destructive to the insulation on the wires. Any entry of oil into the generator should be blocked to insure long generator life. Cleanliness and proper lubrication are vital to the life of any generator. Regular servicing periods will greatly increase generator life and decrease the possibility of failure.

SECTION C -- GENERATOR POLARITY AND POLARIZING PROCEDURES

The magnetism of the pole pieces is determined by the field coil's current and its direction of flow. The residual magnetism and the polarity of each pole will remain the same as induced from the magnetism of its field coil the last time current was passed through it. Generators, therefore, will build up voltage that will cause current to flow in either direction, depending upon residual magnetism in the poles. This was mentioned in a previous section entitled, "What is Polarity". When working on electrical units, and when ringing out circuits with a small battery and bell, it is possible for current to flow through the field coils in the wrong direction, and the generator will become improperly polarized with respect to the battery in the vehicle. An instantaneous flash is all that is required to create a reverse polarity of the generator.

After a generator has been repaired and installed on a vehicle, or at any time after the generator has been tested, it must be polarized. This is to make sure that it has correct polarity to develop voltage that will cause current to flow in the proper direction to the battery it is to charge. Failure to polarize the generator in agreement with the battery on the vehicle may result in burned cut-out relay points, a run-down battery and possible serious damage to the generator itself. If the direction of current flow from the generator to the battery is correct, the battery will be charged. However, if the direction of current flow from the generator to the battery is wrong, voltages of the battery and generator will be added together (connected in series) to give approximately double voltage across the contact points of the cut-out relay.

The high current and voltage developed in an improperly connected or improperly polarized generator produces heat that can weld the contact points together, instantly. Relay points welded together allow the battery and generator to be connected together at all times. Since resistance of the generator is low, the current has a very low resistance path back to the battery and large discharge current will flow from the battery through the generator and back to the battery. This, in a short time, completely discharges the battery and may develop enough heat to burn the armature and render it inoperative for future use.

The importance of polarity cannot be stressed to highly. Lack of understanding of generator polarity and its relationship to the vehicle battery has been responsible for many unnecessary electrical failures in the cut-out relay, battery and generator.

The procedure to follow in correcting generator polarity depends upon the generator regulator wiring circuits, that is, whether the generator field is internally grounded or is grounded through the regulator. Procedures for polarizing "A" and "B" type circuits differ.

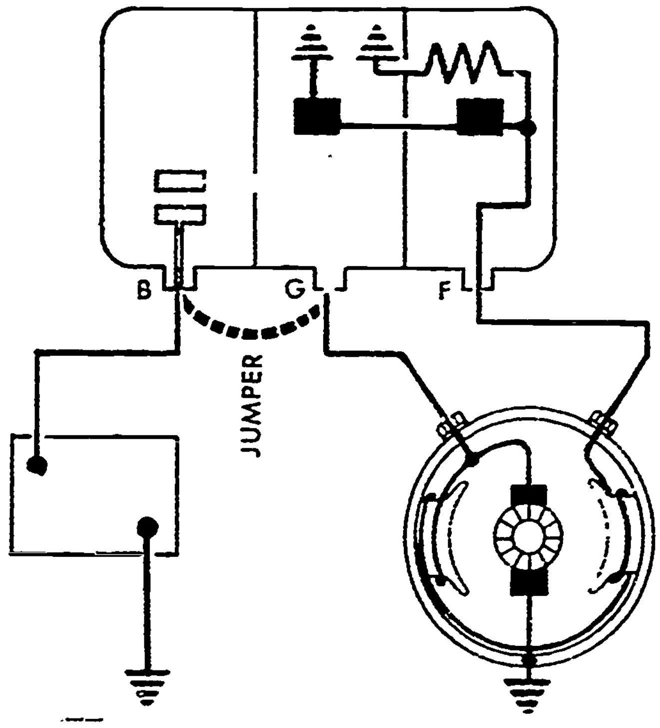


Fig. 22 Polarization of "A" circuit generators

POLARIZATION OF "A" CIRCUIT GENERATORS -- Generators using an "A" circuit are polarized by connecting a jumper lead from the insulated or hot side of the battery to the armature or "A" terminal of the generator. The battery, generator and regulator grounds must be connected. On the vehicle this is done through the frame. The connection described causes current to flow in the normal direction through the field coils which will correctly polarize the generator's pole shoes. A touch of the jumper lead is all that is required and a flash or arc will be noted when the lead is removed. See Figure 22.

Insulating the brushes from the commutator bars with a piece of thin cardboard, or something comparable, is recommended on all 24 or 32 volt generators of circuit "A" construction during polarizing. If the brushes are not insulated, low resistance of the armature will cause an extremely high discharge current through the armature when the jumper lead is connected between the battery and generator terminal, and a badly burned armature may result. With the brushes insulated, only field current will flow.

Generators designed for a "B" circuit are polarized by disconnecting the field lead from the regulator and momentarily flashing this lead to the battery terminal of the regulator. Battery and generator ground circuits must be connected. Current will flow through the field coils in the proper direction to correctly polarize the generator's pole shoes. A touch of the lead is all that is required, and a flash or arc will be noted when the lead is removed. It is important to remove the field lead from the regulator. Failure to do so will result in burned regulator points. A very low resistance

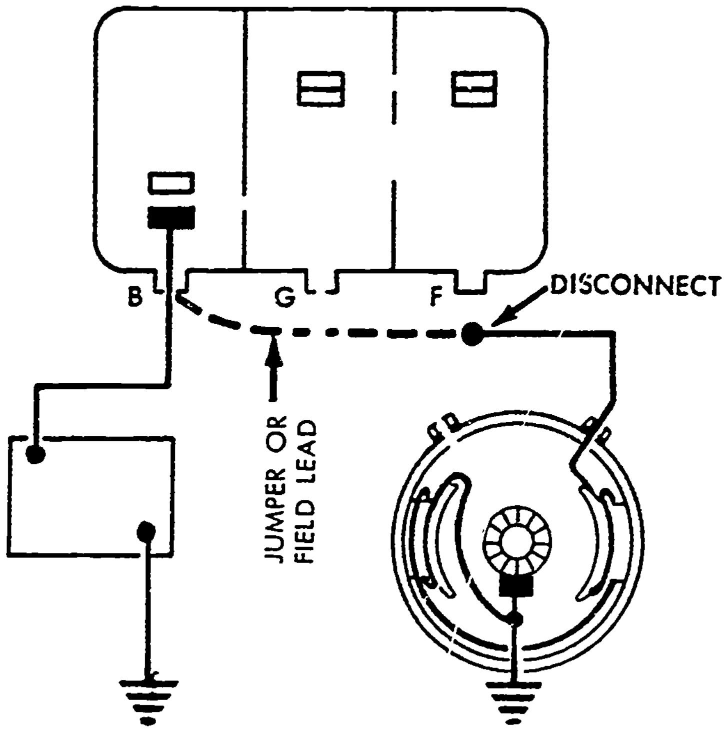


Fig. 23 Polarization of "B" circuit generators

circuit from the battery through the points to the generator armature and back to the battery would carry high current if the connection were not broken.

For proper polarization, the rule should be to pass current through the field coils in a direction that will have the ground side of the coils connected to the ground side of the vehicle battery. See Figure 23.

DIDACTOR PLATES FOR AM 2-15 D

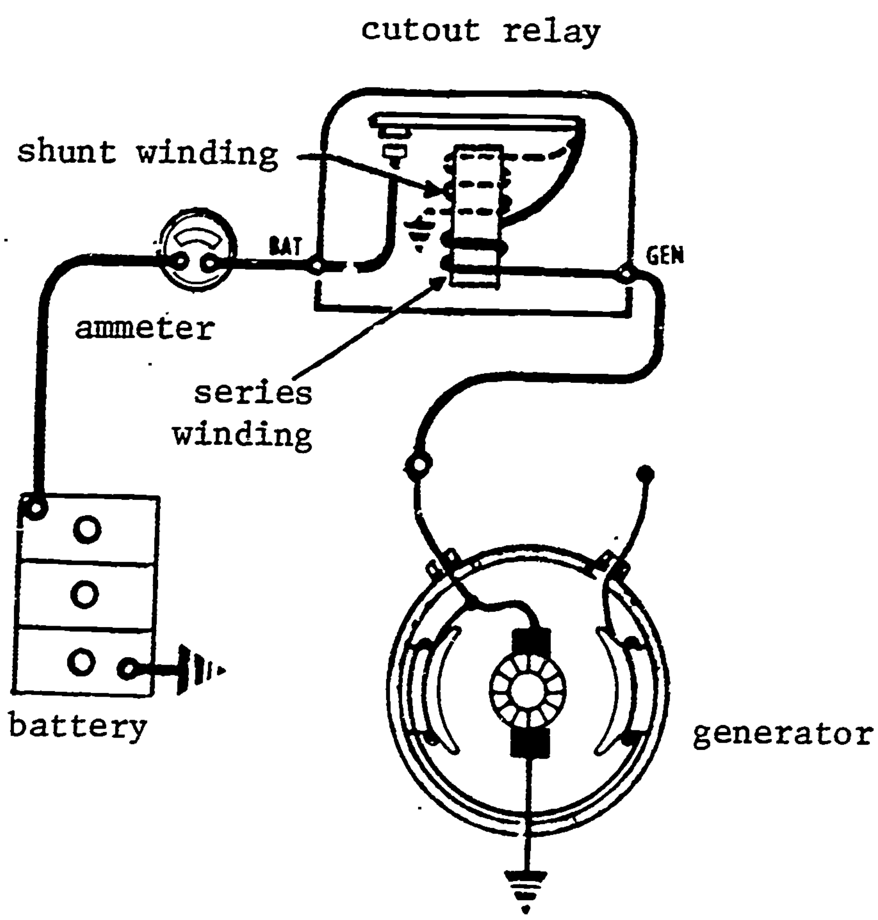


Plate I Cutout relay

CHECKING AND ADJUSTING CUTOUT RELAY

AIR GAP

1. Disconnect battery lead from relay BAT terminal. Do not allow this hot lead to be grounded against any metal parts.

2. Hold relay contact points just barely closed with finger pressure. Do not apply more pressure than needed.

3. Check air gap with feeler gauge.

4. Adjust air gap to manufacturer's specifications:
   a. Loosen adjusting screws.
   b. Raise or lower armature as required.
   c. Tighten adjusting screws, making sure points are properly aligned.

POINT OPENING

1. Make sure battery lead is disconnected from relay BAT terminal. Do not ground this hot lead.

2. Check point gap with feeler gauge.

3. Adjust to manufacturer's specifications:
   a. Bend upper armature stop up or down to obtain proper opening.

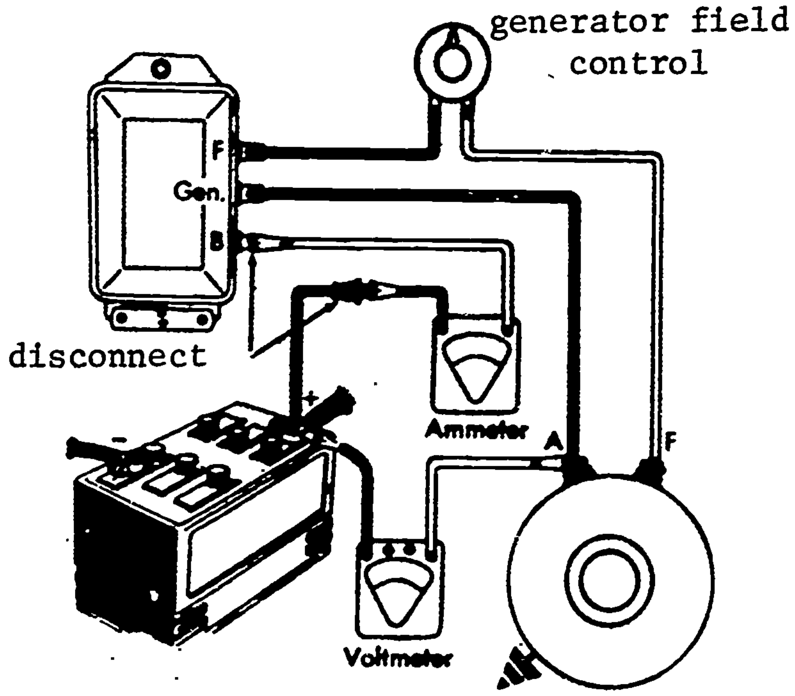
4. Reconnect battery lead to relay BAT terminal.

CLOSING VOLTAGE

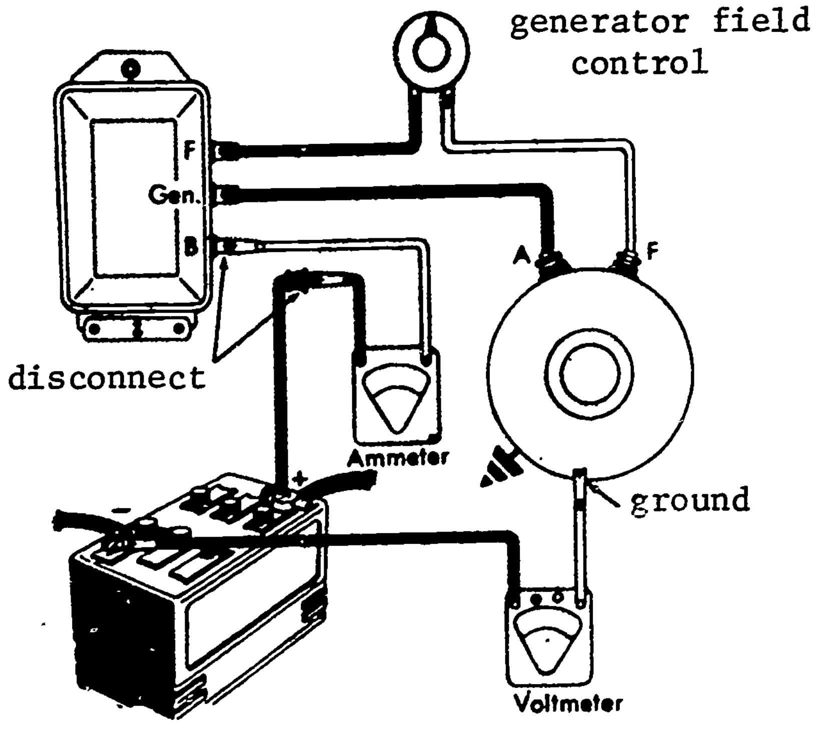
1. To check closing voltage:
   a. Connect voltmeter to relay GEN terminal and to relay base (Ground).
   b. Slowly increase generator speed until points just close. Note voltage reading at this time and compare with manufacturer's specifications.

2. To adjust closing voltage:
   a. Bend armature spring post up to increase closing voltage, down to decrease closing voltage, as necessary.
   b. After each adjustment, stop generator and then increase speed slowly again. Check the closing voltage.
   c. Repeat adjustment until desired closing voltage is obtained.

PLATE II



(a) Testing the insulated side of the charging circuit



(b) Testing the grounded side of the charging circuit

Plate III Charging circuit resistance test

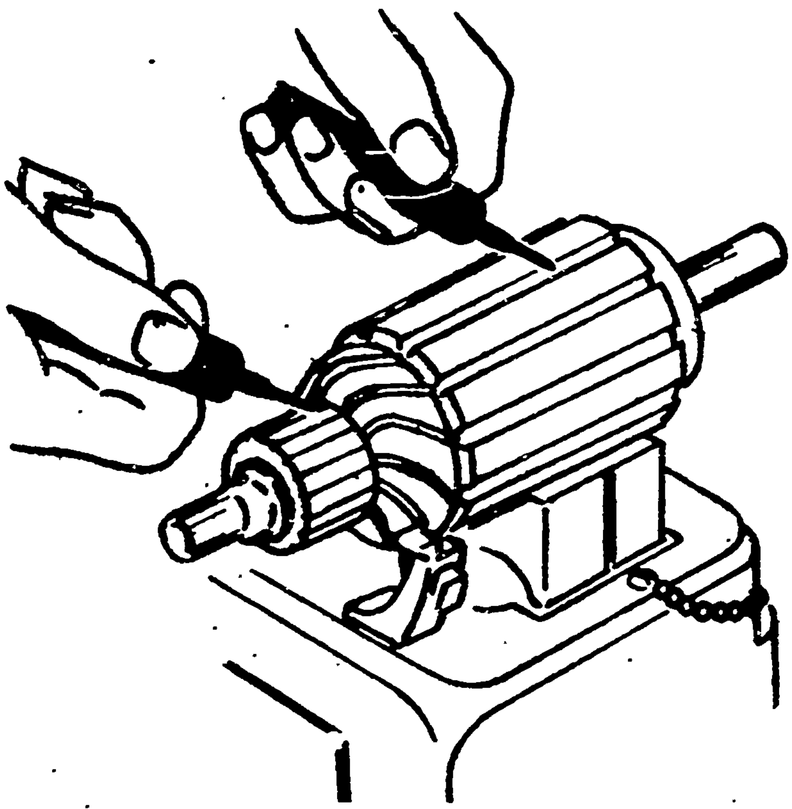


Plate IV Testing the armature for grounds

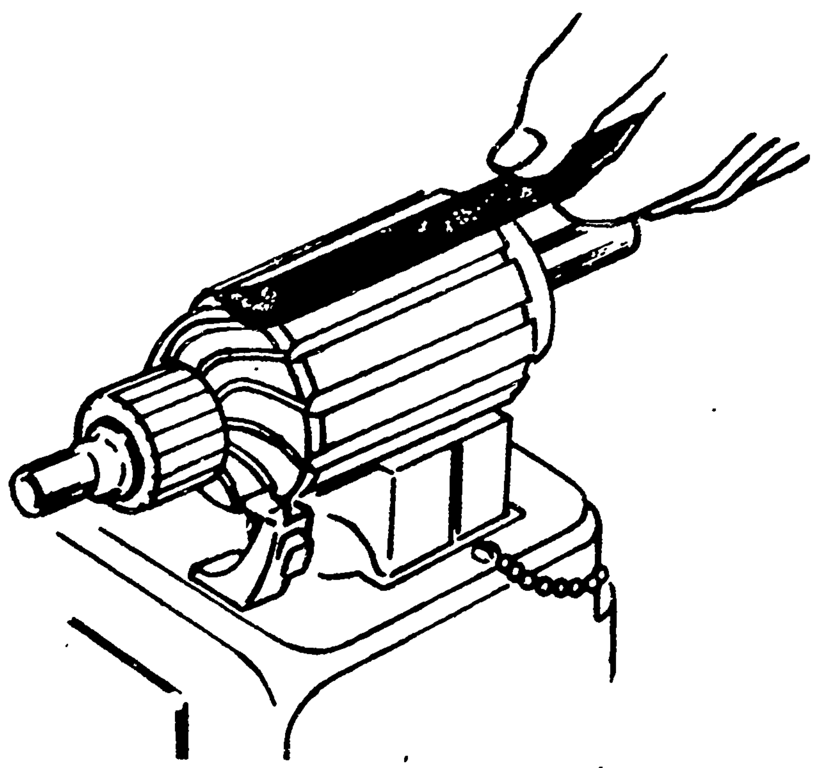


Plate V Testing the armature for shorts with a "growler"

0

AM 2-15D
10/19/67

DC GENERATORS II --
GENERATOR TESTING PROCEDURES

Human Engineering Institute

Minn. State Dept. of Ed. Vocational Education

Press A —1

Check to see that timer and index are OFF.

1

This is the second of two films in which we discuss automotive DC generators and their allied equipment.

We will begin this film with a discussion of the cutout relay -- principles of operation and adjustment procedures.

Then we will discuss various tests and troubleshooting procedures for the DC generator.

Press A —2

1-1

2

In the film on fundamental principles of DC generators, we discussed two important components of automotive electrical systems -- the voltage regulator and the current regulator. These units are extremely important, since they help control the operation of the generator.

Let's discuss a third important component now -- the CUTOUT RELAY.

Press A — 3

1-2

3

The cutout relay is an electromagnetic switch connected in the load circuit. It is connected between the battery and the generator. See Plate I.

The relay consists of a series winding and a shunt winding wrapped around a common iron core. When generator speed is sufficient, current flows from the generator through the series winding and through the shunt winding. This creates a magnetic field which pulls a set of spring loaded contact points CLOSED.

Press A — 3.1

1-3

3.1

During battery charging, current flows through the series winding and through the shunt winding

________________________.

A. in the same direction — 5

B. in opposite directions — 4

1-3.1

4

You are incorrect.

In order to charge the battery, the cutout relay points must be closed. Spring tension tends to hold the points open, however. To overcome the spring tension, a strong magnetic field must be created around the relay windings.

This is accomplished by current flowing in the series winding and in the shunt winding BOTH IN THE SAME DIRECTION.

Press A — 5

1-4

5

OK. The magnetic fields created around the two windings work together during battery charging.

If generator speed drops to a point where battery voltage is greater than generator voltage, current attempts to flow in the OPPOSITE direction -- from the battery back to the generator.

Press A for more. — 5.1

1-5

5.1

This causes current in the series winding to REVERSE its direction. Current in the shunt winding DOES NOT reverse its direction, however.

Current in the cutout relay shunt winding flows

________________________.

A. in opposite directions during battery charging and discharging — 6

B. in the same direction all the time — 7

1-5.1

6

Incorrect.

It is in the SERIES winding that current changes direction. During charge, current flows toward the battery. As the battery discharges, current in the series winding reverses and flows away from the battery.

Current in the SHUNT winding flows in the same direction all the time -- directly to ground. (See Plate I.)

Press A —7

1-6

7

OK. If current flow is reversed in only one winding, the two magnetic fields then work against each other. Their overall attracting force is weakened, allowing spring tension to OPEN the points again. This blocks the flow of current from the battery back to the generator, and thus prevents burning of the generator wiring and insulation, and the commutator bars.

For a brief discussion of the effects of current direction on two adjacent coils, press A.

—8

1-7

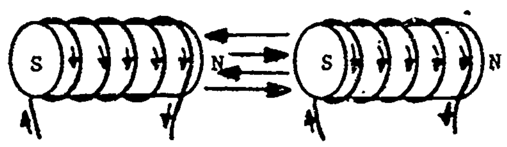
8

The magnetic field around a current-carrying coil is similar to the field around a bar magnet. The field has POLARITY, just as a bar magnet does.

If current flows in the same direction in both coils, the two fields tend to attract and form one strong field.

This is what occurs in the cutout relay during battery charging.

FIELDS ATTRACT



CURRENTS IN SAME DIRECTION

Press A

1-8

—9

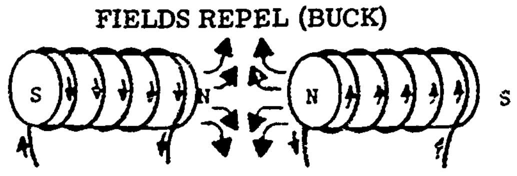
9

If the currents in two adjacent coils flow in opposite directions, the two magnetic fields tend to repel each other. They are said to buck each other.

The two fields work against each other and the overall magnetic strength is reduced. This is what occurs in the cutout relay during battery discharge.

Press A

FIELDS REPEL (BUCK)



CURRENTS IN OPPOSITE DIRECTIONS

1-9

—10

10

The cutout relay requires three checks and adjustments. Manufacturer's specifications should be followed when making any of these adjustments: See Plate II.

1. AIR GAP -- between armature and iron core of the relay
2. POINT OPENING -- point gap when contacts are open
3. CLOSING VOLTAGE -- voltage at which contact points will close

CAUTION: When checking or adjusting air gap or point opening, it is first necessary to DISCONNECT the relay BAT terminal lead.

Press A —11

1-10

11

Plate II gives detailed instructions for checking and adjusting the air gap, point opening and closing voltage for the cutout relay.

The battery lead must be disconnected from the cutout relay battery terminal when checking or adjusting

____

A. air gap —12
B. air gap and point opening —14
C. air gap, point opening and closing voltage —13

1-11

12

Your answer is correct, but is incomplete. See Plate II.

Note that the first step under both air gap and point opening is to disconnect the battery lead from the cutout relay BAT terminal.

If this is not done, battery voltage will be impressed on the relay when the points are pressed closed, or when the circuit is completed across the points by the feeler gauge.

Press A — 14

1-12

13

No.

The battery lead should be disconnected for checking and adjusting air gap and point opening - but NOT for closing voltage.

If the battery lead is disconnected during a check for closing voltage, there will be an OPEN CIRCUIT between the generator and battery. A voltage reading would be obtained on the voltmeter (connected between the GEN terminal and ground), but the contact points would not close because of the open circuit.

Press A — 14

1-13

14

OK.

If you are checking cutout relay closing voltage and you notice that the voltmeter needle reaches a maximum reading, and then drops back to a lower reading just as the points close, which of the two readings is the actual closing voltage?

A. The maximum reading obtained. — 16

B. The lower reading obtained after the needle jumps back. — 15

1-14

15

Incorrect.

When the voltmeter needle jumps back just as the points close, the lower reading is a measure of the generator voltage acting to overcome battery CEMF. This is the charging voltage.

The cutout relay closing voltage is the maximum reading obtained just before the needle jumps back as the points close.

Press A — 16

1-15

16

OK. The maximum reading just before the needle jumps back is the closing voltage.

After each adjustment for closing voltage, the generator must be stopped momentarily before a check at the new setting is made. This allows the points to re-open and assures that they will not be under the influence of any residual magnetism in the relay windings.

If you would like to review this section, press A. — 3

Otherwise, press B. — 18

X (C) - 17

1-16

17

OK. The higher of the two readings is the actual closing voltage. Once the points close, the needle jumps back and the meter reads the charging voltage.

Since you have made an error or two on the questions in this section, let's have a quick review of the cutout relay.

We'll talk about identifying "A" circuits and "B" circuits when you have answered all the questions correctly.

Press A — 3

1-17

18

IDENTIFYING "A" CIRCUITS AND "B" CIRCUITS

In the previous film we learned that there are two major types of automotive electrical systems -- "A" circuit systems and "B" circuit systems. Generator specification sheets usually identify the type.

The two types also can be distinguished by noting the location of the generator field circuit ground.

The field coils of an "A" circuit system are grounded at the ____(1)____; in a "B" circuit system the field is grounded at the ____(2)____.

A. (1) generator (2) regulator - 19
B. (1) regulator (2) generator - 20

2-18

19

You are incorrect.

The rule to remember is:

"A" circuits are grounded EXternally (outside the generator). "B" circuits are grounded INternally.

In an "A" circuit system, the field coils are grounded at the regulator. "B" circuit field coils are grounded at the generator.

Press A — 20

2-19

20

OK.

"A" circuits and "B" circuits may be identified by noting to which generator brush the field coil lead is connected.

Every two-brush generator has one INSULATED brush and one GROUNDED brush. If the field coil lead is connected to the insulated brush, then the generator is ________ circuit generator.

A. an "A" — 22
B. a "B" — 21

2-20

21

Incorrect.

The field circuit must be grounded somewhere in order to function properly.

In the question we just asked, the generator field lead was connected to the insulated brush. This means that the system is grounded OUTSIDE the generator (at the regulator). A generator with externally grounded field coils is an "A" circuit generator.

Press A — 22

2-21

22

OK.

In a "B" circuit generator, the field lead is connected to the ___________ brush.

A. grounded — 24
B. insulated — 23

2-22

23

Incorrect.

The basic rule states that "B" circuits are grounded internally. This means that the field coils are grounded at the generator.

When the field lead is connected to the grounded generator brush, you have a "B" circuit generator.

Press A — 24

2-23

24

OK.

Often it is difficult to inspect the generator visually to determine where the field coils are grounded. Sometimes this cannot be done without removing the generator cover band.

In such cases, an easier method of identifying the type of system may be used.

Press A for more. — 25

2-24

25

A simple method is to disconnect the field lead from the generator "F" terminal, being careful not to let this wire be grounded.

Then connect a voltmeter (or a test lamp) to the generator field terminal and to ground. Operate the vehicle engine at a fast idle.

A voltage reading (test lamp lighted) indicates that the generator is an "A" circuit generator. No voltage reading (no light) indicates a "B" circuit generator.

Press A — 26

2-25

26

In order to test for type of circuit at the generator, you disconnect the lead from the generator ___________ terminal and connect a voltmeter or test lamp between that terminal and ground.

A. armature ("A") — 27
B. field ("F") — 28
C. I don't know — 24

2-26

27

You are incorrect.

In order to identify the type of circuit you must disconnect the lead from the generator field ("F") terminal. Then a voltmeter or test lamp must be connected between the field terminal and ground.

Press A — 28

2-27

28

OK.

With the voltmeter connected, the vehicle engine is operated at fast idle. If you then obtain a voltage reading, you know that the field coils are ___(1)___ at the generator and the unit is ___(2)___ circuit generator.

A. (1) grounded (2) an "A" — 30
B. (1) grounded (2) a "B" — 29
C. (1) insulated (2) an "A" — 31
D. (1) insulated (2) a "B" — 30

2-28

29

Both parts of your answer are incorrect.

With the generator field lead disconnected, if you obtain a voltage reading between the generator "F" terminal and ground it means that current is flowing through the "F" terminal. This means that the "F" terminal is INSULATED.

This in turn means that the field circuit is insulated in the generator, so it must be grounded externally.

Externally grounded field coils mean an "A" CIRCUIT generator. Press A for a review. — 24

2-29

30

Only part of your answer is correct.

With the generator field lead disconnected, and the voltmeter connected between the generator "F" terminal and ground:

If you do obtain a voltage reading, it means that current is flowing through the "F" terminal. This means that the "F" terminal is INSULATED.

An insulated generator "F" terminal means that the field coils are grounded externally. Externally grounded field coils mean that this is an "A" CIRCUIT generator.

Press A — 31

2-30

31

OK.

If you are testing for type of system at the generator and the voltmeter reads ZERO when properly connected, you know that the field coils are grounded ___(1)___, and the generator is ___(2)___ circuit generator.

A. (1) internally (2) an "A" — 32
B. (1) internally (2) a "B" — 34
C. (1) externally (2) a "B" — 32
D. (1) externally (2) an "A" — 33

2-31

32

Only part of your answer is correct.

With the field lead disconnected and the voltmeter placed between the generator "F" terminal and ground:

A zero reading on the meter means that no current is flowing and the "F" terminal is grounded. This means that the field coils are grounded INTERNALLY (at the generator).

Internally grounded field coils mean a "B" CIRCUIT generator.

Press A — 34

2-32

33

Both parts of your answer are incorrect.

With a voltmeter connected between the generator "F" terminal and ground (and the field lead disconnected):

A zero voltmeter reading means that no current is flowing and that the field coils are grounded INTERNALLY (at the generator).

Internally grounded field coils mean that this is a "B" CIRCUIT generator.

Press A — 34

2-33

34

OK.

If you want to determine the type of circuit, but find the generator in an awkward position to test, you may perform the test at the generator regulator.

The test at the regulator is similar to the test at the generator, but the results mean different things.

Press A — ~~35~~ 36

x (C) — 35

2-34

35

OK. No voltage reading means internally grounded field coils (a "B" circuit generator).

Since you have had trouble with one or more of the questions, let's have a brief review of how to identify "A" and "B" circuits at the generator.

When you answer all the questions correctly we'll see how to test for circuit type at the regulator.

Press A — 18

2-35

36

To perform the test for type of circuit at the regulator:

1. Disconnect the field lead from the regulator field terminal. Do not allow this lead to touch ground!
2. Connect a voltmeter or test lamp between the regulator field terminal and ground.
3. Operate the vehicle at fast idle and note whether you DO or DO NOT get a voltage reading (light or NO light with the test lamp).

Press A — 37

2-36

37

When you are testing for type of circuit at the regulator:

If you DO NOT get a voltage reading, the regulator is an "A" circuit regulator.

A voltage reading indicates a "B" circuit regulator.

If you test for circuit type at the regulator and get a ZERO reading, you have ______ circuit regulator.

A. an "A" — 39
B. a "B" — 38

2-37

38

You are incorrect.

When testing for type of circuit at the regulator, a zero voltmeter reading means that the regulator field terminal is GROUNDED. This indicates that the generator field coils are grounded AT THE REGULATOR (EXternally with respect to the generator).

Externally grounded field coils mean that this is an "A" CIRCUIT.

Press A —39

2-38

39

OK.

During a test for type of circuit, the serviceman obtained a voltmeter reading between the regulator field terminal and ground. From these results he may conclude that the generator field coils are grounded ___(1)___ and that he is testing ___(2)___ circuit.

A. (1) internally (2) an "A" — 40
B. (1) internally (2) a "B" — 42
C. (1) externally (2) a "B" — 40
D. (1) externally (2) an "A" — 41

2-39

40

Only part of your answer is correct.

In the test for type of circuit at the regulator:

If you DO obtain a voltage reading it means that the regulator field terminal is INSULATED. This, in turn, means that the generator field coils are grounded back at the generator (INternally grounded field coils).

When the field coils are grounded internally you have a "B" CIRCUIT.

Press A —42

2-40

41

Both parts of your answer are incorrect.

We said that the serviceman DID obtain a voltage reading while testing at the regulator.

A voltage reading between the regulator field terminal and ground indicates that the field terminal is INSULATED (current is flowing through it). This means that the generator field coils are grounded INTERNALLY (back at the generator).

Internally grounded field coils mean that he is testing a "B" CIRCUIT. Press A —42

2-41

42

OK.

You can determine the type of circuit by testing either at the generator or at the regulator.

If you happen to be testing an "A" circuit, you will obtain a ZERO voltage reading between the _______ field terminal and ground.

A. regulator —44
B. generator —43

2-42

43

You are incorrect.

A ZERO voltmeter reading indicates that the field terminal you are testing is GROUNDED.

In an "A" circuit system the field is grounded externally (outside the generator). This means that in an "A" circuit, the field coils are grounded at the regulator. You will obtain a ZERO voltage reading between the REGULATOR field terminal and ground.

Press A —45

2-43.

44

OK. Here is a brief outline of the tests. You may want to copy this chart for later reference.

TEST FOR TYPE OF CIRCUIT
(FIELD LEAD DISCONNECTED; METER OR TEST LAMP BETWEEN FIELD TERMINAL AND GROUND)

	AT GEN	AT REG	
LIGHT OR VOLTAGE READING ?	YES	NO	"A" CIRCUIT
	NO	YES	"B" CIRCUIT

If you would like to review both these tests, press A. —18.
Press B if you want to review only the test at the regulator. —34 If you want to go on to new material, press D. —46

3-44

X(C) - 45

45

OK. An "A" circuit will show a ZERO voltage reading when the test is made at the regulator.

Since you have had trouble with a question or two, we'll have a review of the test for type of circuit at the regulator.

Press A if you also want to review the test at the generator. —18

Press B if you want to review only the test at the regulator.

—34

2-45

46

There are four general types of electrical malfunctions which can occur in automotive electrical systems. The effects produced by these malfunctions vary, as do the means by which they are identified.

The four types of electrical malfunctions are:

1. Short circuits
2. Open circuits
3. Grounded circuits
4. Circuits with abnormally high resistance

Press A — 47

3-46

47

A SHORT CIRCUIT is an undesired connection that permits current to bypass part of the system. A short circuit in the generator armature will cause decreased generator output. Shorts in the field circuit cause abnormally high current draw.

A short circuit may be thought of as an undesired copper to ____________ connection.

A. copper — 49
B. iron — 48

3-47

48

You are incorrect.

Copper is the material used for the wiring in electrical circuits. An undesired COPPER to COPPER connection in a circuit decreases the distance current must flow -- it allows the current to follow an undesired shorter path. This is why it is called a short circuit.

Press A — 49

3-48

49

OK.

An OPEN CIRCUIT is an undesired break in the continuous path along which current is supposed to flow. An open circuit causes extremely high resistance. Normally no current will flow in an open circuit. Open circuits can occur in the generator armature windings, in the field circuit or in the external load circuits.

A test lamp placed across the field coil leads in a generator __________ light if there is an open circuit in the field windings.

A. will — 50
B. will not — 51

3-49

50

Incorrect.

Remember that normally no current will flow in an open circuit. A test lamp connected across the field coil leads of a generator WILL NOT light if there is an open circuit in the field windings.

Press A — 51

3-50

51

OK.

A GROUNDED CIRCUIT is an undesired connection between the insulated and grounded sides of a circuit which permits current to bypass part or all of the circuit. Increased current flows between the undesired ground and the electrical source. No current flows in the bypassed portion.

A grounded generator armature causes decreased generator output at all speeds.

A grounded circuit may be thought of as an undesired copper to __________ connection.

A. copper — 52
B. iron — 53

3-51

52

No. We said earlier that an undesired copper to copper connection is a short circuit.

Most electrical system components are grounded directly or indirectly by connection to the vehicle frame. In a grounded circuit, an undesired COPPER TO IRON connection occurs somewhere before the normal ground of the circuit. This decreases the distance that current flows, much the same as in a short circuit.

Press A — 53

3-52

53

OK.

A circuit with ABNORMALLY HIGH RESISTANCE contains a source that causes total circuit resistance to increase beyond the designed limit. Common sources of high resistance in automotive electrical systems are loose connections, corroded wires or terminals, frayed or broken wires, burned or oxidized contact points and burned brushes or commutator bars.

High resistance causes higher ___(1)___ and lower ___(2)___.

A. (1) current (2) voltage — 54
B. (1) voltage (2) current — 55

3-53

54

Incorrect.

In our discussion of voltage and current regulators in "DC Generators I", we said that voltage will tend to climb as high as necessary to overcome any resistance it meets. Current flow, on the other hand, is retarded by high resistance.

High resistance then, leads to increased VOLTAGE and decreased CURRENT flow.

Press A — 55

3-54

55

OK. Excessive resistance in the battery charging circuit causes abnormally high generator voltage and abnormally low current output to the battery.

Excessive resistance may occur either in the insulated side of the charging circuit or in the grounded side. The test procedures differ slightly for the two sides of the circuit.

Let's begin with the test for excessive resistance on the insulated side of the charging circuit.

Press A — 56

3-55

56

In order to test for excessive resistance in the charging circuit you will need three pieces of equipment -- an ammeter, a voltmeter, and a generator field control unit.

To test the insulated side of the charging circuit; the test equipment is connected as shown in Plate III (a). Disconnect the battery lead from the regulator BAT terminal and hook the ammeter between the disconnected lead and the terminal. Connect the voltmeter between the generator armature terminal and the INSULATED battery post. Connect the field control unit between the generator and regulator field terminals. Press A — 57

3-56

57

The engine should be operated at fast idle. The generator field control unit should be adjusted until the generator charges at 20 amps. It may be necessary to turn on vehicle lights to obtain that amount of current flow.

Check the voltmeter when the charging current reads a steady 20 amps. If the voltmeter reads MORE THAN eight-tenths of a VOLT, there is excessive resistance somewhere in the circuit. Each component will have to be checked separately to locate the source of the high resistance.

Press A — 58

3-57

58

To test the insulated side of the charging circuit for excessive resistance, the field control unit must be adjusted until the generator charges at ___(1)___ amps. Then if the voltmeter reads more than ___(2)___ volt (s), there is excess resistance in the insulated side of the circuit.

A. (1) eight (2) two-tenths — 59

B. (1) two-tenths (2) eight — 59

C. (1) twenty (2) eight-tenths — 60

3-58

59

You are incorrect.

To test the insulated side of the charging circuit, the correct charging rate is twenty (20) amps. The field control unit must be adjusted until generator output reaches that value.

At 20 amps charging rate, if the voltmeter indicates MORE than eight-tenths (0.8) volt, then there is excessive resistance somewhere in the insulated side of the circuit.

Press A — 60

3-59

60

OK.

Plate III (b) shows the instrument hookup for testing the grounded side of the charging circuit.

Note that the connections for the ammeter and the field control unit are the same. But the position of the voltmeter has changed. To test the grounded side of the circuit, the voltmeter is connected between the grounded battery terminal and ground on the generator frame.

Press A — 61

3-60

61

Again the engine is operated at fast idle and the field control unit is adjusted for a 20 amp charge rate. On the grounded side of the charging circuit, if the voltmeter reads MORE THAN 0.1 VOLT, there is excessive resistance somewhere in the grounded side of the circuit.

Maximum allowable total circuit voltage in the insulated side of the circuit is ____________ volt.

A. 0.20 — 62

B. 0.8 — 63

C. 0.1 — 62

3-61

62

You are incorrect.

The charging rate must be adjusted to 20 amps for testing either the insulated or the grounded side of the charging circuit.

The maximum allowable total circuit voltage for the INSULATED side is 0.8 VOLT.

Press A — 63

3-62

63

OK.

The maximum allowable total circuit voltage on the grounded side of the charging circuit is __(1)__ volt.

The generator charging rate for the tests is __(2)__ for each side of the circuit.

A. (1) 0.8 (2) the same — 64
B. (1) 0.8 (2) different — 65
C. (1) 0.1 (2) the same — 66

3-63

64

Only part of your answer is correct. The generator charging rate is the same for both the test on the insulated side and the test on the grounded side -- 20 amps.

But you said that the maximum allowable total circuit voltage on the grounded side is 0.8 volt. That is incorrect.

On the grounded side the maximum allowable voltage is ONE-tenth (0.1) VOLT.

Press A — 66

3-64

65

Both parts of your answer are incorrect.

The generator charging rate must be adjusted to 20 amps for either the test on the insulated side or the test on the grounded side. The charging rate is THE SAME for each -- 20 amps.

The maximum allowable total circuit voltage for the insulated side is 0.8 volt. For the GROUNDED side of the circuit the maximum allowable voltage is ONE-tenth (0.1) volt.

Press A — 66

3-65

66

OK.

Excessive resistance in the charging circuit can cause damage to the generator, the regulator, or the battery. The low current output to the battery also can lead to a severely undercharged condition.

If you would like to review the four types of electrical malfunctions and the tests for excessive resistance in the charging circuit, press A. — 46

Otherwise, press B. — 68

X (C) - 67

3-66

67

OK. Maximum allowable voltage for the grounded side of the circuit is 0.1 volt; for the insulated side. 0.8 volt. The charging rate during the two tests is the same -- 20 amps.

Since you had some difficulty with a question or two in this section, let's review the four types of electrical malfunctions and the tests for excessive resistance in the charging circuit.

Press A — 46

3-67

68

DC GENERATOR TESTING AND TROUBLESHOOTING

If a generator output test shows that no current is being generated, a systematic check of the generator (and regulator) will be necessary to locate the trouble.

If the generator is equipped with a cover band, remove the cover and examine the brushes, the commutator and the internal connections.

If the cover band inner surface is speckled with dots of solder, this indicates that the generator has been severely overloaded and the connections at the commutator bars have melted.

Press A — 69

4-68

69

Overloading can also cause the varnish insulation around armature windings to burn through. If this happens, current may be able to jump from one armature winding to another.

If soldered connections are melted away between the armature windings and commutator bars, this will cause __(1)__ circuits. Current jumping from one exposed armature winding to another causes a __(2)__ circuit.

A. (1) short (2) open — 70
B. (1) open (2) short — 71

4-69

70

Incorrect.

Only if the melted solder runs down onto the commutator bars and forms a direct path between them would short circuits result. Connections which are completely melted through create breaks in the continuity of the series-wound armature windings. A break in the continuous path of a circuit is an OPEN circuit.

When current is able to jump from one armature winding to another due to burned insulation, it creates an undesired copper to copper connection -- a SHORT circuit.

Press A — 71

4-70

71

OK.

If the generator brushes are seated properly and are making good connection with the commutator, the trouble may not be apparent. Then it is necessary to use a test lamp to locate the source of reduced generator output.

Press A — 72

4-71

72

Begin by testing the generator for GROUNDS (undesired copper to iron connections). To perform this test, disconnect the leads from the generator terminals. Then insert a piece of paper between the grounded brush and the commutator.

If the generator is a "B" circuit type, it also is necessary to disconnect the field ground lead before making the test. This will prevent false interpretation of the test for grounds.

Press A — 73

4-72

73

The test lamp should be connected between the insulated brush ("A" terminal) and the generator frame.

If the lamp lights, it indicates that there is an undesired ground in the field circuit.

If you are testing a "B" circuit generator and DO NOT disconnect the field ground lead, the lamp will light ________________________.

A. only if there is an undesired ground in the field circuit — 74

B. whether there is an undesired field circuit ground or not — 75

4-73

74

Incorrect.

In order to test the generator for grounds, it is first necessary to insulate the generator completely. This is done by inserting a piece of paper between the grounded brush and the armature in both "A" circuit and "B" circuit generators.

But with "B" circuit generators, the field ground lead must also be disconnected. Otherwise, the field circuit would still be grounded, and the test lamp would light even if NO undesired ground were present.

Press A — 75

4-74

75

OK. The entire generator must be insulated in order to make an accurate interpretation of the test results. The location of the ground can be pinpointed by insulating all the brushes and then checking the brush holders, armature, commutator and field coils separately.

To test the generator for grounds, the test lamp is connected between the insulated brush and ___(1)___. If there is an undesired ground, the lamp ___(2)___ light.

A. (1) the generator "F" terminal (2) will not — 76

B. (1) the generator "A" terminal (2) will not — 76

C. (1) the generator frame (2) will — 77

4-75

76

You are incorrect.

To perform the test for grounds in the generator, the test lamp must be connected to the insulated brush and to the GENERATOR FRAME (which is grounded).

The generator terminal leads should already be disconnected. An undesired ground in the generator WILL cause the lamp to light.

Press A — 77

4-76

77

OK. As long as the generator is properly insulated, a lighted test lamp indicates that there is an undesired ground in the generator.

If you find that the field coils are the source of the undesired ground, it will be necessary to check the regulator contact points. A grounded field may have caused excessive field current, which could have burned the points. Burned points should be cleaned or replaced as necessary.

Press A — 78

4-77

78

If you find that the generator is NOT grounded, you may then test the field circuit for OPEN CIRCUITS.

The test for open field circuit is also performed with a test lamp. The test lamp connections are different for "A" circuit and "B" circuit generators.

On "A" circuit generators, the lamp is connected between the generator armature terminal and the field terminal.

For "B" circuit generators, connect the lamp between the field terminal and ground.

Press A – 79

4-78

79

If the test lamp DOES NOT light, it indicates that the field circuit is OPEN at some point.

A lighted test lamp indicates that the circuit is continuous and unbroken.

In the test for open field circuit, one test lamp probe is connected to the generator field terminal in both "A" and "B" circuit generators. The other probe is connected to __(1)__ for "A" circuit generators, or to __(2)__ for "B" circuit generators.

–80 A. (1) ground (2) the armature terminal

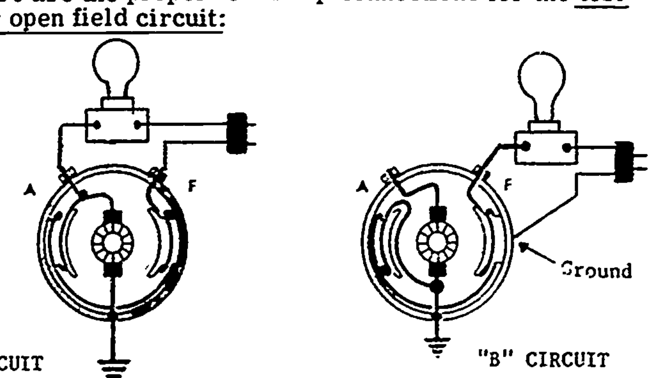
–81 B. (1) the armature terminal (2) ground

4-79

80

You have the correct answers reversed.

Here are the proper test lamp connections for the test for open field circuit:



"A" CIRCUIT "B" CIRCUIT

Press A –81

4-80

81

OK.

In the test for open field circuit, the test lamp __________ light if there is a break somewhere in the field circuit.

A. will not – 83

B. will – 82

C. I'm not sure. – 79

4-81

82

No.

The test lamp WILL NOT light if there is an open field circuit.

Remember that an open circuit is a break in the continuous path which current normally follows. With an open circuit the path is NOT continuous, so no current flows through the test lamp.

Press A – 83

4-82

83

OK. A test lamp will not light if there is an open circuit in the field. A lighted test lamp indicates a continuous circuit but it DOES NOT indicate a SHORT circuit.

If the field circuit is not open, the trouble may be a SHORT circuit in the field. To test for a shorted field circuit, it is necessary to connect a battery of specified voltage and an ammeter IN SERIES with the field coils.

Press A – 85 X (C) –84

4-83

84

OK. The test lamp will NOT light if there is an open circuit in the field.

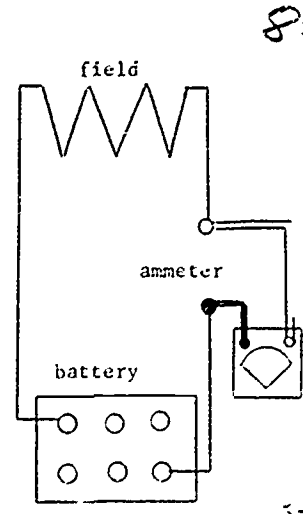
Before we discuss SHORTED field circuits, let's have a quick review of the tests for grounds and opens. When you answer all the questions correctly, we'll see how to test for short circuits in the field.

Press A – 68

4-84

85

Care must be taken during the test not to allow the field coil leads to be grounded, as this could cause increased current draw and simulate a short circuit when none is actually present.



Check manufacturer's specifications for the proper current value. If the ammeter reads MORE than this value, new field coils should be installed.

Press A – 86

4-85

86

If a short is present in the field circuit, an ammeter (hooked in series with a battery and the field coils) will read ___(1)___ than the manufacturer's recommended value. This indicates that the regulator contact points should also be checked, for they may be ___(2)___ .

A. (1) lower (2) out of adjustment — 87

B. (1) higher (2) burned — 88

5-86

87

Incorrect.

When a short circuit occurs, part of the circuit is bypassed. This causes increased current to flow in the rest of the circuit. Increased current results in a HIGHER ammeter reading.

Increased current in the field circuit due to a short may cause the regulator contact points to BURN.

Press A — 88

5-87

88

OK. If the field coils are shorted, they should be replaced. Burned regulator contact points should be cleaned or replaced as necessary.

If you are unable to discover the reason for no generator output by any of the tests we have discussed so far, it will be necessary to test the armature also. The armature is subject to the same malfunctions as the field circuit.

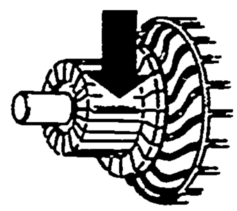
Press A — 89

5-88

89

It may be possible to detect open circuits in the armature visually. One or more commutator bars may be badly burned and pitted due to an open circuit in the armature windings they serve. Severe arcing between the commutator bar and the brushes causes the burned condition.

If the open circuit has occurred at a soldered connection it may be repairable. Otherwise it is advisable to replace the armature.



Press A — 90

5-89

90

If visual signs of an open circuit in the armature are not obvious, you may test the armature for opens with a test lamp.

Touch one test lamp probe to a single commutator bar (making sure there is good contact). Then touch each successive commutator bar with the other test lamp probe.

If you come to a winding in which there is an OPEN circuit, the test lamp ________ light.

A. will not — 92

B. will — 91

5-90

91

Incorrect.

The test lamp will light as long as the circuit is continuous. If there is an OPEN circuit in a particular armature winding, the test lamp WILL NOT light.

Remember that in an open circuit, the current path is broken and no current will flow through the test lamp.

Press A — 92

5-91

92

OK.

If an open armature winding is not the problem, you can test the armature for undesired grounds. This test is also performed with the test lamp.

Touch one test lamp probe to a section of armature core or to the shaft, and the other probe to any commutator bar. (See Plate IV.)

If there is an undesired ground in the armature, the test lamp ________ light.

A. will — 94

B. will not — 93

5-92

93

Incorrect.

You may recall that in the test for grounded field coils, a lighted test lamp indicates that an undesired ground IS present.

The same is true in the test for grounds in the armature. An undesired ground in the armature completes a circuit and causes the lamp to light.

Press A — 94

5-93

94

OK. A lighted test lamp means a grounded armature. The armature should be replaced if a ground is present.

* * * * *

A generator armature is tested for SHORT circuits by placing it in a growler. The growler passes a magnetic field through the armature.

The armature should be rotated slowly in the jaws of the growler, while a short piece of steel (a hacksaw blade, for example) is held 1/4 to 1/2 inch above each successive section of armature core. (See Plate V.)

Press A — 95

5-94

95

If the piece of steel vibrates rapidly, then that section of the armature contains a short.

The short circuit may be in the armature windings themselves. If so, the armature should be replaced.

Shorts may also occur at the commutator bars, due to brush dust or copper forming a path between the bars. Under-cutting the mica insulation between the bars often will eliminate these shorts.

Press A — 96

5-95

96

In the growler test for short circuits in the armature, a short piece of steel held over an armature section ____________ vibrate as long as there is NO short in that section.

A. will — 97

B. will not — 98

5-96

97

You are incorrect.

As long as the piece of steel DOES NOT vibrate, it indicates that the armature is free of short circuits.

A short circuit in the armature causes the piece of steel to vibrate as the shorted section passes under it.

Press A — 98

5-97

98

OK.

In this portion of the film we have covered generator testing and troubleshooting.

If you would like to review the entire section on testing and troubleshooting, press A. — 68

If you want to review only the test for shorted field circuits and armature testing, press B. — 83

Otherwise, press D. — 100

6-98

X (C) — 99

99

OK. As long as the piece of steel does not vibrate, there is NO short circuit in the armature.

You have made an error or two on the questions in the second part of DC Generator Testing and Trouble-shooting. Let's have a quick review of the test for shorted field circuits and armature testing.

Press A — 83

5-99

100

POLARIZING THE GENERATOR

After a DC generator is tested or repaired it must be polarized. The generator must have correct polarity with respect to the vehicle battery.

The generator must be polarized BEFORE the vehicle engine is started! Failure to polarize the generator may result in damage to the generator itself, burned cutout relay contact points and/or a run down battery.

Press A — 101

6-100

101

The final step in any DC generator test or service procedure is to ______________.

A. make sure the brushes are properly seated — 102

B. check the adjustment of the generator drive belt — 102

C. polarize the generator — 103

6-101

102

Not quite.

The answer you chose is an important factor in assuring that the generator will produce sufficient current. But it is not the LAST step in generator testing and servicing.

The last step before turning on the vehicle engine is to POLARIZE THE GENERATOR.

Press A —103

6-102

103

OK.

The method of polarizing the generator depends on whether the system is "A" circuit or "B" circuit.

To polarize an "A" circuit generator, merely flash a jumper wire between the regulator GEN and BAT terminals. This causes a momentary current surge through the generator and polarizes it correctly.

Press A —104

6-103

104

To polarize a "B" circuit generator:

1. Disconnect the generator field lead from the regulator FIELD terminal.
2. Touch the disconnected field lead to the regulator BAT terminal.

This causes a surge of current which correctly polarizes the "B" circuit generator.

Press A —105

6-104

105

When polarizing an "A" circuit generator, the generator field lead ______________ be disconnected from the regulator field terminal.

A. should —106
B. should not —107

6-105

106

You are incorrect.

The generator field lead should NEVER be disconnected from the regulator field terminal when polarizing an "A" CIRCUIT generator.

If the vehicle has a double contact regulator and the field lead is grounded (purposely or accidentally), the upper set of contact points will be instantly burned!

Press A —108

6-106

107

OK. Never disconnect the generator field lead when polarizing an "A" circuit generator.

Accidental grounding of the field lead will cause instant burning of the upper set of points if the vehicle has a DOUBLE CONTACT regulator.

Press A —108

6-107

108

To polarize an "A" circuit generator, temporarily connect a jumper between the regulator ___(1)___ terminal and the regulator ___(2)___ terminal.

A. (1) battery (2) field —109
B. (1) generator (2) battery —110

6-108

109

Incorrect.

The regulator field terminal comes into the picture only when polarizing a "B" circuit generator.

To polarize an "A" circuit generator, flash a jumper between the regulator GEN and BAT terminals.

Press A —110

6-109

110

OK.

To polarize a "B" circuit generator, you disconnect the generator ___(1)___ lead from its regulator terminal, and touch that lead to the regulator ___(2)___ terminal.

A. (1) field (2) BAT — 112
B. (1) armature (2) FIELD — 111
C. (1) armature (2) GEN — 111

6-110

111

No.

It is the generator FIELD lead that is disconnected from its regulator terminal when polarizing a "B" circuit generator.

The disconnected field lead is touched to the regulator BAT terminal.

Press A — 112

6-111

112

OK.

The methods of polarizing "A" and "B" circuit generators given here are approved for most 6 and 12 volt systems, and will work whether the regulator is a single contact or a double contact type.

For polarizing generators in systems of more than 12 volts, consult manufacturer's directions.

For a quick review of generator polarizing, press A. — 100
Otherwise, press B. — 114

6-112

X (C) — 113

113

OK. Touch the disconnected generator field lead to the regulator BAT terminal to polarize a "B" circuit generator.

You missed a question or two, so let's quickly review generator polarizing.

Press A — 100

6-113

114

Congratulations. You have successfully completed this film, "Generator Testing Procedures".

We have attempted here to help improve your ability to diagnose some of the common problems that occur in DC generators.

Press REWIND

6-114

INSTRUCTOR'S GUIDE

Title of Unit: UNDERSTANDING DC GENERATOR PRINCIPLES (PART II)

AM 2-15
9/12/67

OBJECTIVES:

1. To review special generator circuits, how they are constructed and the reasons for their difference in design.
2. Review the automotive type DC generator testing procedures, mechanical problems, and polarizing procedures for different types of generators.

LEARNINGS AIDS suggested:

Visual Aids:
Delco-Remy Training Charts and Manual
No. 5133-E, Generators

Models:
Any generator components, armatures, pole shoes, field coils, voltage regulators, voltmeters, ammeters, variable resistance etc.

QUESTIONS FOR DISCUSSION AND GROUP PARTICIPATION:

1. How many different types of generators are used in automotive applications?
2. Is preventive maintenance necessary for DC generators? Why?
3. What is a common term used to define a short circuit?
4. What is a common term used to define a grounded circuit?
5. Name some of the conditions that may exist in a circuit where resistance is high.
6. Should information in generator specifications include such items as whether a generator is a type "A" or "B" circuit? Why?
7. What effect, if any, does temperature have on generator testing?
8. What instruments are necessary for testing generators? Why?

9. Are the meter connections made the same for testing "A" and "B" circuit generators? Explain.

10. What effect does the variable resistance have on generator voltage?

11. What is the probable condition of a generator if the voltage and current are obtained at a higher speed than specified?

12. A very low voltage reading from a generator whose voltage will not increase with speed of rotation often is caused by what condition?

13. What are some of the most common armature failures caused by?

14. An open circuited armature is easily identified by what visual sign?

15. What is a growler used for in testing generator armatures?

16. How is a test lamp used in testing armatures? What does it show?

17. What is meant by the term "under-cut the commutator bars"?

18. What causes the field strength to change in a generator?

19. How is the magnetic field strength controlled in generators?

20. A grounded field circuit has different effects upon generator output. Is the effect the same for "A" and "B" circuits? Explain.

21. Do a grounded field circuit and a shorted field circuit have the same affect, as far as generator output is concerned? Why?

22. What defect would be indicated by any deviation in current draw when testing field coils? (More or less than specified?)