training chart manual

SECTION e

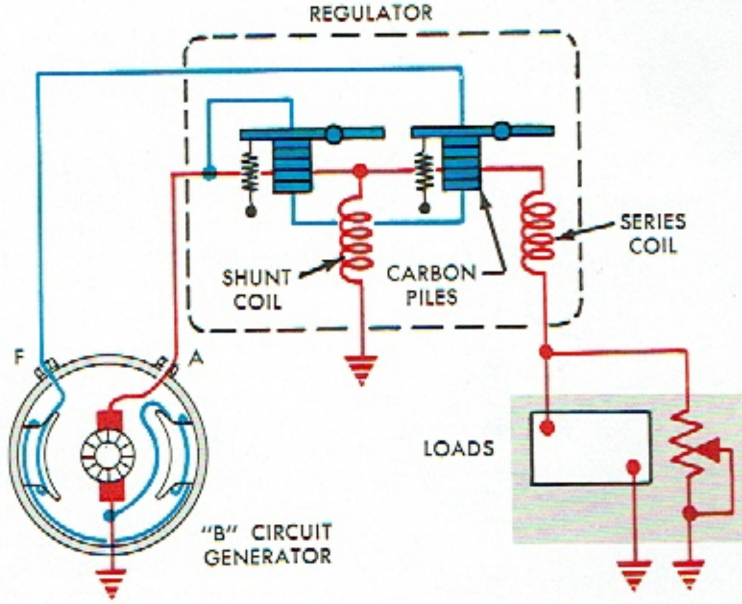
GENERATORS

DELCO-REMY · ANDERSON, INDIANA, U.S.A.
DIVISION OF GENERAL MOTORS CORPORATION

GENERATORS AND CARBON PILE REGULATION

One of the early methods of generator control was by means of the carbon pile regulator. In this type of regulation, the principle of controlling the generator by placing a resistance in series with the field circuit is the same as that for the vibrating point type.

This illustration shows the circuits of a generator regulated by a carbon pile. The similarity to the vibrating point regulated generator should be noted. The carbon stacks in series with the field coil circuit is really the only basic difference.



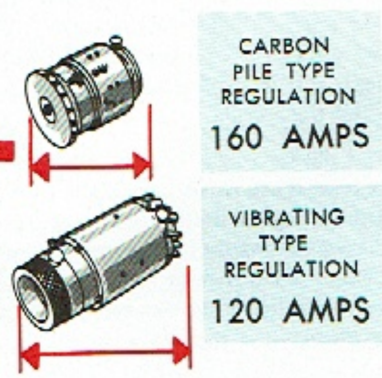
The stack of carbon discs has a very simple electrical characteristic. When it is compressed tightly, its resistance is extremely low. Spring pressure on the armature compresses the stack decreasing the resistance which is placed in series with the field circuit when the generator is first starting to build up voltage and delivered current.

When the stack is not compressed tightly, its resistance is relatively high. When the generator is at operating speeds and loads, the magnetic fields around the "sensing" coils of the regulator pull on the respective armatures and decrease the pressure on the carbon stacks. This raises the resistance in series with the field coil circuit to a higher value thereby decreasing the amount of field coil current and voltage developed in the generator.

Since the carbon stacks do not vibrate and since no arcs are present to burn the carbon discs, there is no limitation, except for heat, on the amount of field current that can be handled by the carbon pile regulator.

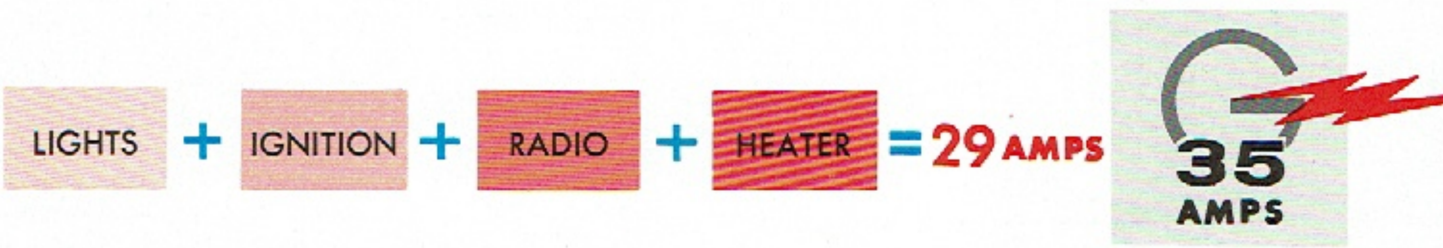
The engineer and designer can, therefore, use this higher field coil current to develop a stronger magnetic field between the poles. Consequently, a much smaller generator can be made which is capable of handling high outputs. With stronger magnetic fields in the generator, less conductors in the armature are needed. Thus, less heat is developed within the generator.

Use of the carbon pile regulator is restricted to specialized services, however, because of its higher cost and because of the narrow range of field resistance that can be used. Vehicles requiring high output generators located in a small space, and vehicles requiring electrical units with a long life with little servicing use this type of charging system. Military tanks and large inter-city busses are examples of applications that use this type of equipment.



APPLICATION OF GENERATORS TO THE JOB

The final selection of a generator that will adequately do the job required of it depends upon many factors. The engineer and designer must analyze carefully each factor and the success of their analysis is proven in the ability of the generator to do its job. The best designed generator will, however, not do its job unless proper maintenance and operating conditions are controlled during the use of the generator.



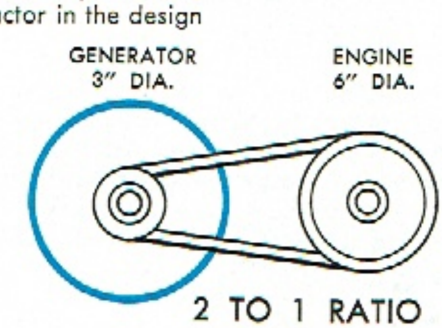
The normal electrical load on a vehicle determines the capacity of the generator to be used. A satisfactory application requires a generator that can produce 10 to 20 per cent more output than is required by the total connected load. This additional output is required to replace the electrical energy used from the battery when the generator is not at operating speed. Momentary electrical loads, such as cigar lighters or cranking motors are not considered in determining the total load.

Extremely dirty, dusty, muddy or wet operating conditions often make it necessary that the generator be totally enclosed to prevent entry of foreign material. Total enclosure does not allow ventilation through the generator, consequently the build-up of internal heat is high. The output of an enclosed generator, therefore, must be less than a ventilated unit of the same size.

The ambient or surrounding temperatures in which a generator must operate may also be an important factor in generator design. High temperature surrounding the generator adds to the heat developed by current passing through the armature conductors and by eddy currents. The generator must be designed to withstand the total heat of operation.

The length of service that is to be expected of the generator must be a part of the generator design also. Ease of replacement of parts is another factor in the design of such units.

The speed at which the armature turns is a very critical factor in generator design and application. The drive ratio of an automotive generator (generator speed with reference to engine speed) may vary from 2 to 1, to as high as 3 to 1.



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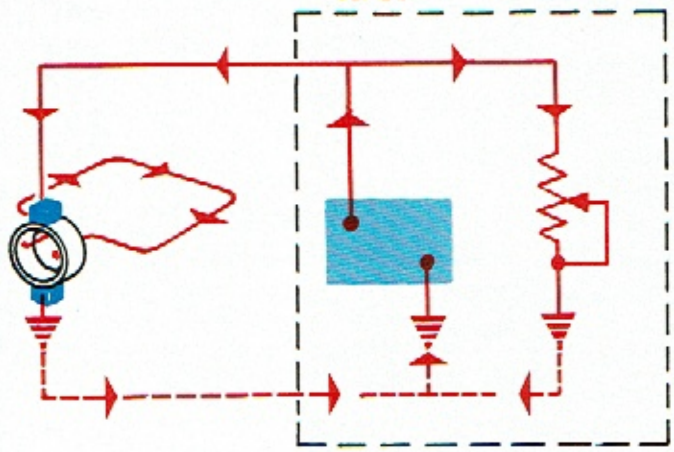
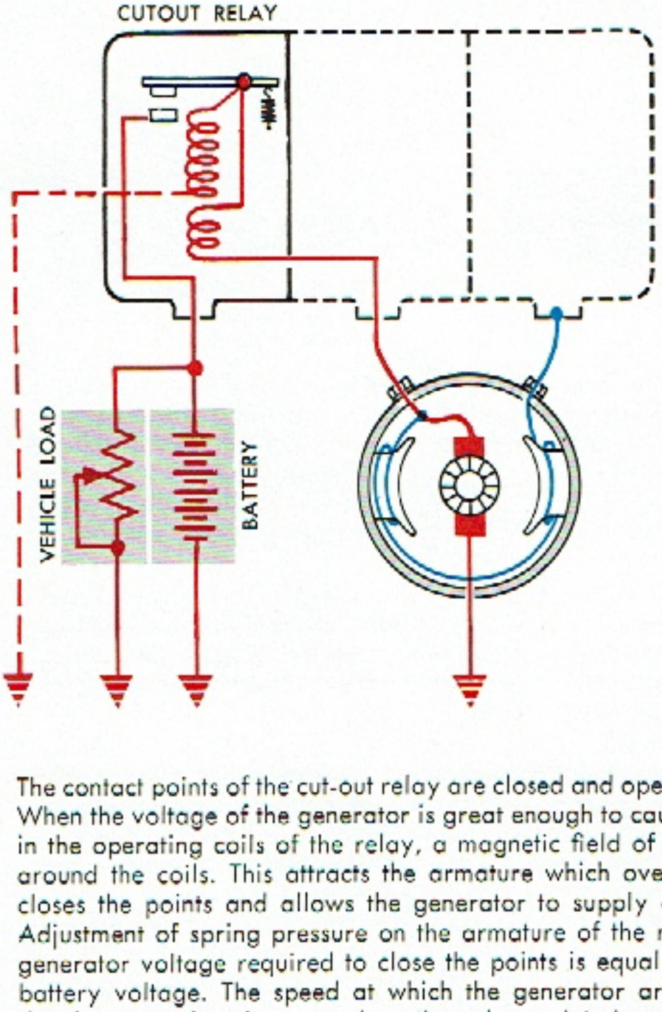


Illustrated is the load circuit only. If the connections between the generator and the battery were joined as shown and the generator voltage is lower than battery voltage, the battery would discharge through the generator to ground and back to the battery. Due to low resistance in such a circuit, high discharge current would produce rapid deterioration inside the generator in the form of burned insulation and wiring. This would also result in a discharged battery.



This illustration shows how the load circuit is broken by an electrical switch to prevent the battery discharge. The normal position of the switch, called the cut-out relay, is shown. It functions to close the circuit between the generator and battery when the generator has developed sufficient voltage to overcome battery voltage. The cut-out relay also functions to open the circuit between the battery and generator when the battery voltage is greater than generator voltage. This condition exists only when the speed of the armature is not sufficient to develop enough voltage to overcome battery voltage. The engine in an "at-rest" position with the vehicle parked, the engine at idle speeds, or at low operating speeds are all conditions where the cut-out relay is open unless the generator is designed to develop voltage greater than battery voltage under these conditions.

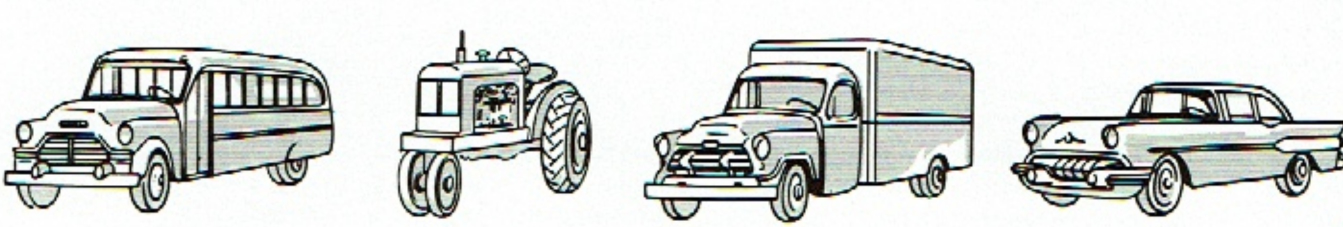
The contact points of the cut-out relay are closed and opened by magnetic attraction. When the voltage of the generator is great enough to cause a certain current to flow in the operating coils of the relay, a magnetic field of sufficient strength is set up around the coils. This attracts the armature which overcomes spring tension and closes the points and allows the generator to supply current to the load circuit. Adjustment of spring pressure on the armature of the relay must be such that the generator voltage required to close the points is equal to or slightly greater than battery voltage. The speed at which the generator armature must be turning to develop enough voltage to close the relay points is called the "cut-in speed" of the generator.

When the voltage of the generator drops because of a reduction in speed to a value less than battery voltage, the higher voltage of the battery will force current back through the series coil of the regulator and the generator. Reversing the direction of current in the series coil causes the magnetic field of the relay to weaken allowing spring tension to open the points of the relay. The generator and battery are then disconnected so that current discharge from the battery will not flow back through the generator and damage it.

It is important that the speed at which the generator "cuts-in" should be at least 100 r.p.m. above or below the engine idle speed. The drive ratio chosen must assure that this condition exists; otherwise, burned out relay points caused by rapid vibration of the contact points will result. Since no engine idles at a constant speed, it has a certain variance in speed when idling. If the cut-in speed of the generator occurs at the exact speed of idling, the points of the relay will close when idle speed is reached. When the engine speed decreases the generator speed will also decrease. Insufficient voltage will be developed to hold the relay points closed and the points will open. Thus, the change in generator speed at this critical point will cause the relay to open and close and the points will be burnt from breaking the circuit repeatedly. Changing pulleys to speed up the generator in an attempt to get a charge rate at engine idle often causes this condition. A smaller drive pulley on the generator may cause trouble by driving the generator so fast at high engine speeds that the regulator cannot control the voltage. A generator driven at excessively high speeds may also develop bearing failures or the armature windings may be thrown from the core by excessive centrifugal force.

The drive ratio between the pulley and the generator, therefore, is quite critical. Generators must be designed for certain speed and load characteristics. Vehicles operating at slow engine speeds with high electrical loads require a generator with low cut-in to keep the battery in a charged condition, whereas, vehicles operating at high engine speeds and high electrical loads do not require a low cut-in generator. Vehicles operating normally at low engine speeds but with periods of high speed operation require a low cut-in generator capable of withstanding high speeds.

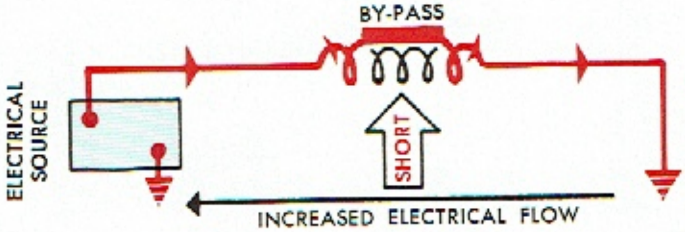
The proper application of a generator, therefore, depends upon many factors. The electrical needs of the vehicle determine the requirements of generator design. Changing conditions for driving such as more congested city traffic or faster operation on the open highway, change in the designs of engines that produce higher speed engines and higher ambient temperatures or increasing the electrical loads by adding air-conditioning systems, bigger heater blowers, seat controls, etc. require that generator design and application keep pace with the times to provide a unit that is capable of doing the job.



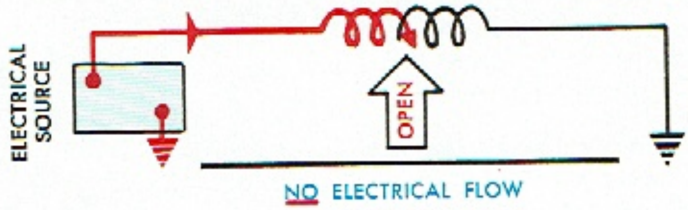
GENERATOR TESTING

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.

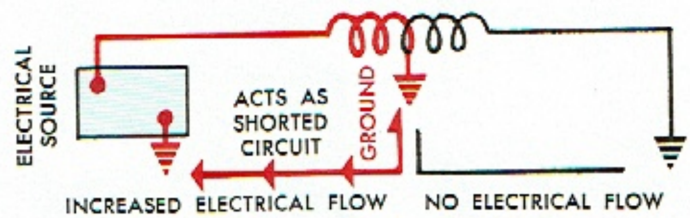
Basic electrical malfunctions can be classified into four groups: short circuits, open circuits, grounded circuits and circuits with abnormally high resistance.



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 any 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.

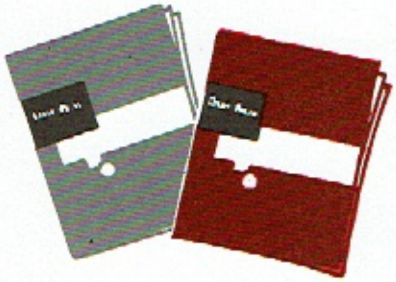
CAUSES OF HIGH RESISTANCE

A circuit with abnormally high resistance is, as the name implies, one containing resistance of a nature that increases the total resistance of the circuit. Poor or loose connections, corroded connections, and frayed or damaged wires are examples of conditions causing high resistance.

POOR OR LOOSE CONNECTIONS — CORRODED CONNECTIONS — DAMAGED WIRES

The following pages are 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.

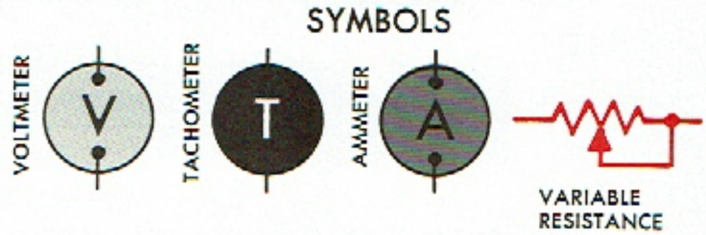
TESTING GENERATOR OUTPUT



DR-324S DR-324S-1
REFERENCE TEXTS

Published specifications for all generators manufactured by Delco-Remy are found in booklet DR-324S and its supplement, DR-324S-1. Review of these booklets 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. Variations in temperature or brush seating may cause deviations of as much as 100 r.p.m. or more from rated speeds. Any inaccuracies in test meters or other test equipment will, of course, also give false information regarding the generator.

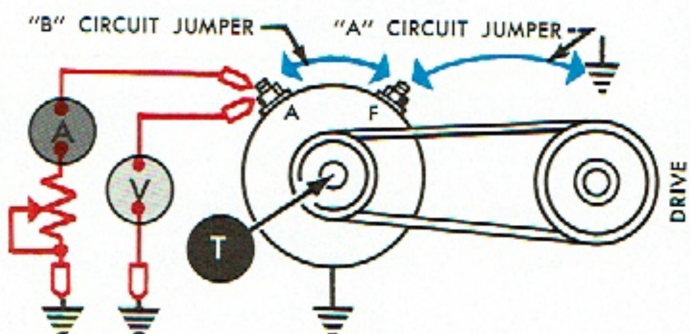
To conduct a generator output test, some means must be provided for driving the generator. It is also necessary to have a voltmeter, an ammeter, a tachometer and a variable resistance unit capable of safely handling the voltage and current involved.



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. 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.



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.

Increase generator speed until the current flow of the circuit is that which is specified in the specification booklets DR-324S or DR-324S-1. 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.

CONTINUED

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 speed lower than that specified, it indicates that the generator is in good electrical condition.

Voltage and current obtained at a higher speed than specified, indicates that the generator is in poor or unsatisfactory electrical condition. 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 following chart lists the possible disorders. A check of each part will be necessary to determine which component or combination of components is defective.

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

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.

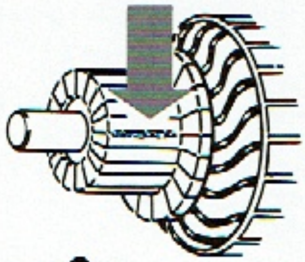
ARMATURE TESTING

As stated before, the four 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.

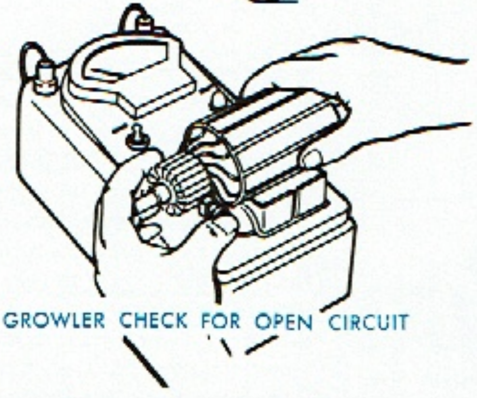
An armature winding with an open circuit will cause severe arcing between the brush and the commutator. Since all the loops of the armature are connected in series, an open circuit in one winding reduces the current paths in the armature by one-half in a two-brush generator. This means the brushes are 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 only develop 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.

VISUAL INDICATION OF
OPEN CIRCUIT IN ARMATURE



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. Severe arcing of the generator can easily be seen during operation.



GROWLER CHECK FOR OPEN CIRCUIT

Some test equipment manufacturers provide an armature testing machine called a "growler". Some growlers include an attachment used to locate the open circuit in an armature. Replacement or re-winding of an armature with an open circuit is required for proper generator repair.

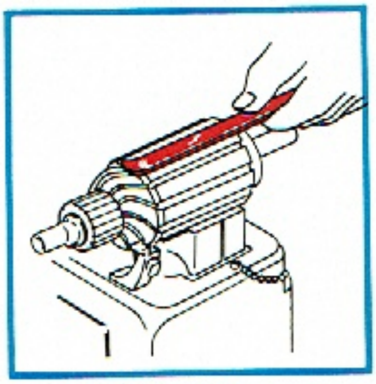
A short circuited armature will cause a decrease in generator output at any speed. An output test will disclose that specified current and voltage are obtained at higher than rated speed.

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 to 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.

CONTINUED

ARMATURE TESTING

An armature with shorted armature windings is identified by a "growler" check. The armature is placed in the oscillating magnetic field of the "growler." The moving field cuts across the loops of the armature. Voltage is developed causing current flow in the complete 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. Replacement or re-winding of the short circuited armature is required for proper generator repair.

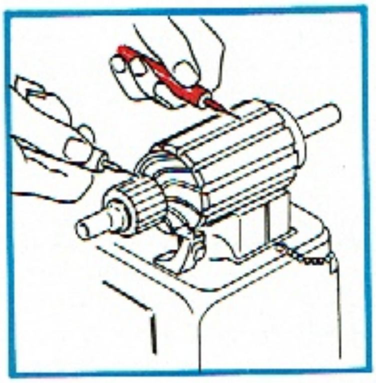


GROWLER CHECK
FOR SHORT CIRCUIT

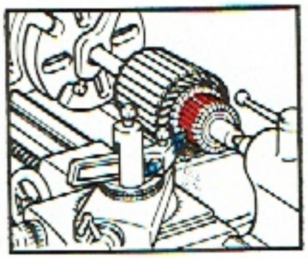
An armature with a grounded circuit will cause decreased generator output at any speed. A generator output test will disclose that specified current and voltage can be obtained only at a higher than rated speed.

This type of 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 grounded portion of the circuit now by-passes 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. When there is a good solid connection, no voltage is developed in the generator.

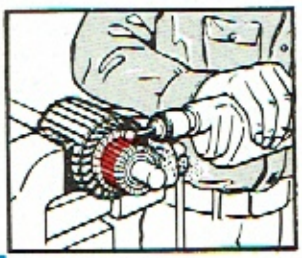
An armature with a grounded circuit is identified by a test lamp. If one prod of a test lamp is placed on a copper portion of the armature and the other prod is placed on the iron portion of the armature, the test lamp will light if the armature is grounded, in which case the armature must be either replaced or repaired. If the armature is not grounded, the test lamp will not light.



TEST LAMP CHECK
FOR GROUND CIRCUIT



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 loops of the armature. A heavy corrosion or film on the commutator bars can successfully insulate the commutator from the brushes prohibiting 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 or 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.