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UNIVERSAL TECHNICAL INSTITUTE

PHASE 17 - DIESEL ELECTRICITY

LIST OF LAB PROJECTS

INSTRUCTOR____________________

STUDENT'S NAME____________________

								TEST BATTERY WITH HYDROMETER.
								PERFORM LOAD TEST ON BATTERY.
								TEST BATTERY WITH SUN 421 TESTER.
								CLEAN AND SERVICE BATTERY.
								DIAGNOSE AND REPAIR AN ELECTRICAL CIRCUIT.
								USE AMMETER TO TEST CURRENT FLOW.
								USE OHMMETER TO TEST RESISTANCE.
								USE VOLTMETER TO PERFORM VOLTAGE DROP TEST.
								TEST ELECTRICAL INSTRUMENT GAUGE CIRCUIT.
								CHECK FOR VOLTAGE DROP ACROSS ALL CONNECTIONS.
								DIAGNOSE AND REBUILD A STARTER.
								DIAGNOSE AND REBUILD A STARTER SOLENOID.
								TEST STARTER AND STARTER CIRCUIT ON VEHICLE.
								DRAW SCHEMATIC OF TRUCK ELECTRICAL SYSTEM.
								DIAGNOSE AND REBUILD AN ALTERNATOR AND TEST ON STAND.

ELECTRICAL TERMS

In order to expertly diagnose electrical system troubles, the tune-up specialist must understand the electrical terms commonly used. So that a student can readily grasp the meaning of these terms, a water analogy is used, comparing the movement of electricity through a wire to the flow of water through a pipe.

A CIRCUIT is a path through which current can flow. Current flows through a circuit much like water flows through a pipe. The principle requirement of any circuit is that it must form a complete path. In tracing circuits, it is important to start at the source of electric power, either the battery or the alternator, then follow the path of current flow through the components of the insulated circuit, and return to the source through the ground circuit. A circuit is NOT complete if the current cannot return to its source.

A CONDUCTOR is a material that will pass electrical current efficiently just as a clean pipe is a good conductor for water. The ability of a conductor to carry current not only depends upon the material used but also on its length, its cross-sectional area and its temperature. A short conductor offers less resistance to current flow than a long conductor. A conductor with a large cross section will allow current to flow with less resistance than a conductor with a small cross section. For most materials, the higher the temperature of the material, the more resistance it offers to the flow of electrical current.

An INSULATOR is a material that will not pass current readily. An insulator is used to prevent leakage of electrical current.

An AMPERE is a unit of measurement for the flow of a quantity of electrical current. In terms of water analogy, this would be compared to gallons.

A VOLT is a unit of measurement of electrical pressure, or electromotive force. Voltage is sometimes described as a difference of potential between the positive and negative terminals of a battery or generator. In terms of water analogy, this pressure would be compared to pounds per square inch. In order for current to flow through a circuit, voltage must be applied to the circuit.

An OHM is a unit of electrical resistance opposing current flow. Resistance varies in different materials and varies with temperature. In terms of water analogy, this resistance would be compared to a restriction in a pipe.

A WATT is a unit of electrical power, and is obtained by multiplying volts and amperes. As a point of interest, 746 watts are equal to one mechanical horsepower.

ELECTRICAL CIRCUITS

The symbol "E" represents Electro-Motive Force (Electron moving force) commonly referred to as VOLTS or electrical pressure.

The symbol "I" represents INTENSITY or current flow in AMPERES.

The symbol "R" represents RESISTANCE which is measured in OHMS. The symbol (Ω) for Omega, the last letter in the Greek alphabet, is used as the ohm symbol to avoid using the letter O which can easily be mistaken for the numeral 0 (zero).

In summation: E is volts; I is amperes; R is ohms.

The automotive electrical system is a combination of interrelated circuits. Many of the electrical components in a system have self-contained circuits. Diagnosing trouble will require a knowledge of where to look when certain conditions are indicated. The ability to trace a circuit will be of great value in pinpointing the difficulty.

SERIES CIRCUIT A series circuit is a circuit where there is only one path in which the current can flow. Any number of lamps, resistors, or other devices having resistance can be used to form a series circuit. The total resistance of a series circuit is the sum of the individual unit resistances. The more resistances that are added to the circuit, the higher will be the total resistance. Since there is only one path for current to flow in a series circuit, this means that all current must pass through each resistance in the circuit. If an opening occurs in any portion of a series circuit, the circuit will become inoperative. This will result in an incomplete circuit. A good illustration of this circuit is the old style Christmas tree lights. If one bulb burns out, it opens the circuit and the rest of the bulbs go out.

The current flow in a series circuit is controlled by the total resistance of the circuit and the voltage applied. The current flow (amperes) will be the same in all places in the circuit. If two ammeters are connected in different places in a series circuit, both ammeters will read alike. If more resistance is added to the circuit, the amperage will become less, and if resistance is removed from the circuit, the amperage will increase.

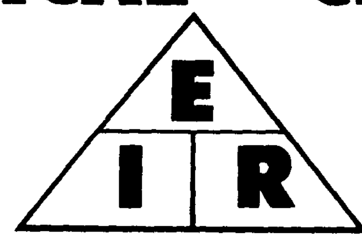
As voltage moves current through a resistor, some of the force is expended, resulting in a loss or drop in voltage. This "voltage drop" always accompanies current moving through a resistance. Therefore, in a series circuit, the total voltage will always equal the sum of the "voltage drop" across the individual resistance units. The total voltage or the voltage across each resistance can be measured with a voltmeter, and this method called "voltage drop test" is widely used to determine circuit conditions.

PARALLEL CIRCUIT The circuit that has **more than one** path for current is called a parallel circuit. Parallel resistances connected across a voltage source have the same voltage applied to each resistance. The resistance of the individual units may or may not be the same value. Since the current divides among the various branches of the circuit, the current through each branch will vary, depending upon the resistance of the branch. However, the total current flow will always equal the sum of the current in the branches. The total resistance of a parallel circuit is always less than the smallest resistance in the circuit. If a break occurs in a parallel circuit, the circuit is not rendered inoperative because there is more than one path for current to flow back to its source. An illustration of this is street lights. If one bulb burns out, the others remain lit.

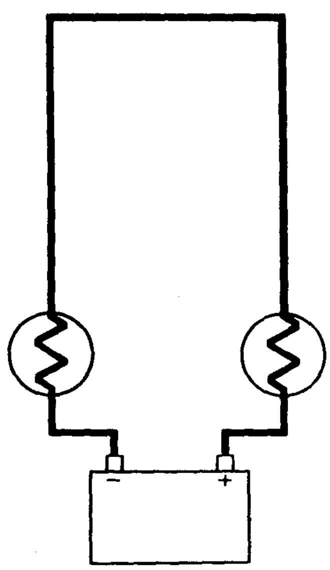
An important thing to remember in a parallel circuit is that the voltage applied remains constant at each branch.

SERIES PARALLEL CIRCUIT Many practical applications in the electrical system of the automobile depend upon a combination of series circuit and parallel circuit. This is called a SERIES PARALLEL circuit. Such combinations are frequently used, particularly in electric motors and control circuits.

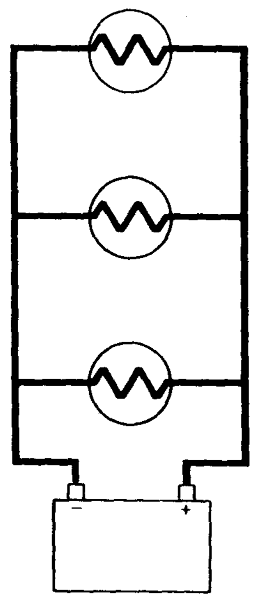
ELECTRICAL CIRCUITS



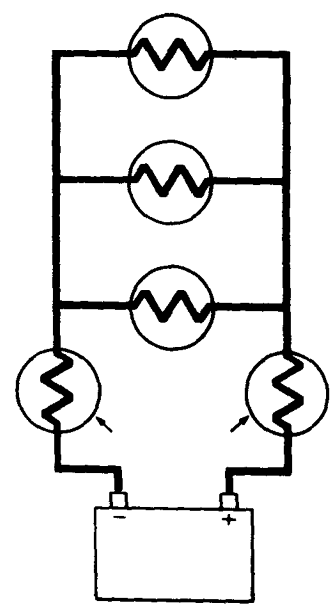
SERIES CIRCUIT



PARALLEL CIRCUIT



SERIES PARALLEL CIRCUIT



OHM'S LAW

Ohm's Law, a basic electrical rule, states that one volt (of pressure) is required to push one ampere (of current) through one ohm (of resistance).

This fundamental rule is applicable to all electrical systems and is of outstanding importance in understanding electrical circuits. It is used in circuits and parts of circuits to find the unknown quantity of voltage, current or resistance when the other two quantities are known.

Using Ohm's Law, the unknown quantity is determined as follows:

To find the amperes – divide the voltage by the resistance.

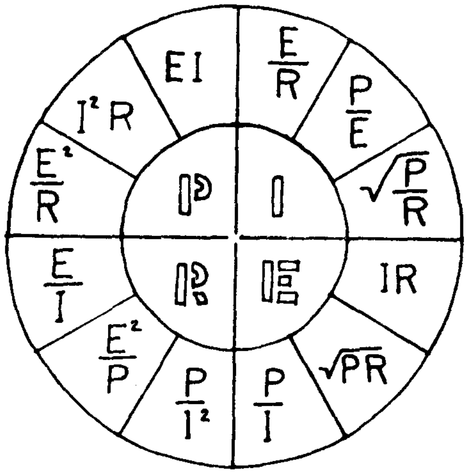
To find the voltage – multiply the amperes by the resistance.

To find the resistance – divide the voltage by the amperage.

Remember this – the current that flows in an electrical circuit is the balance between the applied voltage and the total circuit resistance.

It will not be necessary for you to stop and compute electrical values, using Ohm's Law, during a tune-up. It is advisable, however, that you have a basic understanding of its application. Your test equipment works out these problems for you, giving you the answers in the form of meter indications. With the assistance of the equipment, your attention is quickly directed to the source of the trouble.

As a general automotive electrical system trouble shooting rule, remember this - if the voltage remains constant, as it usually does except in the case of a discharged battery, an increase or decrease in current flow can only be caused by a change in resistance.



1. $E = I \times R$ Ohm's Law

2. $E = \frac{P}{I}$ Watt's Law

3. $E = PR$ By transposing equation 12 and taking the square root

4. $I = \frac{E}{R}$ Ohm's Law

5. $I = \frac{P}{E}$ Watt's Law

6. $I = \frac{P}{R}$ By transposing equation 9 and taking the square root

7. $R = \frac{E}{I}$ Ohm's Law

8. $R = \frac{E^2}{P}$ By transposing equation 12

9. $R = \frac{P}{I}2$ By transposing equation 11

OHM'S LAW

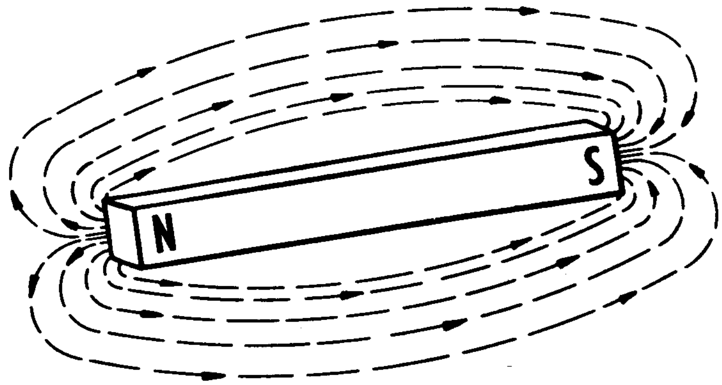
1 VOLT IS NECESSARY TO PUSH **1 AMPERE** THROUGH **1 OHM** OF RESISTANCE.

$$\text{AMPERES} = \frac{\text{VOLTS}}{\text{OHMS}}$$

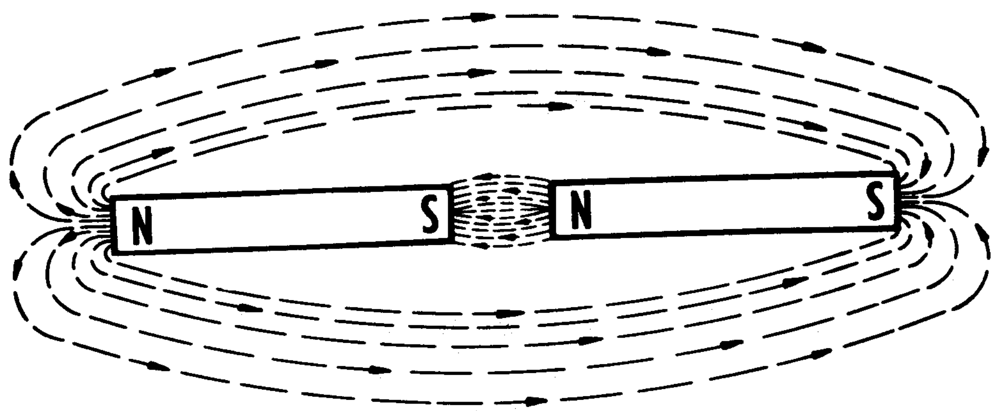
$$\text{VOLTS} = \text{AMPERES} \times \text{OHMS}$$

$$\text{OHMS} = \frac{\text{VOLTS}}{\text{AMPERES}}$$

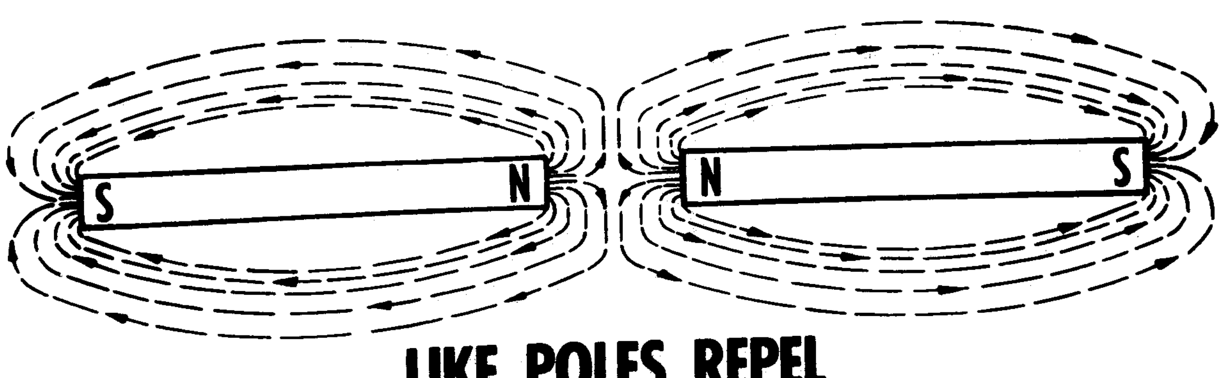
MAGNETISM & PERMANENT MAGNETS



MAGNETIC FIELD

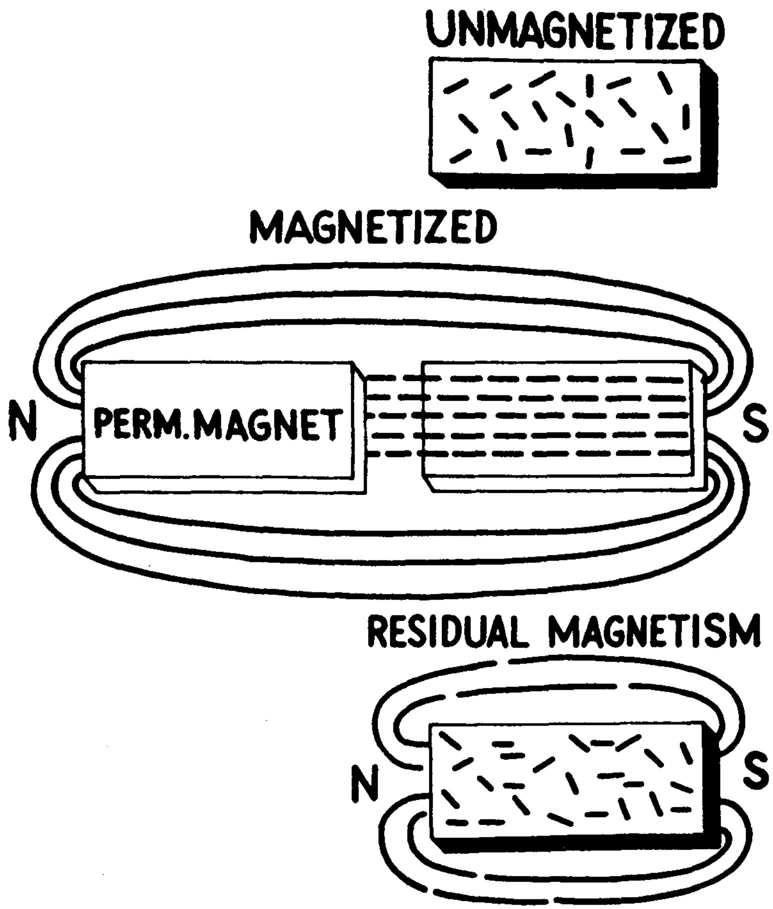


UNLIKE POLES ATTRACT

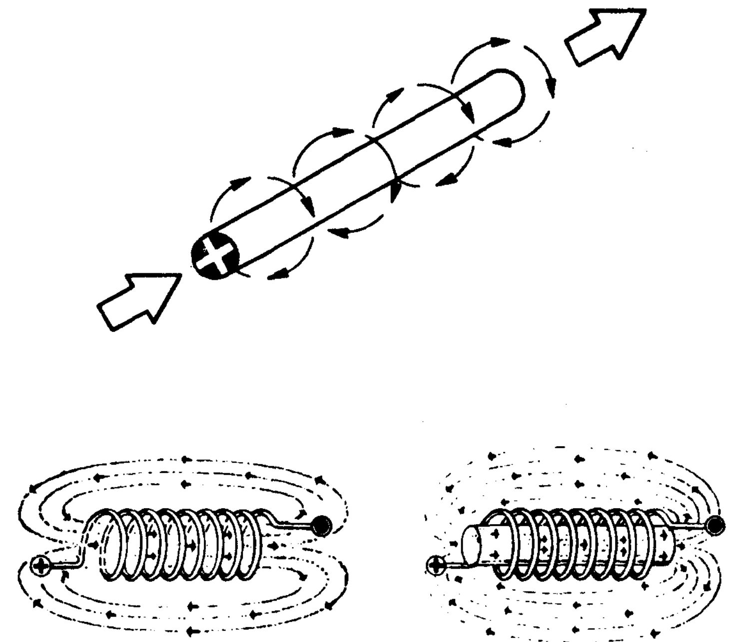


LIKE POLES REPEL

RESIDUAL MAGNETISM



ELECTROMAGNETIC FIELDS



MAGNETIC FIELD SURROUNDING A CURRENT CARRYING CONDUCTOR

MAGNETISM

Approximately 70% of automotive electrical devices use the principle of magnetism. It is important, therefore, that you understand some of the basic laws involved.

Magnetism is an invisible force which attracts certain metals. The area that is under the influence of this magnetic force or flux is called a magnetic field. The strength of the magnetic field is governed by the number of lines of magnetic force it contains.

A magnet has a polarity known as a North Pole and a South Pole. The magnetic flux or field travels from the South Pole of the magnet internally to the North Pole and then externally from the North Pole to the South Pole. In other words, magnetic lines of force always flow out of the North Pole and into the South Pole.

The polarity of magnets becomes evident when two magnets are placed close to each other with unlike poles opposite each other. The two magnets are drawn together by the action of the combined fields making one large magnetic field.

If the magnets are held close together with their like poles opposite each other, the magnets tend to repel each other, with each magnet maintaining its own magnetic field.

You will see how magnetism is used to operate electrical units as this course proceeds.

RESIDUAL MAGNETISM

Soft iron will become magnetized when placed in a field of a magnet but will lose most of its magnetism when removed from this field.

When soft iron is placed in a magnetic field and then removed, only a few of the molecules will remain in magnetic alignment. These few molecules will produce a very weak magnetic field. This is known as residual magnetism.

Residual magnetism is the factor that makes it possible for the DC generator to start its generating cycle. It is a form of self-excitation, without which, the DC generator would not function once it had been stopped.

ELECTROMAGNETIC FIELDS

Electricity and magnetism are two separate but closely related forces. This is demonstrated by the fact that magnetic lines of force are produced around magnets, and also around conductors carrying electrical current. When electrical current is passed through a conductor, there will always be a magnetic field surrounding the conductor. The strength of this magnetic field depends upon the amount of current flow. The higher the amperage, the greater the magnetic strength.

If two conductors are arranged side by side and current passes through both conductors in the same direction, the magnetic field around each conductor will be in the same direction. As a result, the two magnetic fields will combine to form one stronger field surrounding both conductors. This causes the two conductors to be drawn together or attracted to each other. If the current is in opposite directions, the magnetic fields surrounding the two conductors will oppose each other and result in a repelling action. This is the principle involved in the operation of an electric motor such as a starter motor on a vehicle.

If a conductor is wound into a coil, the current passing through it will flow in the same direction in all turns. The magnetic field produced by each turn combines with the field produced by adjacent turns, resulting in a strong continuous field lengthwise around and through the coil. The polarity of the field produced by the coil depends upon the direction of current flow, and the direction in which the coil is wound. The strength of the magnetic field depends upon the number of wire loops and the amount of current passed through the coil This is known as AMPERE-TURNS.

The strength of the magnetic field around the coil can be materially strengthened by placing a core of soft iron inside the coil. Because the iron is a much better conductor for the magnetic lines of force than is the air, the field becomes more concentrated and much stronger. Electromagnetic relays using this basic design are used in many applications in the electrical system of the automobile.

WIRE AND WIRING

New wiring, properly installed, is relatively trouble free, but as the coach ages the wires tend to deteriorate from exposure to heat, oil, fuel, fumes, acid, vibration, etc. Vehicles damaged by collision or fire often require extensive rewiring. The truck mechanic should become familiar with types of wire, sizes, insulation, connections and general installation procedures.

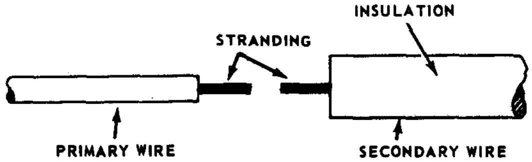
PRIMARY WIRE

The primary wiring handles battery voltage. It has sufficient insulation to prevent current loss at these voltages. All wiring circuits in the coach, with the exception of the ignition high tension circuit, use primary wire. NEVER USE PRIMARY WIRE FOR SPARK PLUG LEADS.

SECONDARY WIRE

Secondary wire is used in the ignition system high tension circuit - coil to distributor, distributor to plugs. It has a heavy layer of insulation to afford protection against excessive corona (loss of electrons to the surrounding air) which could impart sufficient current into an adjacent wire to cause it to fire a plug. This action is known as cross-firing. Even with good insulation, it is important to arrange spark plug leads so that leads to cylinders that fire consecutively are separated. Fig. 111, shows the relative difference in the amount of insulation on primary and secondary wires.

FIG. 111



More insulation is required on secondary wires.

STRANDING MATERIAL

Soft copper is widely used for wire stranding. It is an excellent conductor, bends easily and solders readily. In addition to copper, stainless steel, carbon impregnated thread and elastomer type conductors are used for secondary wire stranding. The carbon impregnated thread and elastomer type (Duoprene G for example) are designed to impart a controlled resistance (about 10,000 - 12,000 ohms per foot) in the secondary circuit for the purpose of reducing radio interference.

Resistance type wires may be identified by such letters as IRS, TVRS, etc.

Automotive wiring uses stranded (conductor made up of a number of small wires twisted together) conductor.

WIRE SIZE

Each conductor size (do not count the thickness of the insulation) is assigned a number. The larger the number, the smaller the wire. The American or Brown and Sharpe wire gauge, is the commonly used standard for wire size.

To find the gauge of a solid wire, simply measure it with a micrometer and locate this answer or nearest one, on a wire gauge chart. Moving across to the wire gauge column, determine the correct wire gauge.

To find the gauge of a stranded conductor, count the number of strands. With a micrometer, measure the diameter of ONE strand. Square this answer and multiply by the number of strands. This will give you the cross sectional area of the conductor in CIRCULAR MILS. Locate this (or the nearest one) number on the chart. Directly across, under the wire gauge column, determine the gauge. Special steel gauges are also available for quickly checking wire gauge. Fig. 112, shows a portion of an AWG (American Wire Gauge) chart.

FIG. 112

AMERICAN WIRE GAUGE	WIRE DIAMETER IN INCHES	CROSS SECTIONAL AREA IN CIRCULAR MILS
0000	.4600	211600
000	.40964	167800
00	.3648	133100
0	.32486	105500
1	.2893	83690
2	.25763	66370
3	.22942	52640
4	.20431	41740
5	.18194	33102
6	.16202	26250
8	.12849	16510
10	.10189	10380
12	.080808	6530
14	.064084	4107
16	.05082	2583
18	.040303	1624
20	.031961	1022
22	.025347	642.4
24	.0201	404.0
26	.01594	254.1
28	.012641	159.8
30	.010025	100.5

American Wire Gauge Chart. (Not all sizes are shown.)

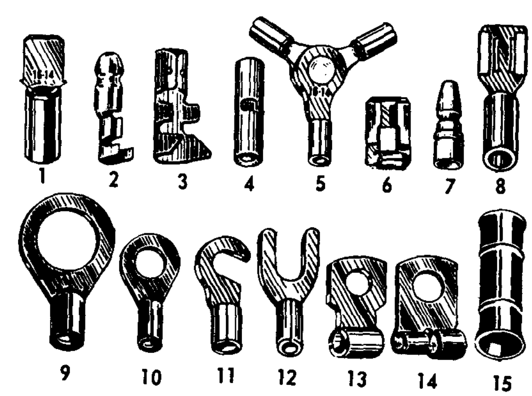
INSULATION

Plastic of various kinds, is used for automotive wire insulation. Rubber is sometimes used. Plastic is highly resistant to heat, cold, fumes, aging, etc. It strips (peels off) easily and offers excellent dielectric (non-conducting) properties. Silicone secondary wire insulation is very heat resistant.

TERMINAL TYPES

Wire end terminals (connecting device) are offered in a myriad of shapes and sizes. In general, primary terminals may be classified as spade, lug, flag, roll, slide, blade, ring and bullet types. They may either be solderable or solder-less. They are generally made of copper - often tinplated. See Fig. 113.

FIG. 113



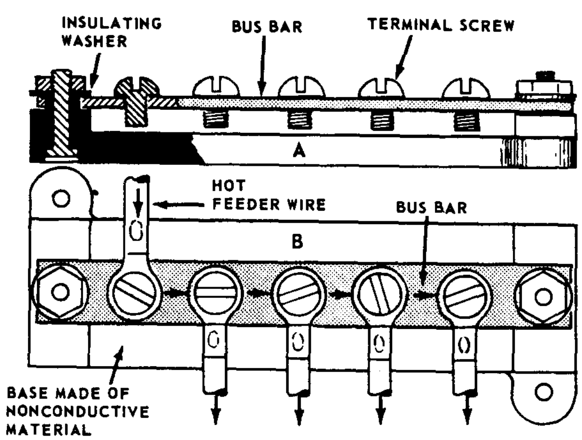
Common primary wire terminal types. 1–Male slide. 2–Bullet or snap-in. 3–Female snap-on. 4–Butt connector (must be crimped). 5–Three way connector. 6–Female slide. 7–Bullet. 8–Female slide. 9–Lug. 10–Ring. 11–Hook. 12–Spade. 13–Roll. 14–Flag. 15–Female bullet connector. (Belden Mfg. Co.)

Terminals on battery cables should be SOLDERED ON. This will insure a good connection with no appreciable voltage drop (lowering of line voltage due to loose, dirty or corroded connections). It will also protect against the entry of battery acid and fumes.

TERMINAL BLOCKS

The terminal block is used to supply current to several circuits from one feeder source. The hot wire (wire connected to source of electricity) is attached to one terminal. This terminal is connected to all others by a bus bar (metal plate), Fig. 114.

FIG. 114

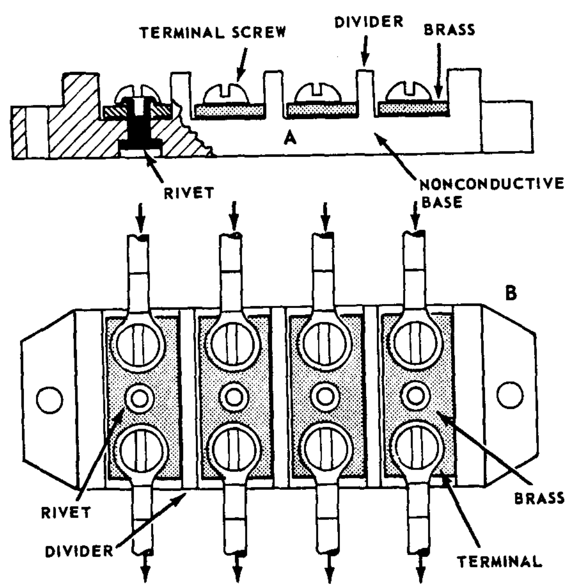


One type of terminal block. Notice how the one hot wire is attached to the bus bar thus supplying current to the other leads.

JUNCTION BLOCK

The junction block serves as a common connection point for a number of wires. It may be of the terminal screw or the plug-in type. Unlike the terminal block, the junction block merely connects one wire to a corresponding wire on the other side. There is no common bus bar, Fig. 115.

FIG. 115



Junction block. (Screw type.)

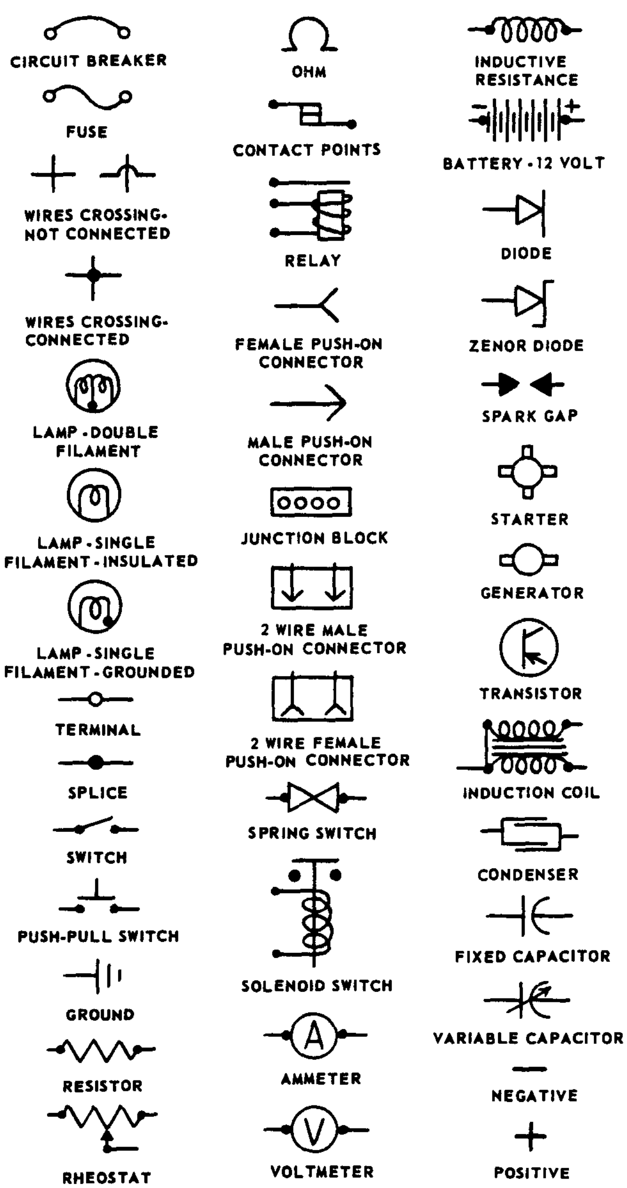
WIRING DIAGRAMS

A wiring diagram is a drawing showing electrical units and the wires connecting them. Such a diagram is helpful when working on the wiring system. As mentioned, wiring diagrams are available in various shop manuals. Use them!!!

ELECTRICAL WIRING SYMBOLS

There is a wide variation in the use of electrical symbols. Some companies use their own drawings for some units and standard symbols for others. The units basic internal circuit is sometimes shown and in other diagrams, symbols are used for all units. Fig. 116, illustrates a number of typical symbols widely used in electrical diagrams.

FIG. 116



Electrical symbols commonly used in automotive wiring diagrams.

SELECTING CORRECT WIRE GAUGE

Line voltage, electrical load and wire length are the three important factors in determining correct wire gauge or size.

Keep in mind the fact that as wire length INCREASES, resistance (with resultant voltage drop) INCREASES. Resistance causes the conductor to heat. Excessive resistance can heat it to the point where the insulation will melt and the wire burn.

As wire size INCREASES, resistance DECREASES. A simple rule then would be to state that to prevent high resistance and voltage drop, wire size must be increased as length is increased. It is obvious then, that with a given voltage and load, a wire 20 ft. long must be of a larger gauge than one 2 ft. long.

The electrical load imposed on a wire is merely the sum of the individual loads of each unit serviced by that wire. Common automotive system voltage is now 12 or 24 volts.

Most wire manufacturers furnish charts, similar to that shown in Fig. 117, to assist the mechanic in proper gauge selection. To use the chart shown, determine the total length of the wire needed. The wire lengths shown in the chart are for a single wire ground return (no wire needed from the unit as the frame or metal parts of the coach act as a return ground wire). If installing a two-wire circuit (one wire to the unit and another from the unit to ground), count the length of both wires.

Next compute the total electrical load to which the wire will be subjected. Be certain to figure the load of ALL units concerned. If the load will fluctuate, use the peak load figure. The load may be figured in AMPERES, WATTAGE, candlepower.

When the load is determined, look on the chart under the correct voltage column for the nearest listed load. Move across the chart horizontally until under the nearest listed footage. This will give you the recommended gauge.

For example, say you have a 12v. system, a computed electrical load of 20 amperes and a wire length of 15 feet. Looking on the chart you will find the recommended gauge to be No. 14. For the same load and length but with a 6v. system, the recommended gauge is 10. You will notice that a 12v. system uses a smaller gauge wire than a 6v. system.

Using a larger gauge than necessary will cause no particular harm unless the wire being replaced MUST produce a specific resistance in the circuit.

FIG. 117

Total Approx. Circuit Amperes		Total Circuit Watts		Total Candle Power		Wire Gauge (For Length in Feet)											
6V	12V	6V	12V	6V	12V	3'	5'	7'	10'	15'	20'	25'	30'	40'	50'	75'	100'
0.5	1.0	3	6	3	6	18	18	18	18	18	18	18	18	18	18	18	18
0.75	1.5			5	10	18	18	18	18	18	18	18	18	18	18	18	18
1.0	2	6	12	8	16	18	18	18	18	18	18	18	18	18	18	16	16
1.5	3			12	24	18	18	18	18	18	18	18	18	18	18	14	14
2.0	4	12	24	15	30	18	18	18	18	18	18	18	18	16	16	12	12
2.5	5			20	40	18	18	18	18	18	18	18	18	16	14	12	12
3.0	6	18	36	25	50	18	18	18	18	18	18	16	16	16	14	12	10
3.5	7			30	60	18	18	18	18	18	18	16	16	14	14	10	10
4.0	8	24	48	35	70	18	18	18	18	18	16	16	16	14	12	10	10
5.0	10	30	60	40	80	18	18	18	18	16	16	16	14	12	12	10	10
5.5	11			45	90	18	18	18	18	16	16	14	14	12	12	10	8
6.0	12	36	72	50	100	18	18	18	18	16	16	14	14	12	12	10	8
7.5	15			60	120	18	18	18	18	14	14	12	12	12	10	8	8
9.0	18	54	108	70	140	18	18	16	16	14	14	12	12	10	10	8	8
10	20	60	120	80	160	18	18	16	16	14	12	10	10	10	10	8	6
11	22	66	132	90	180	18	18	16	16	12	12	10	10	10	8	6	6
12	24	72	144	100	200	*18	18	16	16	12	12	10	10	10	8	6	6
15	30					18	16	16	14	10	10	10	10	10	6	4	4
20	40					18	16	14	12	10	10	8	8	6	6	4	2
25	50					16	14	12	12	10	10	8	8	6	6	2	2
50	100					12	12	10	10	6	6	4	4	4	2	1	0
75	150					10	10	8	8	4	4	2	2	2	1	00	00
100	200					10	8	8	6	4	4	2	2	1	0	4/0	4/0

* 18 AWG indicated above this line could be 20 AWG electrically—18 AWG is recommended for mechanical strength.

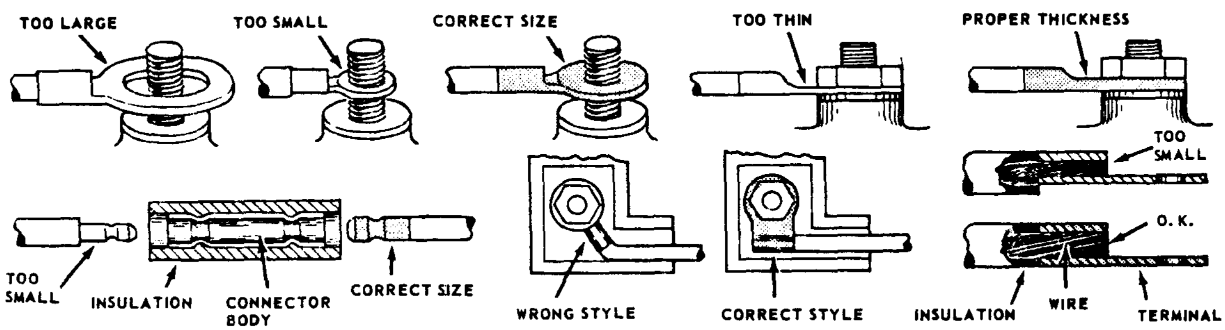
Wire gauge selection chart. Wire lengths shown are for a single wire ground return. (Belden Mfg. Co.)

SELECTING PROPER TERMINALS

After the wire gauge is determined, select the proper size and type terminal. The terminal selected must be suitable for the unit connecting post or prongs. It must have sufficient current carrying capacity and should be heavy enough to prevent breakage through normal wire flexing and vibration. Fig. 118, shows some common errors in terminal selection.

Arrange the terminals so they have clearance from metal parts that could ground or short them out. On critical applications or where heavy vibration is present, use a terminal such as the ring type that completely encircles the post. In the event it loosens, the wire will not fall off.

FIG. 118



Some common errors in terminal selection.

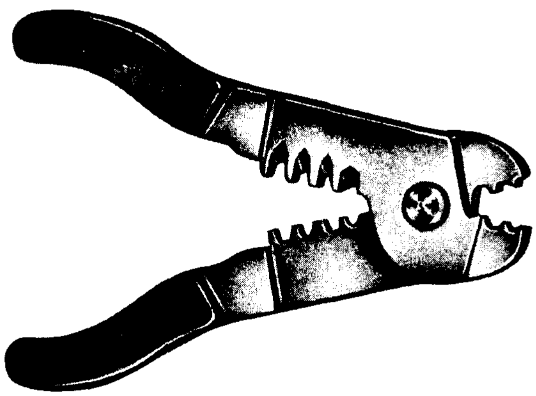
ATTACHING TERMINALS

Terminals may be either soldered or crimped in place. For general use, crimping is fast and forms a good connection. Soldering, if properly done, forms an excellent connection, and on some important applications may be desired. It is possible to both solder and crimp a connection. Solder is used to form an electrical path and is not depended on for mechanical strength!

CRIMPING TERMINALS

A crimping tool is shown in Fig. 119, it will cut and strip the wire as well as form a proper crimp.

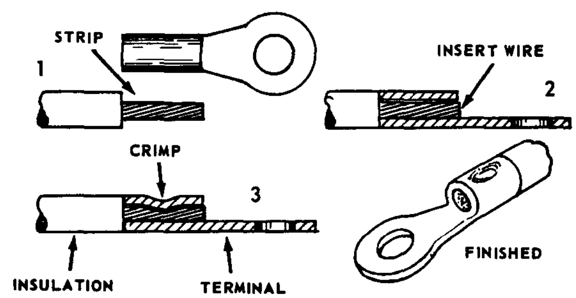
FIG. 119



Crimping tool. (Cole-Hersee Co.)

The first step is to strip the insulation back for a distance equal to the length of the terminal barrel. The wire is then shoved into the barrel and while being held in, the crimping tool is placed over the spot to be crimped. Be sure to use the proper crimping edge. The handles are squeezed together and the terminal barrel firmly crimped to the wire. Follow the tool manufacturers instructions. Use the correct barrel size for the wire used. NEVER CRIMP A WIRE WITH THE CUTTING EDGE OF A PAIR OF PLIERS. This would crimp the barrel but would also weaken it, Fig. 120.

FIG. 120



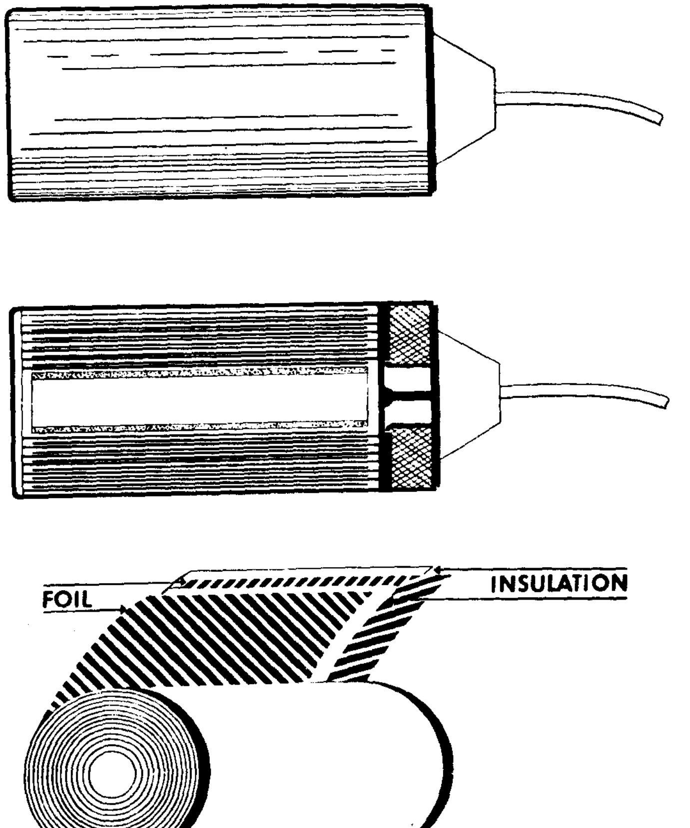
Crimping a terminal.

CONDENSER CONSTRUCTION

The condenser is constructed of layers of aluminum foil, insulated from each other by layers of high dielectric insulating material. One layer of aluminum foil extends beyond the insulating material on one side, while the other layer of foil extends beyond the insulating material on the other side. The layers of aluminum foil and insulating material are then rolled into a tight cylinder and inserted into the condenser case. The layer of aluminum foil extending at one side will contact the bottom of the case and represents the ground terminal of the condenser. The other layer of foil will contact a disc which is connected to the insulated lead of the condenser.

Current does not flow through a good condenser. If it does, the two layers of foil are touching or there is a hole in the insulating material. If either condition exists the condenser is defective and must be replaced.

CONDENSER CONSTRUCTION



AUTOMOTIVE GROUND CIRCUITS

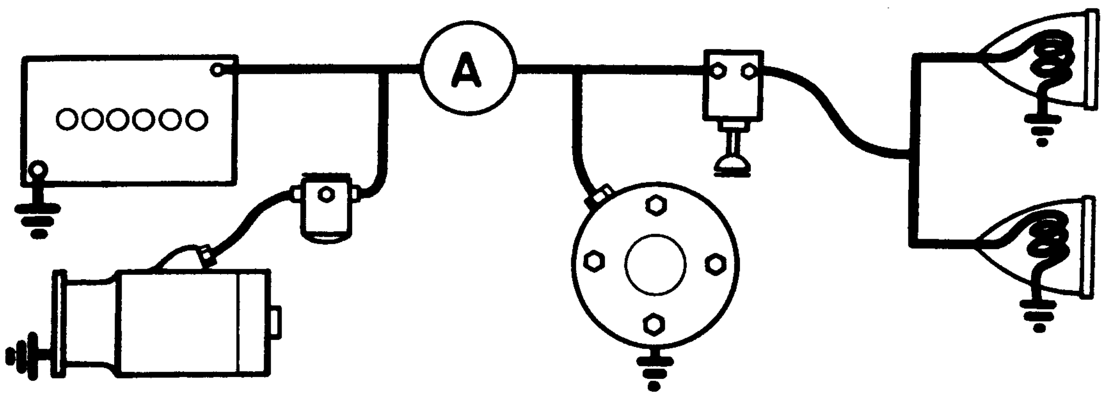
Every individual circuit in the automotive electrical system has both an insulated circuit and a ground circuit. The insulated circuit contains the source of electrical power.

The ground circuit, of equal importance to the insulated circuit, contains the ground connections and the metal parts of the vehicle that serve to return the current flowing in the circuit back to its point of origin, either the battery or the alternator or both. The metal parts of the vehicle are the frame, the firewall, the body and the ground straps.

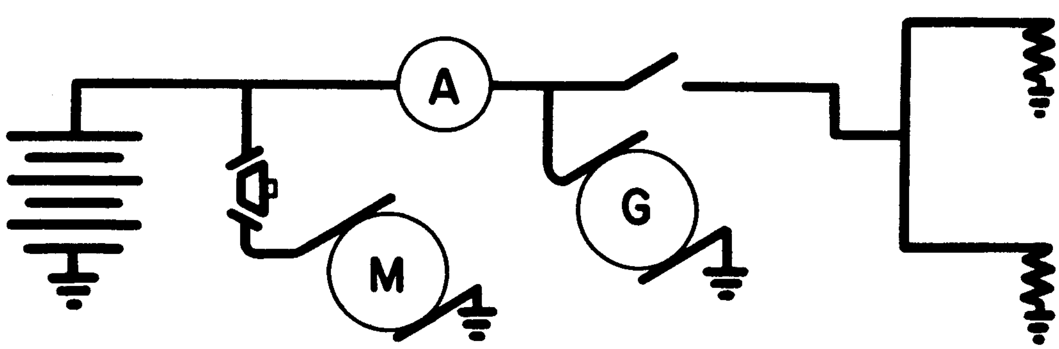
The ground straps are an essential part of the ground circuit since the engine and body are mounted on rubber mounts or biscuits. These rubber mounts absorb engine and road vibration and noise and prevent their being transmitted into the body. The ground straps are usually braided metal straps that are bolted between the engine and firewall and between the engine and the body or fender sheet metal.

All electrical system testing is divided into two groups – testing the insulated circuit and testing the ground circuit. Proper functioning of both circuits is essential to the efficient operation of every electrical unit. Examples of these test procedures will be covered in detail as the course progresses.

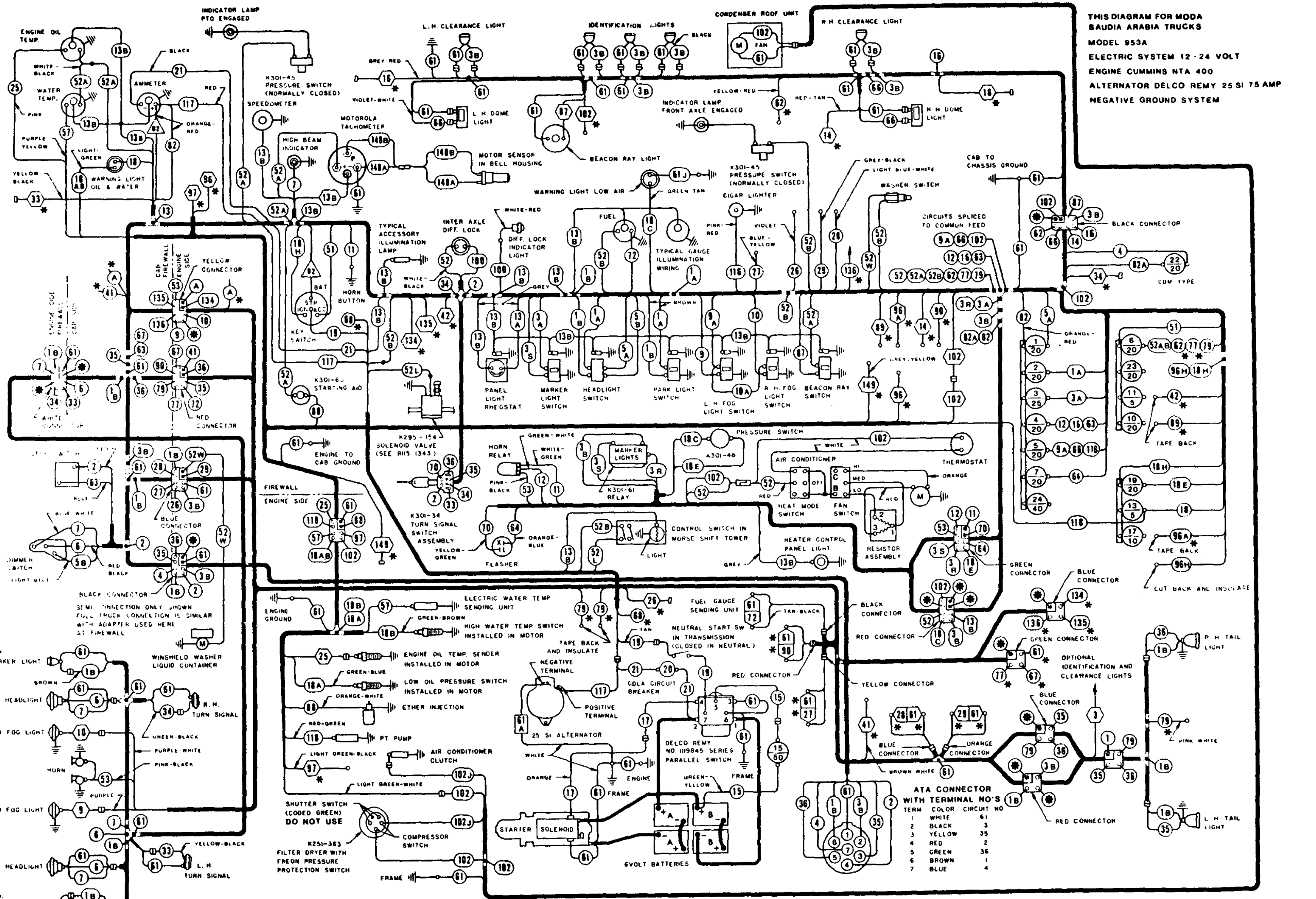
WIRING DIAGRAM



SCHEMATIC DIAGRAM



THIS DIAGRAM FOR MODA SAUDIA ARABIA TRUCKS
MODEL 953A
ELECTRIC SYSTEM 12 - 24 VOLT
ENGINE CUMMINS NTA 400
ALTERNATOR DELCO REMY 25 SI 75 AMP
NEGATIVE GROUND SYSTEM



MALE TERMINAL (TYPICAL)
FEMALE TERMINAL (TYPICAL)
BLANK TERMINAL WITH 3 INCH WIRE (SPARE UNUSED CIRCUIT)

O INDICATES TERMINAL CONNECTOR
● INDICATES CIRCUIT SPLICE
CIRCUIT WITH LETTER SUBSCRIPT ARE PART OF THE NUMBERED CIRCUIT

WITH CIRCUIT NO. INDICATES NOT USED

INDICATES PLUG TYPE CONNECTOR
INDICATES OPTIONAL EQUIPMENT CIRCUIT
INDICATES CIRCUIT BREAKER (TYPICAL) REF CIRCUIT BREAKER CHART R076-2046

WIRE IS COLOR CODED IF NOT SOLID COLOR FOR EXAMPLE:
ORANGE RED
BODY COLOR STRIPE

FOR ADDITIONAL WIRING CIRCUIT NO'S. SEE R076-914

ELECTRICAL SYSTEM
WIRING KEY

KENWORTH STANDARD NUMBERING OF ELECTRICAL CIRCUITS & WIRES

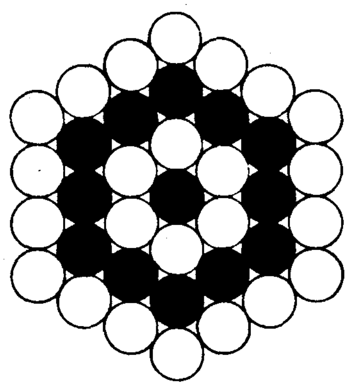
1.	Tail Light and Side Marker Lights	ATA Brown
2.	Stop Lights	ATA Red
3.	Identification Lights and Clearance Lights	ATA Black
4.	Hot Wire for Auxiliary Devices on Trailer	ATA Blue
5.	Head Lights	Lt. Blue
6.	Low Beam	Red/Black
7.	High Beam and High Beam Indicator	Blue/White
8.	Parking Lights	Brown
9.	LH Road (9 A) or Fog Light (9 B)	Purple
10.	RH Road (10 A) or Fog Light (10 B)	Purple/White
11.	Horn Relay Ground	White/Green
12.	Horn Relay Hot	Green/White
13.	Panel Lights	Grey
14.	Flood or Loading Light	Red/Tan
15.	Battery Charging	Green/Yellow
16.	Post Spot Light	Grey/Red
17.	Starter Solenoid to Series Parallel Switch	Orange
18.	Hot Line to Buzzer and Warning Devices	Lt. Green
	A. Low Oil Pressure - - D. Warning Light, Alt or Gen	Green/Blue
	B. High Water Temperature	Green/Brown
	C. Low Air Pressure	Green/Tan
19.	Starter Switch to Solenoid	Tan
20.	Ignition Switch to Coil or Solenoid	Red/Green
	2020 Second Ignition Switch to Coil	Red/Green
21.	Battery to Ammeter-main Charge and Discharge Line	Black
22.	Regulator Battery Terminal to Ammeter Charging Line	Black
23.	Generator Arm. Term. to Regulator Arm. Term.	Red
24.	Generator Field Term. to Regulator Field Term.	White/Blue
25.	Engine Oil Temperature	Pink
26.	Main Transmission Oil Temperature	Violet ★
27.	Auxiliary Transmission Oil Temperature	Blue/Yellow ★★
28.	First or Single Rear Axle Temperature	Lt. Blue/White
29.	Second Rear Axle Temperature	Grey/Black ★★
30.	Heater-Passenger Side	Lt. Blue/Black
31.	Heater-Driver Side	Lt. Blue/Yellow
32.	Air Brake Low Air and Breakaway Buzzer	Lt. Green/Yellow
33.	Left Front Directional Signal Lamp	Yellow/Black
34.	Right Front Directional Signal Lamp	Green/Black
35.	Left Rear Directional Signal Lamp	ATA Yellow
36.	Right Rear Directional Signal Lamp	ATA Green
37.	Left Trailer Directional Signal Lamp	ATA Yellow
38.	Right Trailer Directional Signal Lamp	ATA Green
39.	Hot Feed Line to Pressure Auxiliary Switch	Red/Pink

40.	Return Line from Pressure Auxiliary Switch	Red/Violet
41.	Sanders	Brown/White
42.	Radio Receiver	Green/Red
43.	Radio Transmitter	Green/Orange
44.	Cold Side of Starter Push Button Sw. to Relay Coil	Obsolete
45.	Hot Side of Starter Push Button Sw. to Relay Contact	Obsolete
46.	(A-) No. 1 Switch to A+ Battery	Black
47.	B+ No. 2 Switch to B-Battery	Black
48.	Starter to B+ Battery	Black
49.	Starter Solenoid to A-Battery	Black
50.	SP Switch to Circuit Breaker (to Ground through Breaker)	Tan/White
51.	Feed from Acc. Term. of Ign. Sw. to Circuit Breaker	Red/Yellow
52.	Circuit Breaker to Accessories	White/Black
53.	Horn Relay to Horn	Pink/Black
54.	Starter Push Button Feed	Lt. Green/Tan
55.	Speedo Switch to Electric Adapter	Obsolete
56.	Trailer Emergency Stop Lite Sw. Feed	White/Yellow
57.	Electric Water Temp.	Purple/Yellow
58.	Electric Water Temp. High Warning	Purple/Orange
59.	Battery to Starter	Black
60.	Battery - to Starter	Black
61.	Ground (can be Lighting or Battery Ground or Both)	ATA White
	A. Generator to Regulator Ground	White
62.	Defroster Fan	Yellow/Red
63.	Stop Switch Feed	Blue
64.	Turn Signal Feed	Orange/Blue
65.	Field Relay to C. B. No. 5 or No. 4	Red/Yellow
66.	Dome Light - Front	Violet/White
67.	Dome Light - Sleeper	Tan/Yellow
68.	Voltage Regulator Energizing Control Line	Red/Blue
69.	Turn Signal Pilot Light to Flasher	Yellow/Blue
70.	Turn Signal Flasher to Switch, Volt Reg. or Pressure Switch	Yellow/Green
71.	Reversible Motor Common Wire to Switch	Black/Green
72.	Fuel Gauge	Tan/Black
73.	Fuel Gauge - LH Tank with Two Senders	Tan/Red
74.	Engine Stop Switch to Fuel Pump Solenoid	Red/Green
● 75.	Emergency Engine Stop Switch to Air Control Solenoid	Red/Purple
76.	AC Generator Battery Terminal to Ammeter	Red
77.	Sleeper Heater Switch Feed	Blue/Orange
78.	Sleeper Heater Switch to Heater	Blue/Grey
79.	Backup Light	Pink/White
80.	Sign Light	Red/Orange
81.	Voltage Regulator to Field Relay	White/Red
	A. AC Generator to Field Relay	Blue/Green
82.	Load Circuit Between Ammeter or Volt Meter, Circuit Breakers and Key Switch	Orange/Red
83.	Cold Side Starter Relay to Starter Solenoid	Orange/Black
84.	Starter Relay Feed	Black/Orange
85.	Reversible Motor to Switch - Up or Forward	Black/Red
86.	Reversible Motor to Switch - Down or Reverse	Black/Yellow
87.	Air Conditioning or Cooler	Yellow/White

88.	Glow Plug	Orange/White
89.	Mirror Heat	Brown/Yellow
90.	Expello Valve	Purple/Red
91.	Dash Lockout Switch to 2 or 3 Speed Shift Knob Switch	Obsolete
92.	2 or 3 Speed Shift Knob Switch to Forward Rear Axle Solenoid	Obsolete
93.	2 or 3 Speed Shift Knob Switch to Rear Axle Solenoid	Obsolete
94.	Dash Lockout Switch to Axle Lockout Switch	Obsolete
95.	Axle Lockout Switch to Power Divider Lockout Solenoid	Obsolete
● 96.	Dash Switch to Throttle Sw. (Jacobs Brake Yellow)	Lt. Green/Black
▶ 97.	Dash Sw. to Throttle Sw. Thru Clutch Sw. (Jacobs Brake Green)	Lt. Green/Black
98.	Throttle Sw. to Brake Units (Jacobs Brake Red)	Lt. Green/Black
99.	Hot Feedline from Ignition Switch	Lt. Green/Red
100.	Interaxle Differential Lock Indicator Light	White/Red
101.	Heater Defroster Feed	Lt. Blue/Red
102.	Air Conditioner Clutch Control	Lt. Green/White
103.	Sun Tach. Power Unit "Plus" Terminal to A. Tach. "Plus" Terminal	Black/Red
103.	Sun Tach. Power Unit "Black-Minus" Terminal B. to Tach. "Minus" Terminal	Black/Red
103.	Sun Tach. Power Unit "Black Minus" Terminal C. To Black Wire in Tang Cable	Black
103.	Sun Tach. Power Unit "White" Terminal to D. White Wire in Tang Cable	White
103.	Sun Tach. Power Unit "Red" Terminal to E. Red Wire in Tang Cable	Red
104.	Ammeter Neg. Term. to Motorola Alternator-output Term.	Red
105.	Green Lead of Motorola Alternator Cable Assembly to Alternator Field Terminal	Green
106.	Red Lead of Motorola Alternator Cable Assembly to Alternator Auxiliary Terminal	Red
107.	Black Lead of Motorola Alternator Cable Assembly to Alternator Negative Output Terminal	Black
108.	Motorola "Polarity Protector" No. 1 Terminal to 120 Amp Alternator Center Phase Tap	Obsolete
109.	Red Lead of 120 Amp Voltage Regulator (TVR12 X 22) Cable Assembly to Alternator Positive Output Terminal	Obsolete
110.	Leece Neville Reg. Bat. Term to L. N. Alt. Output Term.	Black
111.	Charge or Discharge Circuit	Black
112.	Load Circuit - Battery to Inst. Panel Feed	Black
113.	Feed from Ign. Term. of Key Switch to Circuit Breaker	Red/Brown
114.	Grd. Term of Magnetic Sw. to "B" Term of Sensing Relay	Black/White
115.	Sensing Relay "R" Term to AC Generator Relay Terminal or 1 of 3 AC Terminals	Black/White
116.	Cigar Lighter	Pink/Red
117.	Charging Circuit, Alternator or Generator to Circuit	Red
118.	Cummins to PT Pump 8V-71 & Cat. to Fuel Shutdown	Red/Green
119.	Engine Compartment Light(s)	Pink/Green
120.	Red Flasher	Black/Blue
121.	Beacon Ray Light	Black/Tan
122.	Alt. Relay Term. to Warning Light Relay Bat. Term. or Gen. Armature Term. to Charging System Warning Light	Lt. Green
123.	Feed Wire from Electric Alternator Term. to Electric Tach.	

124. Sleeper Box Air Conditioning Control Circuit	Lt. Green/White
125. Gunite Skid Control Circuit L.H. Fwd Valve	
126. Gunite Skid Control Circuit L.H. Fwd Sensor Circuit	
127. Gunite Skid Control Circuit R.H. Fwd Valve Circuit	
128. Gunite Skid Control Circuit R.H. Fwd Sensor Circuit	
129. Gunite Skid Control Circuit L.H. Rear Valve Circuit	
130. Gunite Skid Control Circuit L.H. Rear Sensor Circuit	
131. Gunite Skid Control Circuit R.H. Rear Valve Circuit	
132. Gunite Skid Control Circuit R.H. Rear Sensor Circuit	
133. Gunite Skid Controller Feed Circuit	
134. Radio Speaker Ground Circuit	Grey/Orange
135. R.H. Speaker Circuit	Black/Grey
136. L.H. Speaker Circuit	Grey/Green
137. Nycal System Hot Feed Wire to Control Box Term. No. 11	
138. Nycal System Warning Buzzer Circuit	
139. Nycal System Warning Light Circuit	
140. Nycal System Control Box Term. No. 6 to Oil Press Sender	
141. Nycal System Control Box Term. No. 7 to Water Temp Sender	
142. Nycal System Circuit Breaker No. 13 to Control Box Term. No. 1	
143. Nycal System Over-Rule Sw. to Control Box Term. No. 12	
144. Horton Fan Clutch Circuits	
145. Dump Gate Front	
146. Dump Gate Rear	
147. Torque Limiting Circuit, PT Pump to Pressure Switch	Red/Green
148. Electric Tach & Speedo Sending Circuit	Black/Red
149. Hobbs Hour Meter	Grey/Yellow
150. Mark 4 Monitor Module Feed Circuit	
151. Mark 4 $\pm$ 12 V Feed Circuit Monitor to Wheel Computer	
152. Mark 4 Monitor -- Wheel Computer F Circuit	
153. Anti-Lock Brake System Monitor Feed	Pink/Purple
154. Anti-Lock Brake System Power	Purple/Pink
155. Anti-Lock Brake System Warning-Fail Circuit	Purple/Brown

★ Connecting Plug in Wire - Pink
★★ Connecting Plug in Wire - Lt. Blue/White
● COE Cat Brake Saver to Throttle Switch from Solenoid Valve
▶ COE Cat to Fuel Press Gauge



In a uniformly stranded cable, each layer contains six more strands than the previous layer, running 6, 12, 18, 24, 30, 36, 42, etc. The total of the strands in all layers, plus one (the center strand), gives cables of 7, 19, 37, 61, 91, 127, 169 (etc.), strands.

HOW TO SELECT PROPER SIZE CABLE

IMPORTANCE OF ADEQUATE SIZE CABLE

:able too small in gauge size for the load (lamps, .tarter and other equipment) will cause a drop in :he battery voltage delivered to such equipment. A 10% drop in battery voltage to the lamps will result in a 30% loss in candlepower. This means that if there are 6 volts at the battery and, because of undersize cable, additional equipment or a long cable, the voltage at the headlamps is 5.4, a 32-candlepower lamp will deliver only *22.4 actual candlepower.*

To determine the proper size of cable for a circuit to be used for an electrical system, use the chart below, and proceed as follows: (Page 21)

RECOMMENDED CABLE SIZES FOR REPLACEMENT OR ADDITIONAL ELECTRICAL UNIT INSTALLATIONS

Original equipment cable sizes on some vehicles may vary slightly from recommendations due to special electrical system design. See note (2) below.

This chart applies to grounded return systems. For two-wire circuits, use total length of both cables, or the double length to most distant electrical unit.

6-VOLT SYSTEM		12-VOLT SYSTEM		Total Length of Cable in Circuit from Battery to most Distant Electrical Unit									
AMPERES (APPROX.)	CANDLE POWER	AMPERES (APPROX.)	CANDLE POWER	10 Feet	20 Feet	30 Feet	40 Feet	50 Feet	60 Feet	70 Feet	80 Feet	90 Feet	100 Feet
				Gauge	Gauge	Gauge	Gauge	Gauge	Gauge	Gauge	Gauge	Gauge	Gauge
0.5	3	1.0	6	18	18	18	18	18	18	18	18	18	18
0.75	5	1.5	10	18	18	18	18	18	18	18	18	18	18
1.0	8	2	16	18	18	18	18	18	18	18	16	16	16
1.5	12	3	24	18	18	18	18	18	16	16	16	14	14
2.0	15	4	30	18	18	18	16	16	16	14	14	14	12
2.5	20	5	40	18	18	18	16	14	14	14	12	12	12
3.0	25	6	50	18	18	16	16	14	14	12	12	12	12
3.5	30	7	60	18	18	16	14	14	12	12	12	10	10
4.0	35	8	70	18	16	16	14	12	12	12	10	10	10
5.0	40	10	80	18	16	14	12	12	12	10	10	10	10
5.5	45	11	90	18	16	14	12	12	10	10	10	10	8
6.0	50	12	100	18	16	14	12	12	10	10	10	8	8
7.5	60	15	120	18	14	12	12	10	10	10	8	8	8
9.0	70	18	140	16	14	12	10	10	8	8	8	8	8
10	80	20	160	16	12	12	10	10	8	8	8	8	6
11	90	22	180	16	12	10	10	8	8	8	8	6	6
12	100	24	200	16	12	10	10	8	8	8	6	6	6
18	–	36	–	14	10	8	8	8	6	6	6	4	4
25	–	50	–	12	10	8	6	6	4	4	4	2	2
50	–	100	–	10	6	4	4	2	2	1	1	0	0
75	–	150	–	8	4	2	2	1	0	0	00	00	00
100	–	200	–	6	4	2	1	0	00	000	000	000	0000

NOTE–

(1) For battery cables larger than No. 1 gauge, it is suggested the serviceman determine the gauge size of the original equipment battery cable by following the method described on page 19 (How to Determine Cable Size). The same or next larger size cable can then be purchased and a duplicate battery cable assembled.

(2) Some 12-volt systems are designed with No. 20 gauge cable in certain circuits. (Vehicle manufacturers' service manuals generally show the size of cable used for original equipment in each circuit.)

1. Measure cable length required

Determine the length of cable needed to reach from the battery to the most distant electrical unit in the circuit. (Return circuit has been allowed for in the chart, which applies to grounded returns. For two-wire circuits, use total length of both cables, or the double length to most distant electrical unit.)

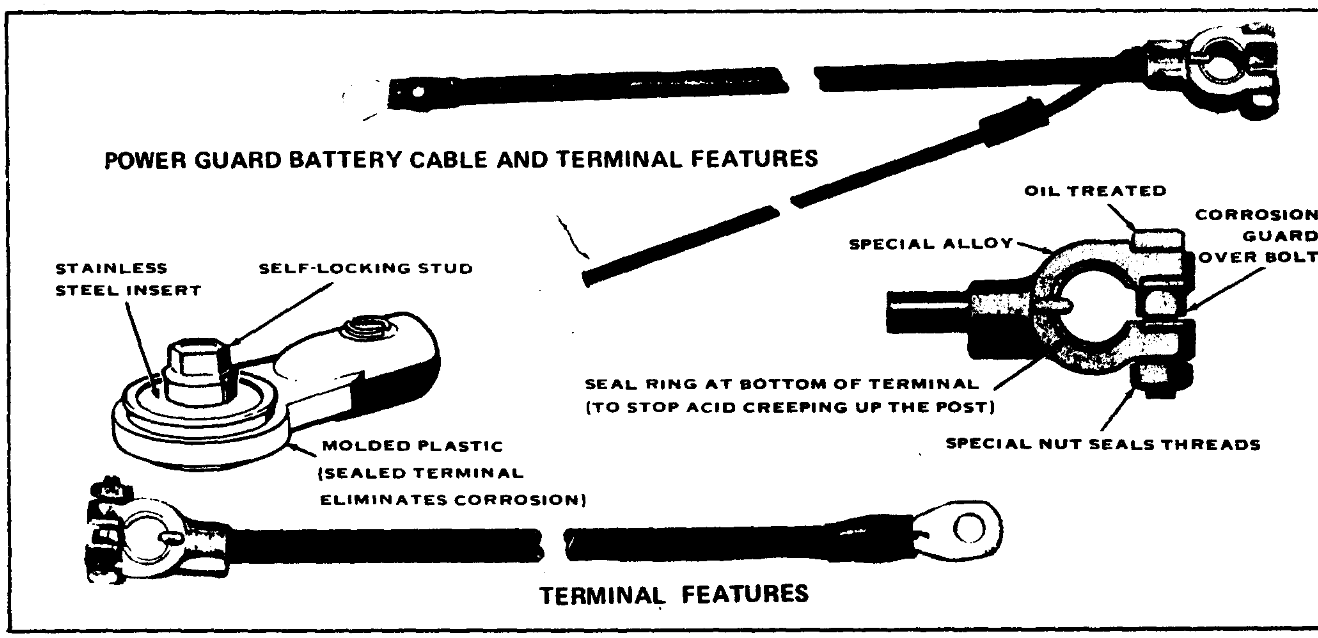
2. Add amperes or candle power

(a) *By candlepower* – Add up the total maximum candlepower ever to be used in the circuit. (If you now use a 3-C.P. bulb where you might later change to a 6-C.P., use 6 in adding up C.P.) Read down to the closest corresponding figure in the *candle-power* column of the chart.

(b) *By amperes* – If the approximate total amperes load in a circuit is known, read down the *amperes (approx.)* column of the chart to the closest corresponding figure.

3. Read chart

Read across the line representing the C.P. or the amperes of the circuit to the correct foot-length column. The figure there indicates the proper gauge of cable to be used *throughout the circuit.*



Battery Cables

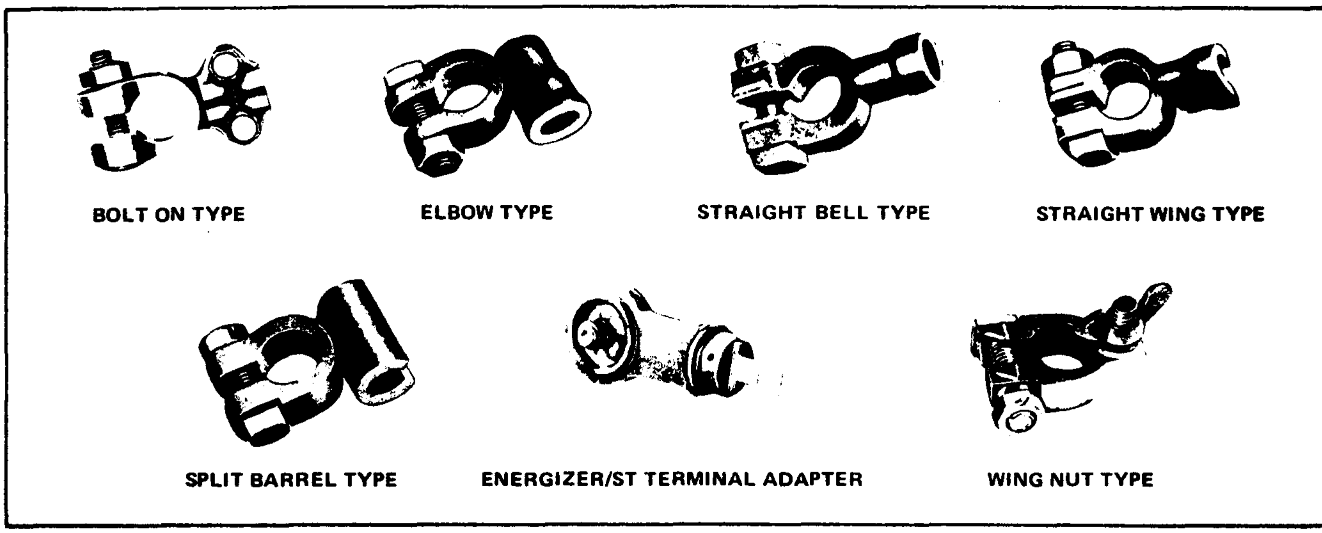
BATTERY AND CRANKING MOTOR CABLE

Correct cable and connections from the battery to the other components of the cranking motor circuit will result in greater dependability of equipment under severe weather and climate conditions.

Replacement cranking motor cable must always be as large as used by the vehicle manufacturer. If you are not sure of the gauge size, use the procedure shown on Page 19. It is always safe to use larger cable for service than was used as original equipment.

Most battery cables are insulated with a vinyl plastic material. Vinyl is not affected by battery acid, gasoline, oil, etc. Special precaution must be taken to keep battery cable away from excessive heat such as engine exhaust manifolds and if exposed to abrasion, loom should be slipped over the cable. When heat is a problem Insulex Cable should be used.

Virtually all battery cables are insulated with a vinyl plastic material. Vinyl is not affected by battery acid, gasoline, oil, etc. Special precaution must be taken to keep battery cable away from excessive heat such as engine exhaust manifolds and if exposed to abrasion, loom should be slipped over the cable.



Typical Replacement Terminals

BATTERY TERMINALS

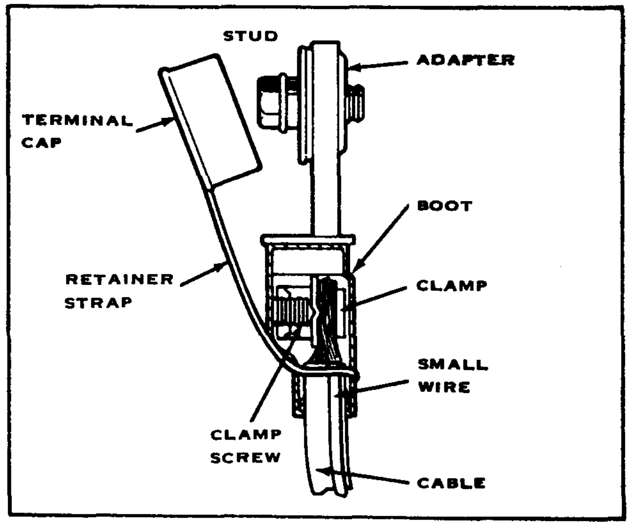
When selecting terminals, be certain they are physically strong enough to withstand vibration, corrosion and other elements to which it will be exposed.

Terminals are attached to cables three different ways; soldering, crimping, and clamping. In all cases the cable insulation must be stripped from the conductor, exposing only enough conductor to fill the portion of the terminal where the connection is to be made.

A winged terminal should have the front wings bent around the cable conductor and the rear wings around the cable insulation. Solder terminal using rosin flux. Acid flux (unless thoroughly washed off) will corrode the connection. Heat should be applied to the terminal until the solder melts and flows freely. Avoid using too much heat or leaving the heat applied after the solder has flowed. Do not cool the solder joint by immersing in water, allow to cool at room temperature. Improper soldering will result in high resistance connections which will result in voltage drops in the electrical circuit.

Solderless terminals must be crimped or clamped so as to tightly mate with the core. The crimp must not weaken the terminal or cable so that vibration will cause breakage. Use United Delco tool No. 1400 designed especially for the application of automotive terminals.

When replacing a standard Energizer with an Energizer /ST a cable terminal adapter is necessary.



Energizer S/T Adapter

To install the adapter cut the old clamp off the cable as close to the clamp as possible. Strip one inch of the insulation from the end of the cable and any other wire. Place the boot and retainer strap of the terminal cap over the end of the cable and wire. Then insert the exposed ends of the cable and wire into the clamp and tighten clamp screw tightly.

The wiring on late model vehicles makes use of many types of "push on" or "snap type" terminals. These terminals should be attached using crimping tool and/or solder.

LOW TENSION AND LIGHTING CABLE

Lighting and Accessory Cables used by vehicle and trailer manufactures are insulated with:

1. PLASTIC
2. BRAIDED
3. INSULEX

PLASTIC

Plastic insulated cable is the most popular for rewiring use. This cable is smaller in diameter, more flexible and more economical than cable insulated with other material. United Delco plastic compound is impervious to oils, fuels and chemicals. Plastic cable is not recommended where excessive temperatures are present or where a short in one cable in a harness can melt and destroy adjacent cables in the harness.

BRAIDED

To produce cable with extreme resistance to abrasion, acids, fuels, etc., cotton is braided over a plastic insulated cable. This cotton braid is then coated with many layers of high quality lacquer. This cable was used exclusively prior to the availability of plastic materials, when the insulation used was rubber with braid and lacquer applied to provide abrasion resistance.

INSULEX

Delco Insulex cable is insulated with Delco's special thermosetting compound. This cable insulation is recommended for applications where heat, cold, abrasion, aging, and chemicals are encountered. Insulex will not melt or burn even though the cable is subjected to heat which would melt other types of cable. If one conductor in a harness is shorted, the insulation will not burn or melt, destroying the other cables. Insulex offers 25% more resistance to abrasion, provides 10% more protection from pinch and stands up to 300° F. heat, 3 times longer.

SPECIAL CABLE

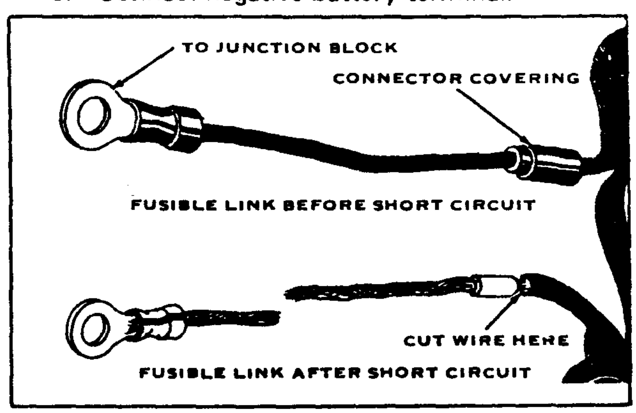
FUSIBLE LINK

A fusible link is a short length of wire incorporated in the engine or forward (LP) wiring harness to prevent damage to the unfused circuit in the event a short circuit would occur. If a short circuit does occur the fusible link opens, protecting the rest of the circuit.

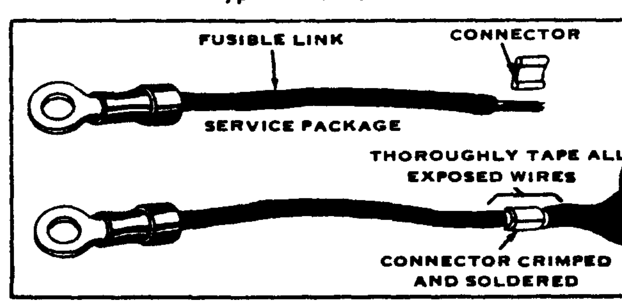
Therefore, after the short circuit is located and repaired, it is only necessary to replace the fusible link rather then an entire wiring harness or major electrical component. Always replace fusible links with this cable or protection of the link will be lost.

To replace the fusible link proceed as follows:

1. Disconnect the negative battery cable.
2. Remove the fusible link from the junction block.
3. If necessary, remove the fusible link connection covering to expose the connector. Cut the wire directly behind the connector.
4. Bare all wires, including the fusible link, approximately 1/2".
5. Position the clip around the wires and crimp so that all wires are securely fastened.
6. Solder the connection using rosin core solder. Use sufficient heat to obtain a good solder joint.
7. Tape all exposed wires with plastic electrical tape to prevent corrosion and shorting.
8. Connect fusible link to junction block.
9. Connect negative battery terminal.



Typical Fusible Link



Installing New Fusible Link

Additional special cables are available, which have been designed for particular situations. Reference to the Delco Cable catalog 16A100 will acquaint you with:

1. Generator brush lead cable
2. Test lead and charger cable
3. Flex-O-Cord
4. Super Duty plastic cable
5. Non Metallic Loom
6. Trailer-Tractor cable

Selection of these special cables for specific installations will result in extra cable life and less vehicle downtime. Using Delco cable and exercising good installation techniques will result in trouble free, long life electrical circuits. (Figure 16)

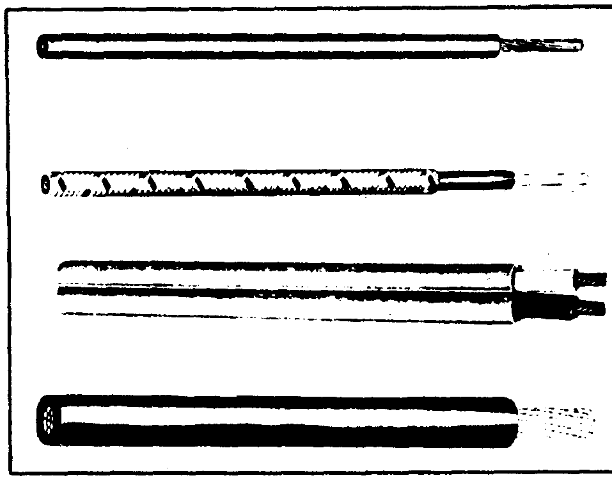
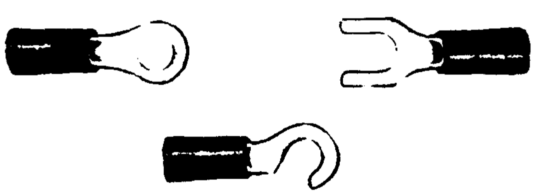
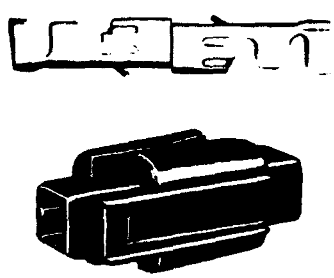


Figure 16 - Cable Examples

PRIMARY TERMINALS



INSULATED SOLDERLESS TERMINALS



TWIN LOCK CONNECTORS

Primary Terminals

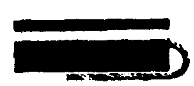
Insulated solderless terminals and splice connectors provide a good mechanical and electrical bond for applications on wire sizes from 22 gauge to 10 gauge. The terminals are applied with solderless terminal tool No. 1400. The terminal insulation grips the conductor insulation to give improved mechanical strength.

Twin lock terminals provide a means for making a snap connection between wires with one No. 7651 terminal and one No. 7660 connector body used for both male and female.

SPARK PLUG AND COIL LEAD TERMINALS

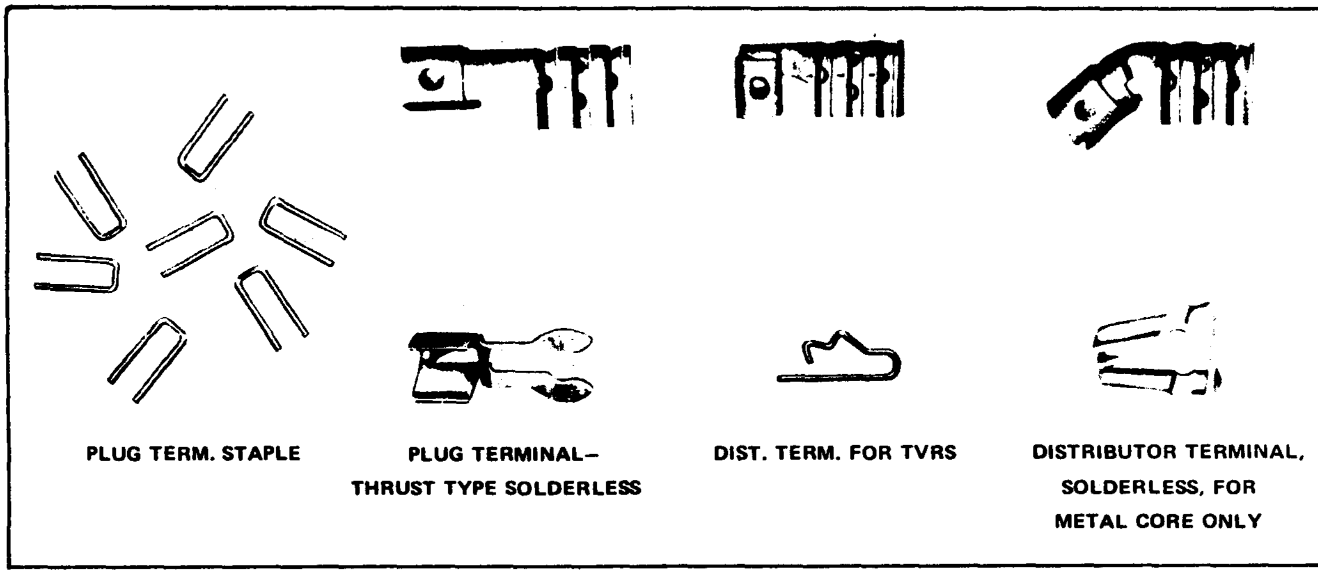
Terminals for TV R Suppression cables must be attached by using a staple, which provides a connection between the cable core and the terminal body.

MONEL METAL STAPLE (#7920) provides contact with cable core & plug terminal. Must use with all suppressor (TVRS) cable. Stainless steel will not rust.



(With metal core cable, strip 3/4 inch of insulation from cable core & fold core back over cable jacket.)

Staple and Metal Core Spark Plug Terminals



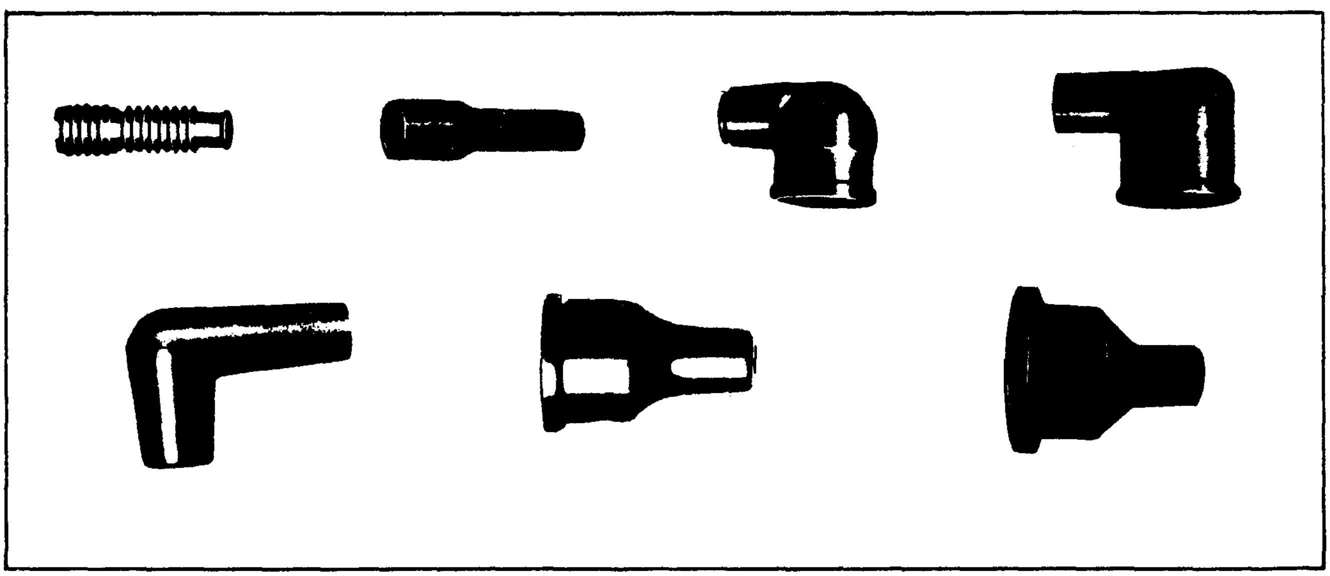
Ignition Terminals

It is recommended that United Delco staples be used to install all spark plug terminals and to terminate all distributor ends of plug wires and coil leads.

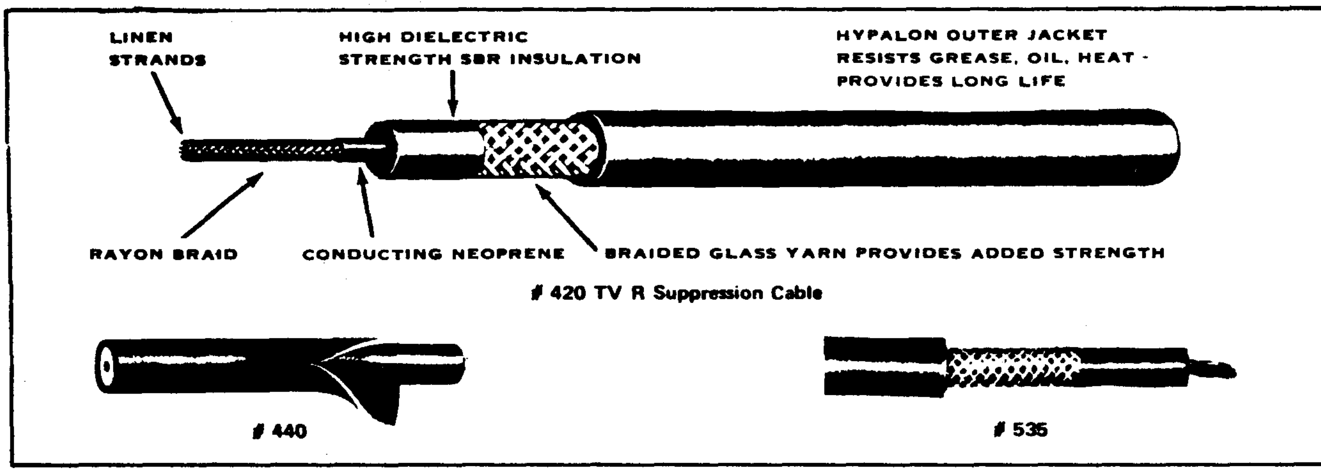
Terminals for metal core cables are attached by stripping 3/4 inch of insulation from cable core, folding core back over insulation and crimping terminal body on to the cable providing contact to the cable core.

On applications where extreme vibration and corrosion are encountered, soldering the terminal in addition to crimping, on metal core cables will result in longer cable life.

Extremely important parts of the spark plug wiring are the distributor and coil nipples and the spark plug boots. Todays' high compression engines require a high spark plug firing voltage. Good quality, tight fitting nipples and boots will keep dirt and moisture off the plugs and out of the distributor and coil towers. Clean, dry connections will not allow the high voltage to escape to ground.



Boots and Nipples



High Tension Ignition Cable

HIGH TENSION IGNITION CABLE

WHY SUPPRESSOR IGNITION CABLE

The operating characteristics of automotive ignition systems are such that during normal operation certain high frequency electrical signals are produced. These signals tend to interfere with car radio and television reception. Practically all automotive ignition systems incorporate some form of resistance or suppression to eliminate this undesirable interference.

One of the most common methods of suppression is the use of secondary ignition suppressor cable. This type of cable serves the dual purpose of conducting current at required voltages to the spark plugs and, at the same time, because of sufficient resistance incorporated over its entire length, eliminates radio interference. It should be recognized that controlled resistance is needed in the secondary ignition circuit and that it does not affect spark plug firing voltage.

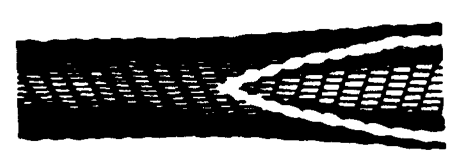
Various types of insulation and conductor core are available for special applications. For most applications, Hypalon insulation is used since it resists oils, fuels, chemicals, heat and abrasion. Silicone rubber insulation should be used where extremely high temperatures cause early failure of cable insulation.

INSTALLATION TIPS

NON–METALLIC LOOM

Cable which passes over a sharp edge of any kind, or is subjected to crushing or constant rubbing, should be protected by tape or a piece of loom over the section or sections subjected to such conditions.

Non-Metallic Auto Loom (such as Delco No. 1205) is a seamless, spirally woven conduit designed for use in protecting cable, fuel and oil lines. Some operators use loom to cover all cables that are exposed on the exterior of the truck or trailer. The use of loom is not generally considered necessary with Delco Super Duty cable, which is more economical in cost and installation expense than other cable installed in loom.



Non-Metallic Loom

SUPPORTING CABLES WITH WIRING CUPS

Wiring clips should be used liberally so that cables will be well anchored. This will prevent vibration which causes abrasion of the insulation and destructive flexing of the copper conductor. A choice of push-on or bolt-on type clips is available. For speed and convenience, the push-on can be used wherever it can be slipped over a flat metal edge. The bolt-on clip will handle most other installations.

Tr. No. 7690

Tr. No. 7691

Wiring Clips

METALLIC CONDUIT

Metal conduit provides extra protection against abrasion, crushing and weather conditions, but due to its higher cost and installation expense it is not commonly used on most types of trucks and trailers. However, the Association of National Tank Truck Carriers, Inc., recommends that metal conduit always be used on tank-trucks.

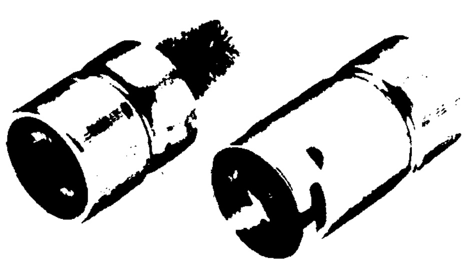
A common source of trouble on many trucks is the directional signal mounted on the front fender without adequate protection for the cable on the under side of the lamp base. In this case, the cable is suspended under the fender, and passes through an opening into the engine compartment. In winter, snow and ice build up under the fender and around the cable until the ice breaks loose from the fender and falls off... Often breaking the cable. Road splash is also thrown into the base of the directional signal lamp causing corrosion of the ground connections.

To prevent this condition, mount a small junction box directly under the directional signal lamp base and run flexible metal conduit from the box to the engine compartment openings. Each end of the conduit should be attached with a coupling. Attach a piece of cable to the lamp pig-tail connection and run the cable through flexible metal conduit into the engine compartment. This type of installation will seal out road splash and have sufficient strength to resist breakage of the cable or connections by accumulated ice and snow.

TUBING OVER SPARK PLUG CABLES

On some engines, the spark plug cables pass very close to the exhaust manifold and are subjected to extreme heat. The cables can be partially protected from radiated heat by sliding a length of loom over the exposed section (Delco Nos. 1204 and 1205) or a length of glass braided tubing generally available from electrical supply houses.

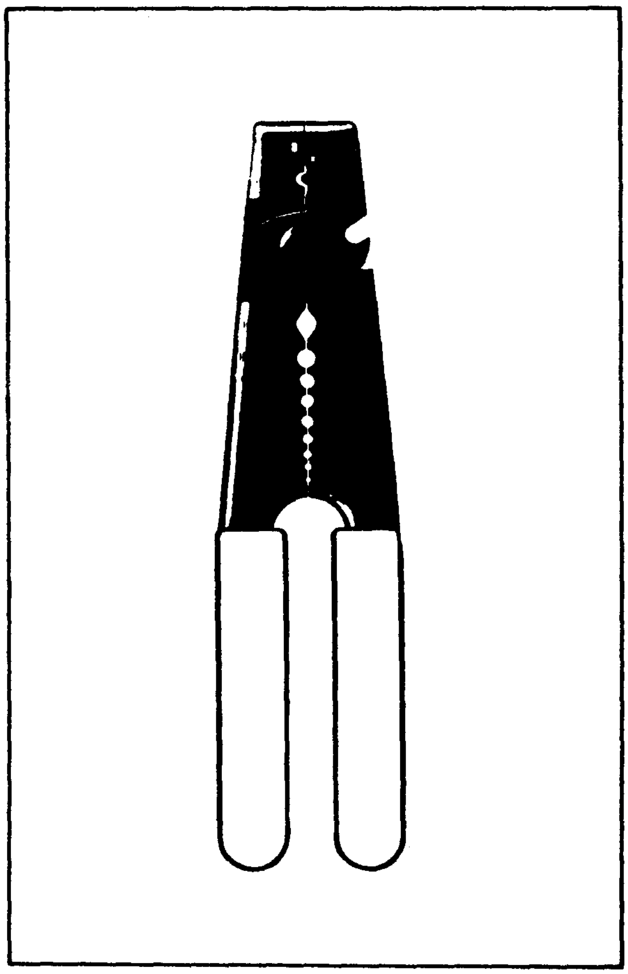
TOOLS



M16-115 Terminal and Post Cleaner

When installing battery cables, the M16-115 United Delco tool is recommended for insuring good battery connections. It is easy to remove oxide from the surface of battery posts and terminal post holes. A procedure especially important when using lead type terminals. Brass battery terminal jaws should spread apart far enough so the terminal can be installed easily. This problem, of course, is not encountered with the United Delco Spring Ring type battery terminal. Simply insert a screwdriver between the tangs of the terminal to spread the jaws and install on the post. Never force or hammer the terminal, either nut and bolt or Spring Ring type onto the battery post.

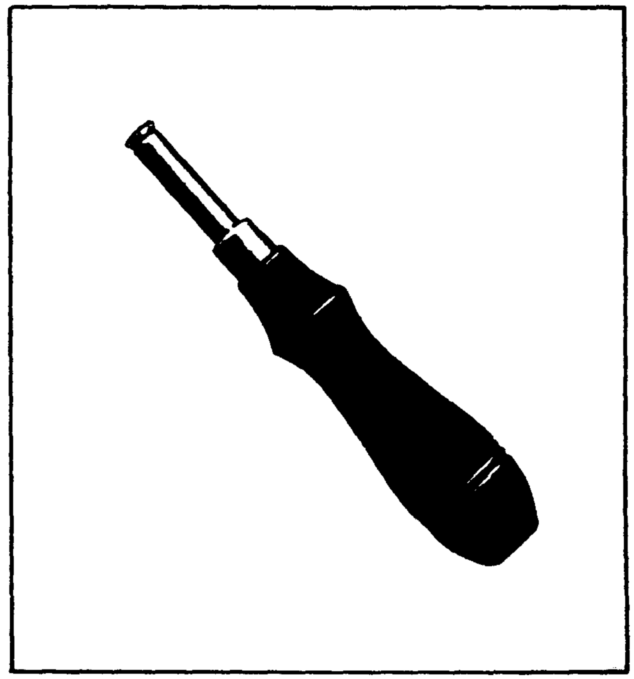
The 1400 tool attaches solderless terminals by indenting the terminal into the copper strands and compressing the wings to grip the insulation. It can also be used to cut and strip cable and to close the wings of other types of terminals including spark plug terminals. Other types of terminals can be attached with the 1400 tool by bending the terminal wings around the copper strands and indenting the terminal into the copper strands. The 1400 type tool is required for attaching United Delco "Snap-Fast" and twin lock terminals.



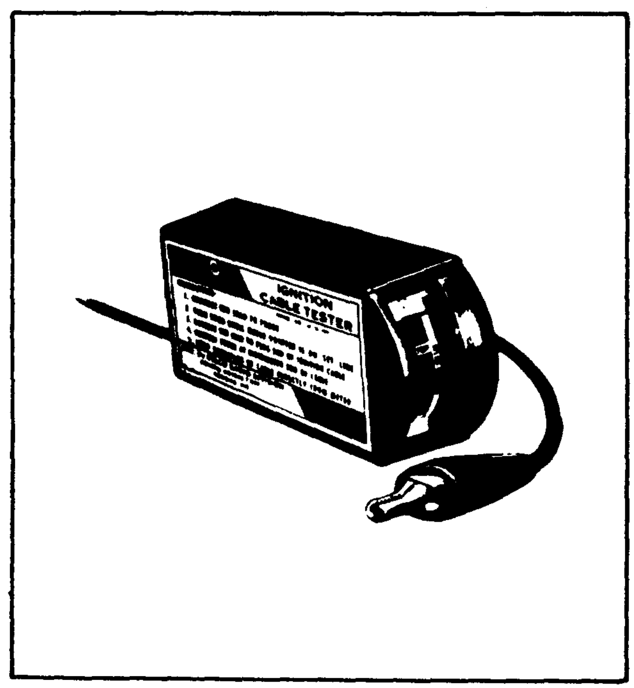
1400 Terminal Attaching Tool

Delco Ignition Cable Tester (M16-109) provides the cable installer with an easy accurate means of checking for bad cables and/or connections in the ignition circuit. This tester will check all brands and types of ignition cable. It also checks for continuity or "shorts" in switches, bulbs and connectors in primary circuits.

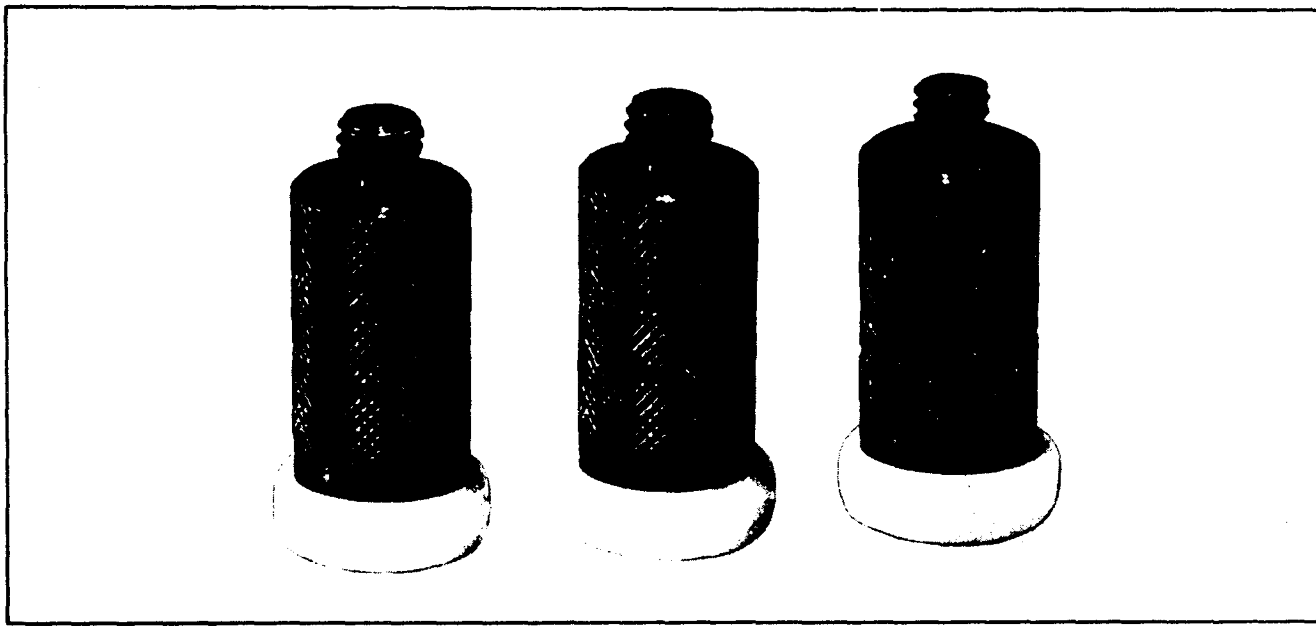
Cleaning out corrosion in distributor head towers is a required operation when replacing ignition cables and this can be done very efficiently with United Delco No. 146 tool.



146 Distributor Cap Cleaning Tool



M16-109 Delco Ignition Cable Tester

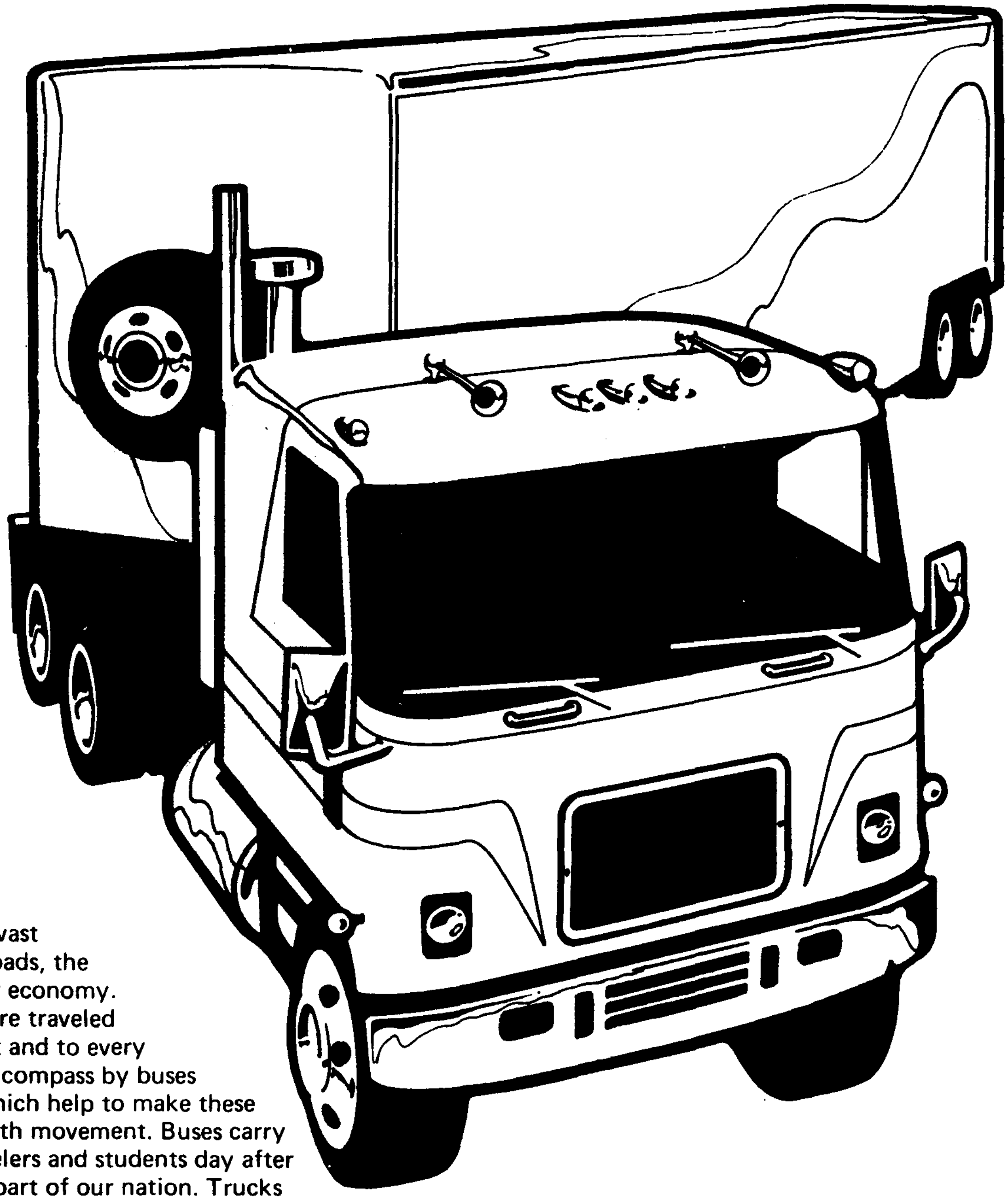


Energizer S/T Charging Adapters

When charging or testing an Energizer/ST it is necessary to use Delco Energizer/ST terminal adapters, Cat. No. BT-3573. The tips are insulated to prevent accidental shorting. The adapter is knurled for hand tightening, no tool is required.

The adapter makes contact on the face of the terminal rather than the bolt threads. The Terminal adapters are long enough to accept all charger clamps.

FLEET SECTION



Our nation is covered by a vast network of roads, the lifeline of our economy. These roads are traveled day and night and to every corner of the compass by buses and trucks which help to make these roads alive with movement. Buses carry tourists, travelers and students day after day in every part of our nation. Trucks plying the roads carry almost every type of product necessary to feed, clothe, and maintain our nation. To keep the buses and trucks operating efficiently and safely, good cable or wire is a necessity. As roads are the nerves of the nation, so cable is the nerve center of the bus or truck. Good cable assures the most efficient, economical and safe operation. It reduces costly breakdown and helps to reduce tie up time on buses and trucks. Because wiring is so vital, the selection of cable for various wiring or rewiring needs should be guided by two considerations. Cables should be of proper gauge size to handle maximum required electrical loads. Cables should feature insulating and covering materials which provide the longest cable life possible. The Sections following will supply aids in selection of proper gauge, proper cable, understanding the necessity of good quality cable, and C.F.R. and A.T.A. regulations.

SEMI TRACTOR CRANKING CIRCUIT

At first glance it would appear that the cranking motor is the heart of the cranking circuit, and it certainly is important. However, it can only convert the electrical energy supplied by the battery to mechanical energy to crank the engine. With insufficient power supplied by the battery, the cranking motor cannot do its job.

Therefore, the starting point for proper cranking circuit operation is to be sure that the cranking power of the batteries is at least equal to that of the original equipment batteries. You will notice that we said cranking power, not ampere-hours. The ampere-hour rating is a measure of the batteries ability to supply a light load for a long period of time, not cranking power. That is why Delco went to the peak watts method of rating batteries. This rating indicates the cranking power available at 0° indicated in watts. The higher the rating, the more cranking power is available.

Battery capacity is especially important on units using the Delco Remy 12 volt high performance cranking motor in lieu of the former 24 volt cranking motor used with a series parallel switch.

Even with a battery of sufficient capacity and a good cranking motor, cranking problems can occur if the cables which connect the two together are not large enough to do the job. It is not sufficient for cables to look good and be in good condition, they must also have the proper current carrying capacity.

One way to determine if the cables are large enough is to make a voltage drop check of the cables. This should be done by measuring the cranking current and voltage drop between the battery and the cranking motor with the engine at operating temperature. The voltage drop should be no greater than the following:

24 volt system — 1.2 volts per 1,000 amps.
12 volt high performance system — .75 volt per 1,000 amps.

For Example: At 500 amps., the maximum voltage drop on 24 Volt system would be .6 volt and 12 volt high performance .4 volt.

If new cables are being installed, the proper size can be determined by measuring the total length of the cranking circuit (including any portion of the vehicle frame used to carry the current) and using the following charts.

A good idea is to stock #00 cable and parallel two of them if larger cable is required. Stranded copper cable is recommended.

TABLE I
24 VOLT AND 32 VOLT SYSTEMS

Total Length of Cranking Circuit	Size of Cable
Up to 188"	#0
188" – 237"	#00
237" – 300"	#000
300" – 380"	#0000

TRAILER CIRCUITS

CABLE GAUGE RECOMMENDATIONS and COLOR CODING for REWIRING

These recommendations conform to American Trucking Association Specifications No. E-3-1961 April 10, 1961.

Note: For exceptionally long trailers, check cable gauge size chart, to be sure gauge sizes are large enough.

7-CONDUCTOR CONNECTOR PLUG CODING

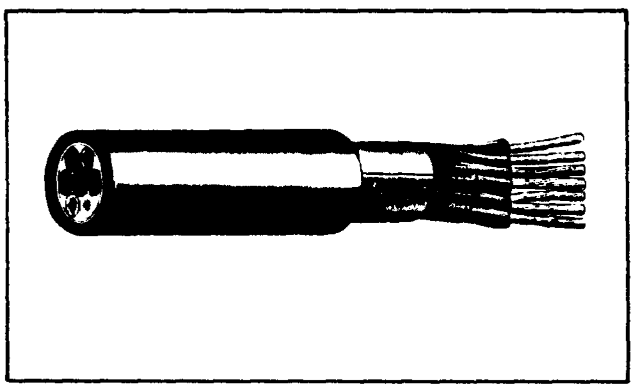
No. 1 – White 10 ga.–Ground return to towing vehicle.	No. 4 – Red 8 ga.–Stop Lamps.
No. 2 – Black* 12 ga.–Identification, clearance, and side-marker lamps.	No. 5 – Green 12 ga.–Right Hand Turn Signal and Disability Signal.
No. 3 – Yellow 12 ga.–Left Hand Turn Signal and Disability Signal.	No. 6 – Brown* 12 ga.–Tail, Clearance, and side-marker lamps.
	No. 7 – Blue 12 ga.–Auxiliary.

Ground return for all circuits–10 ga. white

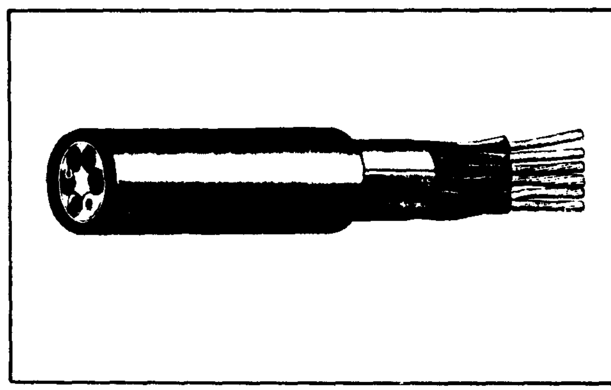
All auxiliary circuits–12 ga. blue

* An effort should be made to balance the number of clearance and marker lamps on these two circuits. Rear identification lamps are to be on the Black circuit and the tail lamps are to be on the Brown circuit.

TRACTOR–TRAILER CORDS



Seven Conductor Cord

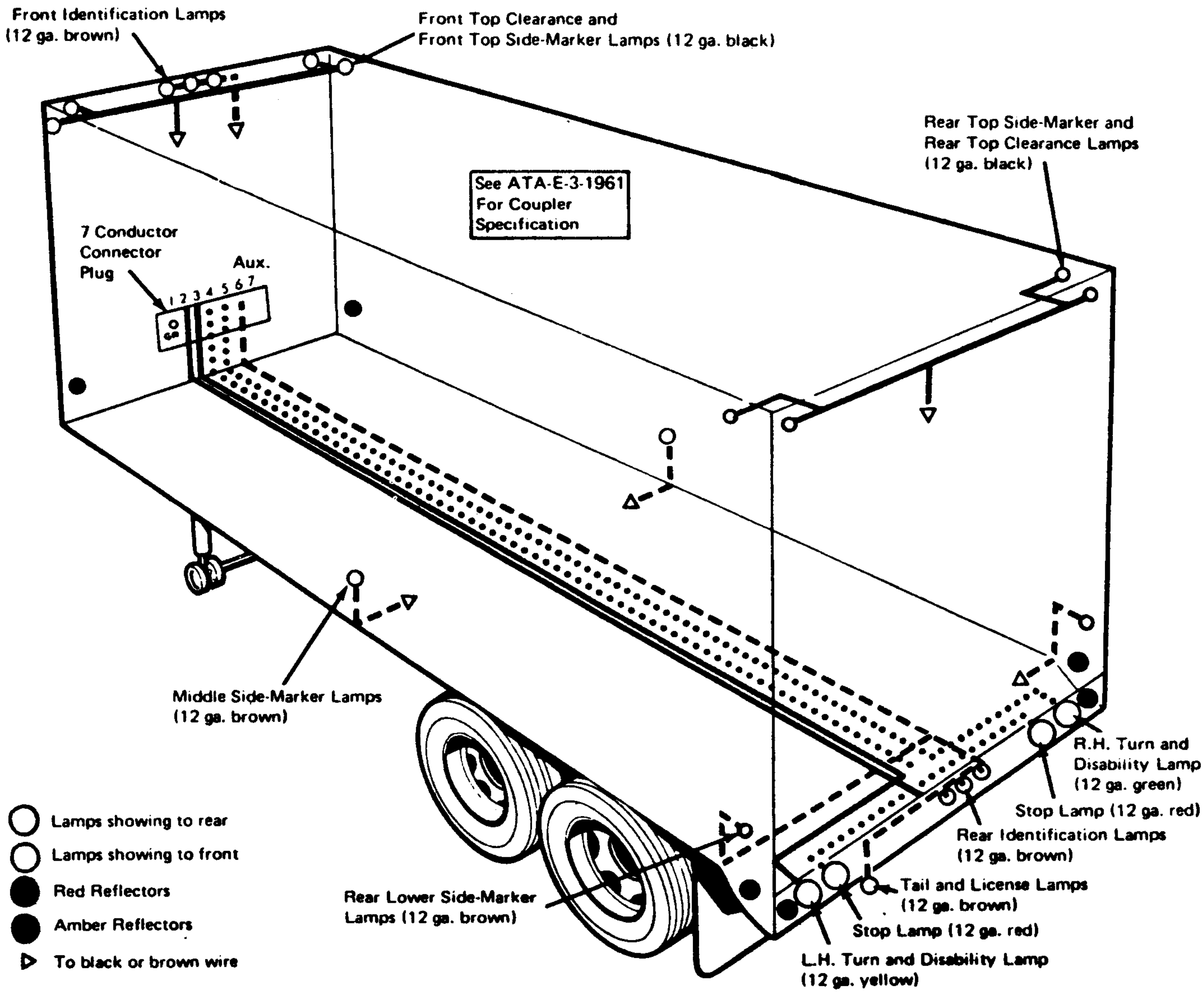


Six and Four Conductor Cord

Seven - Conductor Cord (Delco No. 197-D, 50ft. and No. 197, 100ft.) exceeds American Trucking Associations, Inc. specification No. E-I-1961 and the applicable SAE specifications.

The A.T.A. recommends that all operators standardize on the seven - conductor cord. It has heavy gauge size conductors to carry the electrical current without excessive voltage drop. (Six 12-gauge conductors for power supply and one 10-gauge conductor for ground return).

Delco Trailer Cords have proved themselves by years of satisfactory service. The individual synthetic rubber-insulated conductors are twisted and then covered with a separator. A heavy outer jacket of rubber then covers the separator, which provides overall protection for the conductors.



Seven Conductor Cord Wiring Diagram

DELCO CABLE NUMBERS FOR TRAILER WIRING

12-Gauge Cable				
Connector Pin No.	**Code**	**Color**	**Plastic Covered**	**Insulex**
6	▬ ▬ ▬ ▬ ▬ ▬	Brown	954	812X
2	▬▬▬▬▬▬▬	Black	954-B	812-BX
5	● ● ● ● ● ● ● ● ● ● ●	Green	954-G	812-GX
4	● ● ● ● ● ● ● ● ● ● ●	Red	954-R	812-RX
7	▬ ▬ ▬ ▬ ▬	Blue	954-U	812-UX
3	▬▬▬▬▬▬▬	Yellow	954-Y	812-YX
1		White	954-W	812-WX

LIGHT LOCATIONS

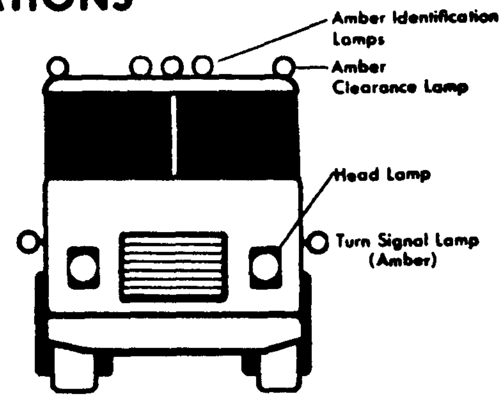
The approximate light locations illustrated, conform to the specifications in the American Trucking Associations Specification E-3-1961 and the requirements specified in the Code of Federal Regulations, 49, as of January 1971. If additional information is required, copies of these regulations and specifications may be obtained from:

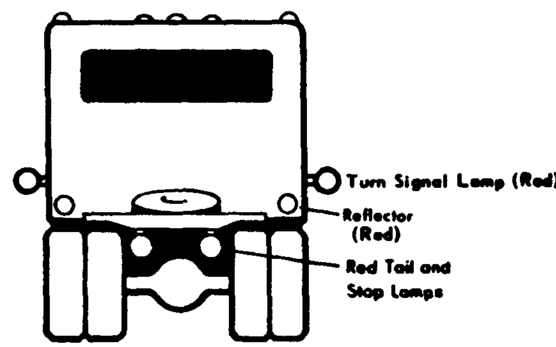
Specification E-3-1961
American Trucking Associations, Inc.
1616 "P" Street, N.W.
Washington, D.C. 20036

Code of Federal Regulations, Title 49
Superintendent of Documents
U.S. Government Printing Office
Washington 25, D.C.

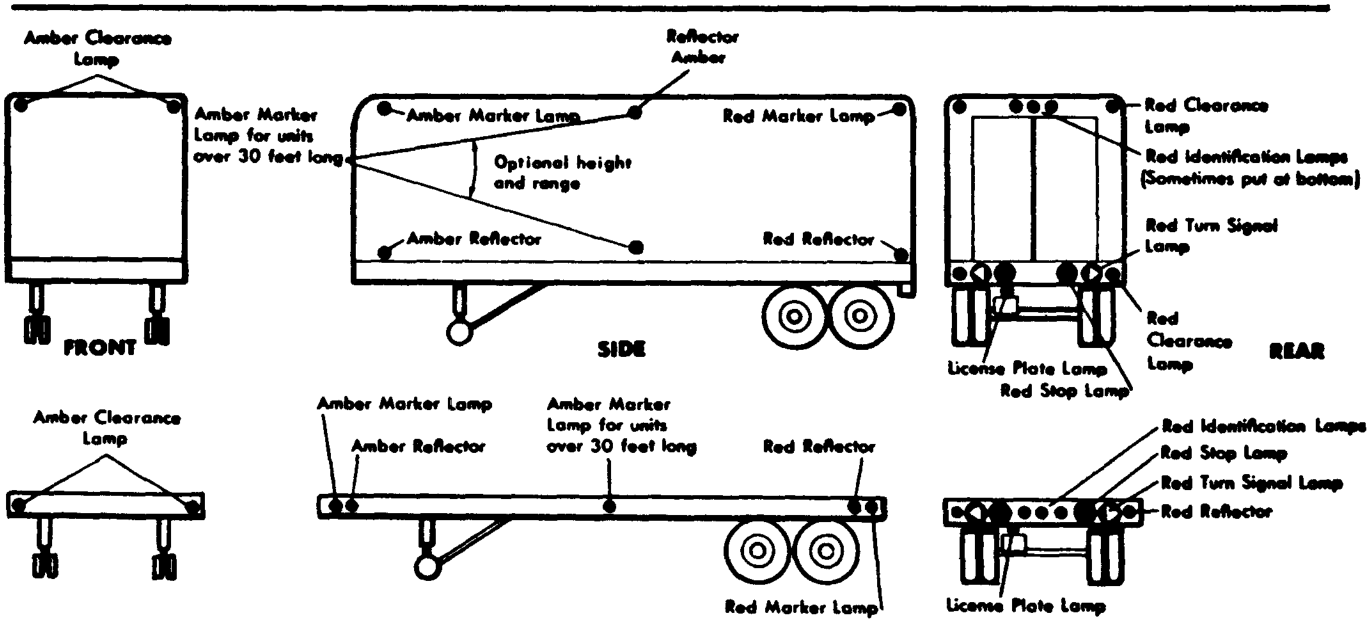
Note: The Interstate Commerce Commission "Motor Carrier Safety Regulations" are incorporated in the Code of Federal Regulations, (Page 36)

Note: Spacing of identification lamps is not specified in the Code of Federal Regulations, but certain states require a spacing of not less than six inches nor more than twelve inches measured from center to center of lens.

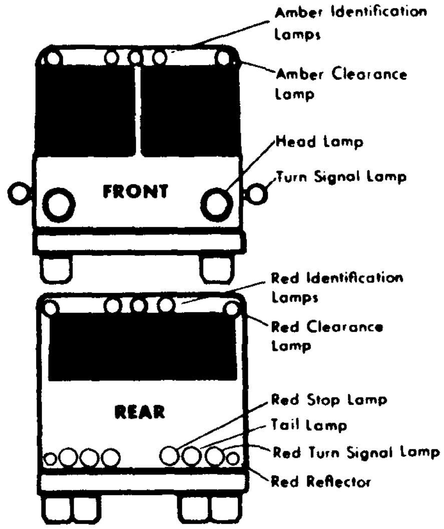


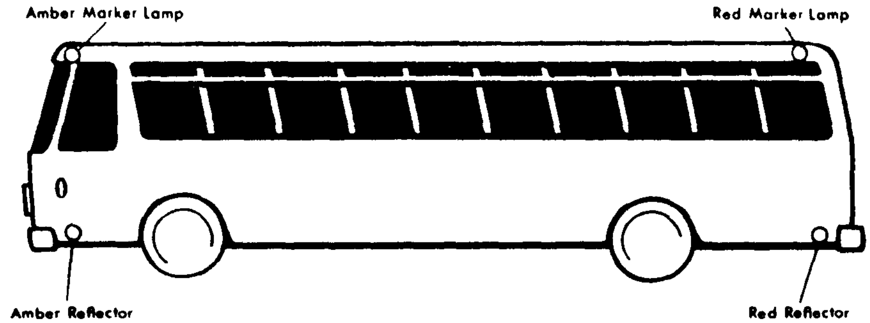


Truck Cab or Tractor



Truck Body or Trailer

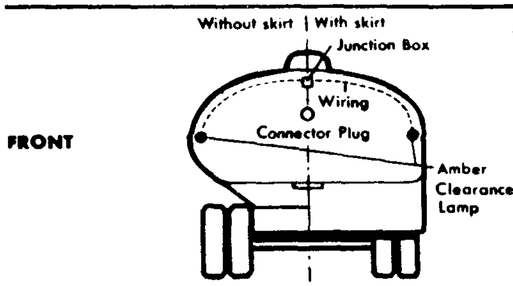


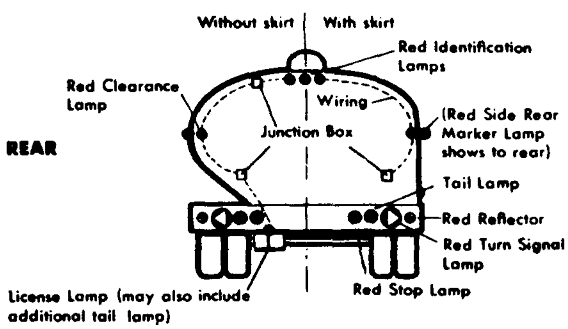


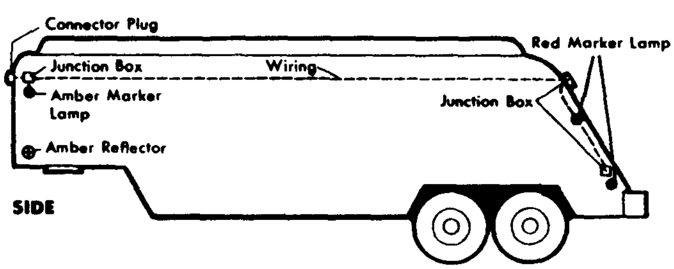
NOTE: Refer to C.F.R. "Motor Carrier Safety Standard" 108 Section 4.14 for school bus regulations.

Buses

Tank Truck







NOTE: Rear to be equipped with two stop lamps, two tail lamps and set of S.A.E., Class A, Type 1 directional signals. Any or all three of these type lamps may be in the same housing. All lamps required to conform to the requirements of 1964 S.A.E. Standards.

1. Drawing illustrates only general locations of lamps, reflectors, junction boxes and wiring. Wiring is shown with main line on roadside, outside overturn protection with branch lines to curbside, but main line may be on curbside.

2. Clearance lamps (lamps showing width of vehicle) are to be separate from lamps showing length (side marker lamps). Axis of lamp to be within 15° of direction in which lamp is supposed to face.
Clearance lamps may be mounted at optional heights, but must indicate the extreme width of the vehicle.

3. Cable should be color coded and wired as per current ATA-SAE recommended standard.*

4. Cable to be enclosed in metallic tubing; to be outside of overturn protection; not to be located beneath tank; and to be provided with at least junction boxes shown.

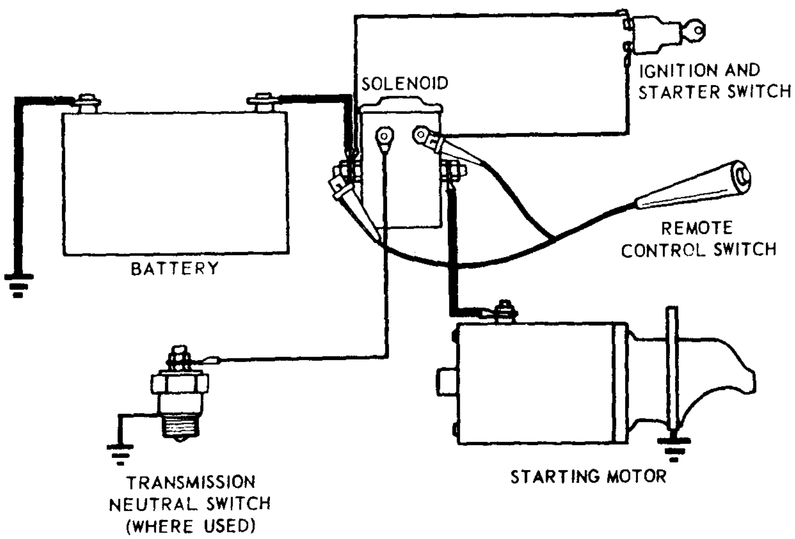
5. Wiring shall be at least as good as type known as Type 3 which requires wiring in conduit with threaded joints; waterproof and vapor-proof connections at lamps; no boxes required around lamps.

6. All lamps, reflectors, wiring and terminal to comply with ICC requirements.

7. Reflectors to be smooth faced plastic.

*Most Delco Cables exceed applicable S.A.E. Specifications.

THE STARTING CIRCUIT



THE STARTING CIRCUIT

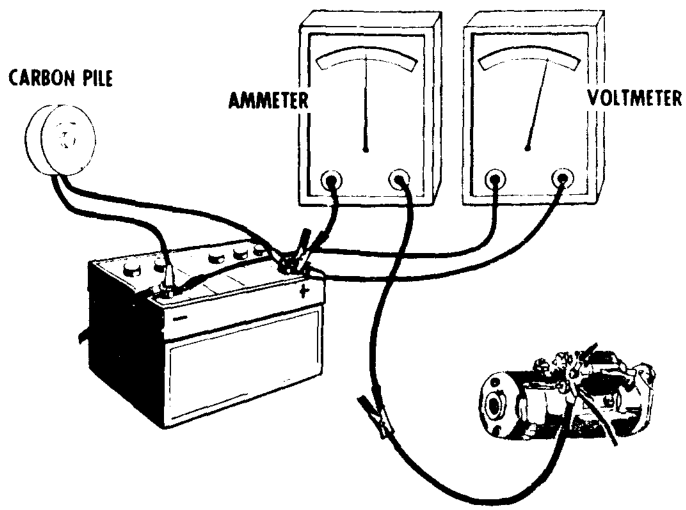
A starting motor, starting switch, battery, and cables, which comprise the starting circuit, provide the power for cranking the engine. The motor receives electrical power from the battery and converts it into mechanical power which is transmitted to the engine through a drive pinion gear and the flywheel ring gear. The starting switch controls the operation by making and breaking the circuit between the battery and the motor.

The battery, starting motor, starting switch, and the wiring are all designed for the high current flow needed to produce efficient cranking power. The condition of these components is extremely critical, as even a small amount of resistance can cause a marked reduction in cranking ability. This indicates the necessity for testing the various components in the starting system.

The starter is connected in series with the battery. This is known as the high-amperage circuit. The solenoid is the switch between the battery and the starter, and is activated by a low current carrying circuit known as the control circuit.

When using a solenoid starter switch (remote control switch), **follow the hook-up instructions** that came with the switch to avoid the possibility of damaging the starter control circuit on the vehicle. For example, if the remote control switch lead is clipped to the solenoid terminal of the transmission neutral switch, the neutral switch will be burned out when the remote control switch is actuated. Also observe the precautions for remote control switch use that are covered in the Compression Test of the Tune-Up Procedure near the back of this text book.

STARTING MOTOR AMPERAGE DRAW TEST



STARTING MOTOR AMPERAGE DRAW TEST

The starting motor amperage draw test is an on-the-vehicle check conducted with a Battery Starter Tester to detect trouble in the starting motor. If the starting motor is operating properly its amperage draw will be within specifications, 150 to 200 amperes for example, and the cranking speed will also be normal, for example 180 to 250 rpm.

So that this test can be considered a true test of the starting motor, other influencing variables will be considered to be within limits. The battery is more than ¾ charged; the cable clamps are clean and tight; the engine oil is of the recommended viscosity, and the engine temperature is normalized. Further, it is considered that the starter solenoid connections are tight, the ignition switch is functioning properly and the starter insulated and ground circuits are normal.

The Battery Starter Tester is designed with a high-reading ammeter, a voltmeter and a carbon pile which is a high-capacity variable resistor.

The starting motor amperage draw test is conducted as follows:

- Connect the tester leads.
- Connect a jumper lead from the distributor primary terminal to ground to prevent the engine from starting. Some manufacturers recommend disconnecting the primary lead from the coil, others suggest grounding the coil secondary lead.
- Crank the engine and accurately observe the EXACT voltage indicated on the voltmeter.
- Without cranking the engine, turn the tester carbon pile control until the voltmeter again reads the EXACT voltage it did while the engine was being cranked. Then read the ampere flow on the ammeter and release the tester carbon pile control. The ammeter reading is the starting motor amperage draw and should be within the manufacturer's specifications.

Higher than normal current draw, usually associated with slow cranking speed, is an indication of mechanical or electrical trouble in the starting motor. Remove the starter for repair or replacement.

Lower than normal current flow, also associated with slow cranking speed, indicates high resistance. This condition is caused by poor connections in the field or armature circuits; poor brush and commutator contact; or a defective commutator condition. Starting motor removal for service or replacement will be required.

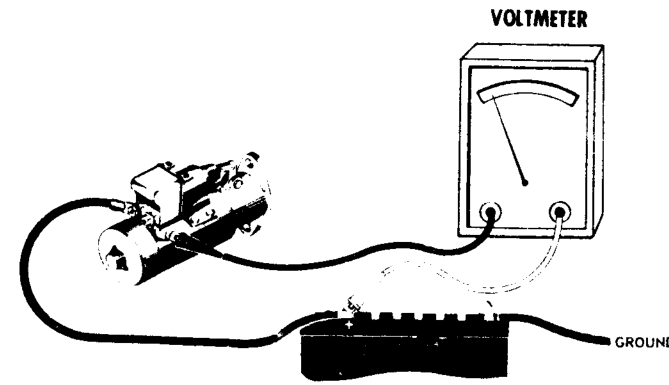
As a word of caution—do not be too quick to condemn the starting motor unless you are certain the other factors, previously mentioned, are known to be functioning properly.

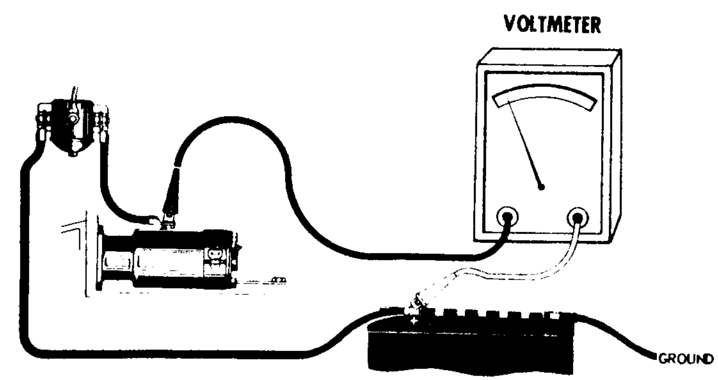
STARTER INSULATED CIRCUIT TEST

Loose or dirty connections or defective cables represent a power loss between the battery and the starter. Circuit resistance tests are made to determine if the insulated cable, switches, and ground connections can carry the current demanded by the starter. This resistance is indicated by a voltage drop. VOLTAGE DROP is the voltage expended in overcoming resistance in a given circuit. Permissible voltage drop in the average starter insulated circuit is .3 volt. The voltage drop allowed in this circuit is .1 of a volt per cable or switch. If the resistance is excessive, the result will be an extreme power loss in the starting system. When a starter motor is in operation, the high-amperage draw magnifies this seemingly low resistance value. This greatly reduces the efficiency of the entire starting system. Therefore, the circuit resistance tests are performed while the system is under normal cranking load.

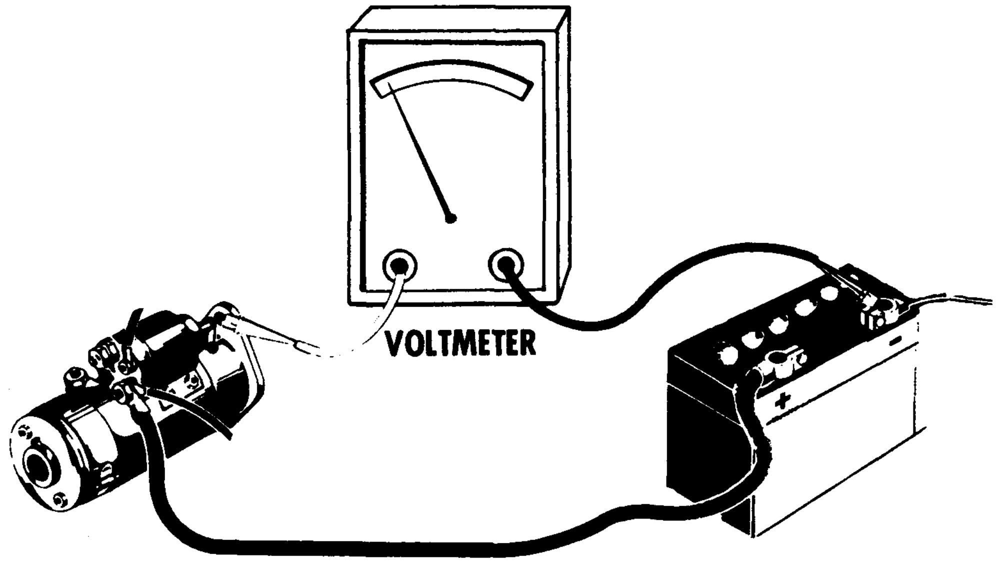
To test the insulated circuit, one voltmeter lead is connected to the insulated battery terminal and the other voltmeter lead is connected to the large armature terminal on the starting motor or solenoid. Crank the engine and observe the voltmeter. If the voltage drop for the entire circuit is not excessive, objectionable resistance does not exist and no further testing is necessary. If the test results indicate excessive resistance, separate detailed tests of each component in the circuit must be conducted.

STARTER INSULATED CIRCUIT TEST

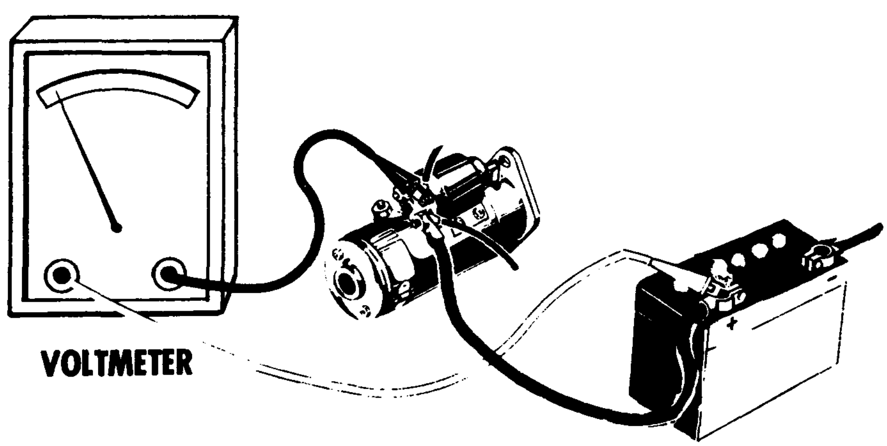




STARTER GROUND CIRCUIT TEST



SOLENOID SWITCH CIRCUIT RESISTANCE TEST



BATTERY CAPACITY TEST

Most engine starting failures are caused by the inability of a battery to maintain a voltage high enough to provide effective ignition while cranking a cold engine.

THREE MINUTE CHARGE TEST

A battery that is less than fully charged may be tested with a fast battery charger and a "Three Minute Charge Test." A fast battery charger is used in conjunction with the Battery/Starter Tester for this test. Fast charge the battery three minutes at not more than 40 amps for a 12-volt battery and 75 amps for a 6-volt battery. With the charger in operation, observe the voltage of the battery. If the voltage exceeds 15.5 volts for a 12-volt battery, or 7.75 volts for a 6-volt battery, the battery is sulphated or worn out. This indicates that the plates will no longer accept a charge under normal conditions and the battery should be discarded.

BE SURE to observe all precautions relative to working around a battery while it is being charged. Explosive hydrogen gas is liberated from the electrolyte while the battery is being charged. Sparks from a lighted cigarette or from charger clamps being disconnected while current is still flowing may cause an explosion that will destroy the battery and possibly inflict personal injury.

Also BE SURE that all the precautions that are relative to working on a battery installed in a car that is equipped with an alternator are observed. These precautions will be fully covered in our discussion on alternator charging systems. These precautions also pertain to a car equipped with a transistorized ignition system or transistorized fuel injection.

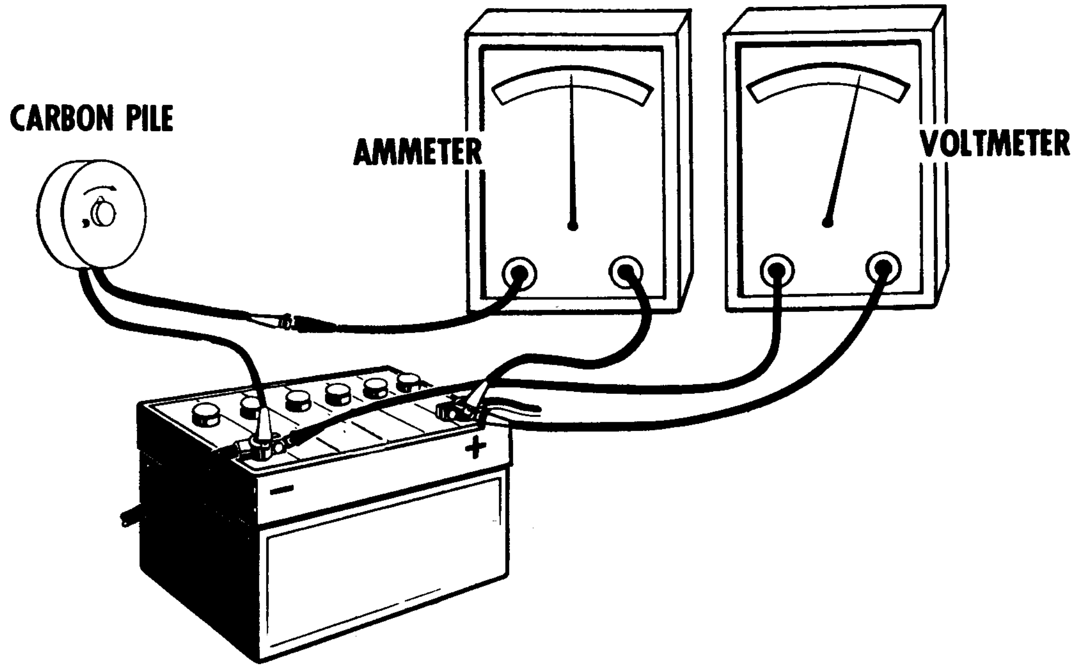
A battery with a one-piece, hard-top cover must be tested with the capacity test since individual cell tests cannot be conducted. Individual cell tests require that the meter test prods contact the cell connectors, by piercing the sealing compound if necessary. Under no circumstance should there be an attempt to pierce the one-piece battery cover with meter prods to conduct an individual cell test.

BATTERY CAPACITY TEST

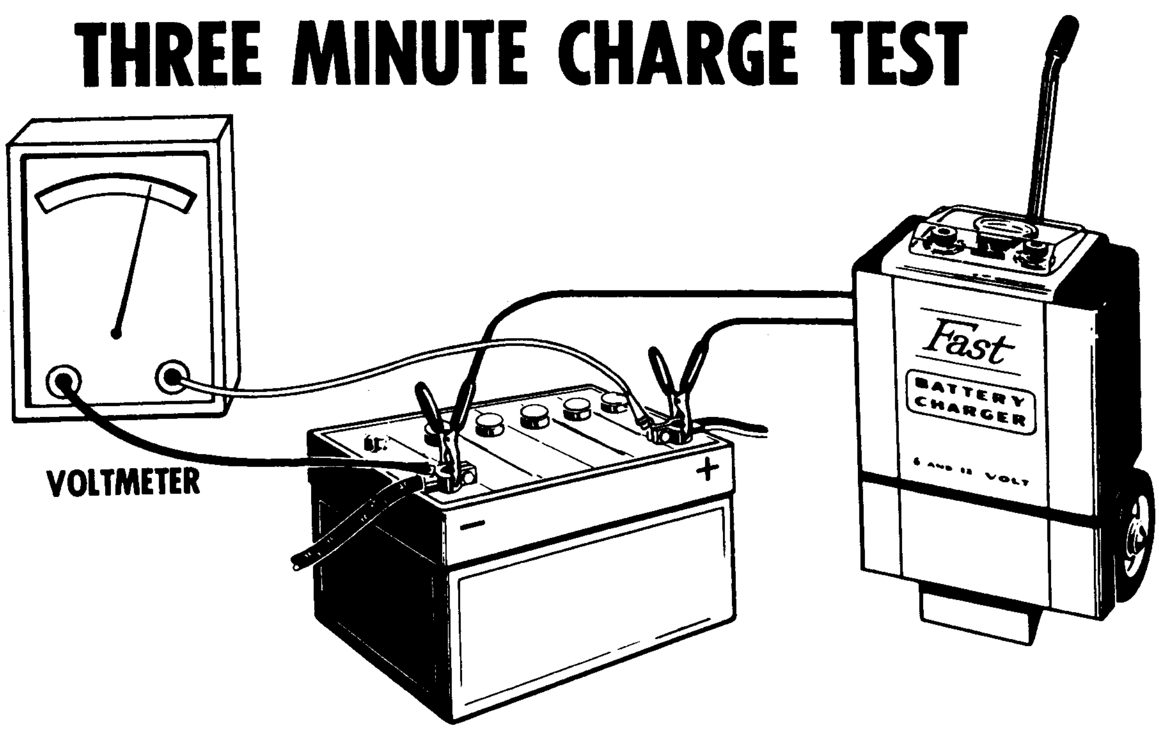
The function of the battery capacity test is to duplicate the battery drain of a cold engine start while observing the battery's ability to maintain voltage. A battery that passes the capacity test will provide dependable performance.

The Battery/Starter Tester has an ammeter, a voltmeter and a carbon pile, which is a battery loading device. The charged battery is discharged at a rate of three times its ampere-hour rating for 15 seconds while its voltage is observed. The voltage of a 12-volt battery should not drop below 9.0 volts or that of a 6-volt battery below 4.5 volts. A reading below this specification indicates a defective battery that should be replaced.

BATTERY CAPACITY (LOAD) TEST



THREE MINUTE CHARGE TEST



BATTERY VISUAL CHECKS

It has often been stated that the man who tests the most batteries, sells the most batteries.

Battery care and testing are relatively simple. A basic knowledge of how a battery is constructed, how it works, along with a few pieces of test equipment and simple test procedures, will provide any serviceman with the essentials he needs to provide excellent service in this money-making phase of tune-up.

The primary function of the battery is to provide power to operate the starting motor. It must also supply the ignition current during the starting period and accomplish this even under adverse conditions of temperature and other factors.

The battery can also serve, for a limited time, as a source of current to satisfy the electrical demands of the vehicle which are in excess of the output of the generator.

Batteries used in automobiles are known as storage batteries. This term storage battery is sometimes misinterpreted. A battery does not store electricity but does store energy in a chemical form. It accomplishes its task by a chemical process which takes place inside a battery when it is connected to a complete circuit.

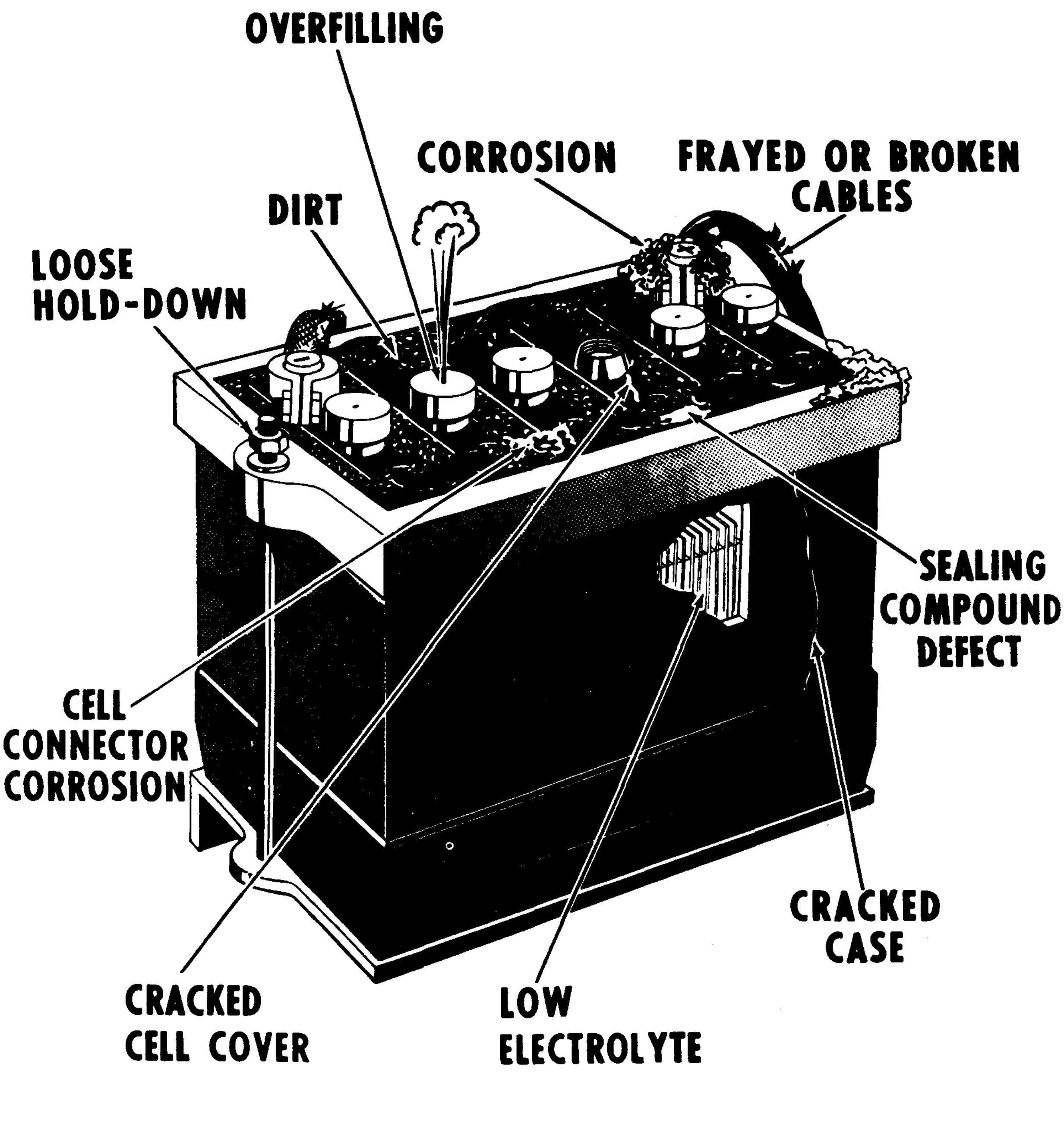
Basically stated, a battery is composed of two dissimilar metals in the presence of an acid. The battery is constructed of a series of positive and negative plates. These plates are insulated from each other by means of separators. All the positive plates are interconnected and all the negative plates are interconnected. These interconnected series of positive and negative plates are submerged in the container filled with a sulphuric acid and water solution known as "electrolyte".

The first test of a battery is a visual inspection. If a battery is cracked or otherwise defective, it must be discarded. If the electrolyte level in the battery is low, or if the ground connections or insulated connections are defective, the battery cannot operate efficiently. It is also very important that the battery be kept clean. Dirt and moisture can serve as a conductor and slowly discharge the battery over a period of time.

When activating a dry-charge battery, follow the battery manufacturer's service procedure and be sure to fill each cell properly with the electrolyte supplied. Apply a warm-up charge of 15 amperes for 10 minutes after activating the battery, when so instructed. Observe charging cautions.

Dry-charge batteries will be damaged if moisture enters the battery while it is stored. Always store dry-charge batteries in the coolest, and driest location possible.

BATTERY VISUAL CHECKS



THE MAINTENANCE-FREE BATTERY

A new type of battery, called "maintenance-free," will be seen on some late model cars. It can easily be identified by its lack of filler caps; the top of the battery is a solid cover. These batteries are designed to operate without periodic additions of water throughout their normal service life. Since the addition of water is the only maintenance normally performed on batteries, the elimination of this service results in a truly maintenance-free battery.

Such batteries are still classed as lead-acid batteries and still function in the same manner as the conventional variety. The only difference is in the lead alloy used to make the plates. Conventional batteries use a lead-antimony alloy for plate construction because antimony increases the strength and casting qualities of lead. Pure lead, by itself, is not a suitable plate material.

Although antimony adds the necessary mechanical properties to lead, it also affects the electrical properties of the battery. It tends to increase a battery's normal self-discharge rate and also to lower its "gassing" potential.

Self-discharge is what causes an otherwise normal battery to gradually run down if left without charging for long periods, especially in temperatures over 60°F. Normally, this is not a problem for batteries in regular service, but can be for new batteries left in stock or for vehicles left unattended for long periods. Eliminating antimony minimizes this internal self-discharge.

"Gassing" is what happens to the electrolyte when a battery is under normal charge. This is what causes the water in the electrolyte to gradually "boil away." Actually, the water does not boil but, instead, is broken down by the charging voltage into its two elements—hydrogen and oxygen. By eliminating antimony from the plates, the voltage at which water breaks down, or "gasses," is raised. Therefore, at normal charging voltages, the original water in the electrolyte of a maintenance-free battery can last several years or more before it finally boils away.

In place of antimony, the lead in a maintenance-free battery is alloyed with calcium to give it the necessary manufacturing characteristics. Calcium, however, is a more difficult material to process and results in higher battery costs. But the result is a battery with a very low self-discharge rate and a greatly reduced tendency to boil off its water.

Although such batteries do not require servicing as do conventional ones, there are times when they must be tested to see if they are still serviceable. This is most commonly done with a battery capacity test as described previously. If the battery voltage under load remains above the specified minimum (typically 9.6 volts), the battery is considered serviceable. However, if it falls below the minimum, it could be either defective or merely in a discharged state. Before it can be condemned, further steps are needed.

If the battery has a built-in "hydrometer," evidenced by a small window in the cover, check to see if a green dot appears in the window. If it does, it means that the battery is sufficiently charged (over 1.225 sp. gr.) to be load tested. If it now fails the load test, it means that the battery is defective. However, if it fails the load test without the presence of the green dot, the battery must be recharged until the dot appears. It is then given a second load test.

Batteries without a built-in hydrometer, if they fail the load test, must be fast charged for a period of time specified by the manufacturer. If they fail the load test after the specified charge period, the battery is considered defective.

BATTERY RATING METHODS

Over the years, many methods have been devised to specify the capacity or electrical size of batteries. Presently, only three methods are commonly used: (1) the amp-hour method, (2) cold cranking performance and (3) reserve capacity. In addition to electrical rating methods, batteries are also arranged according to their physical size by "group numbers." Batteries with the same group number have the same dimensions and are physically interchangeable. However, they may have widely varying electrical capacities and for this reason are not always interchangeable.

THE AMP-HOUR METHOD

The Amp-Hour Method has been used for many years, although it is being gradually replaced by the Cold Cranking and Reserve Capacity ratings. A battery's amp-hour rating is determined by discharging a fresh, fully charged battery at a constant rate so selected that at the end of 20 hours the voltage will have fallen to 1.75 volts per cell (or 10.5 volts for a 12-volt battery). This discharge current, times 20 hours, gives the battery's amp-hour rating. For example, if the required discharge current was 3.0 amperes, the battery would be rated at 3 × 20 or 60 amp-hours. It should be noted that this does *not* mean that such a battery can be discharged at 60 amperes for one hour, or any other combination, with the same results. When replacing batteries, always replace with the specified, or higher, amp-hour battery.

COLD CRANKING PERFORMANCE

This is a more recent rating method designed to show a battery's cold weather cranking ability. A Cold Cranking rating shows how many *amperes* can be drawn from a battery at 0°F for 30 seconds before its voltage drops below 1.2 volts per cell (or 7.2 volts for a 12-volt battery). As a rough rule-of-thumb, a battery's Cold Cranking rating in amperes should approximate the engine's displacement in cubic inches. Most new batteries have this rating, and sometimes the amp-hour rating, imprinted on the battery cover. There is no convenient way to convert between amp-hour ratings and cold cranking ratings.

RESERVE CAPACITY

The Reserve Capacity rating is specified in *minutes* and indicates for how long a vehicle can be driven with battery only in the event of charging system failure. The rating is established by noting how long it takes a fully charged battery (at 80°F) to drop to 1.75 volts per cell (or 10.5 volts for a 12-volt battery) at a constant 25 ampere discharge rate. This discharge rate represents a typical nighttime electrical load with headlights and heater.

SOURCE: CHILTON 1979 PROFESSIONAL MECHANICS REFERENCE GUIDE (FACTORY BULLETINS)

COMPARING BATTERY RATINGS

For many mechanics, the battery manufacturer's change over from the AMP-hour to the cold cranking AMPS (CCA) rating system has been very confusing. Engineers at applied power's marquette tester division prepared this chart listing the CCA rating and its approximate equivalent in AMP-hours. If the load setting that you dial in on your battery tester is determined by the AMP-hour rating of a battery, use the chart to find the load to apply to late model batteries that are rated in CCA's. Remember the following two points:

-- The CCA rating is the amount of current a battery can deliver at $0^{\circ}F$ ($-17.6^{\circ}c$) without battery voltage dropping below 7.2 volts.

-- As a rule of thumb you should have 1 CCA of battery capacity for every cubic inch of engine displacement.

BATTERY RATING SYSTEM COMPARISON		
CCA	(AMPS x VOLTS) WATTS	COMPARATIVE EQUIVALENT AMP HOUR
200	1800	35 - 40
250	2100	41 - 48
300	2500	49 - 62
350	2900	63 - 70
400	3250	71 - 76
450	3600	77 - 86
500	3900	87 - 92
550	4200	93 - 110
600	4600	---

BATTERY RATINGS AND ENGINE CRANKING REQUIREMENTS

REGULAR COMMON CARRIER CONFERENCE MAINTENANCE COMMITTEE

The old familiar ampere-hour ratings of the past do not reflect modern-day engine cranking requirements. Because of this, SAE has changed over to a more meaningful rating system. This system, SAE J537h, is based on cold cranking ampere (CCA) and reserve capacity ratings and can be keyed directly to engine cranking requirements.

Likewise, diesel engine cranking specifications change. Using new battery ratings, the engine manufacturers have issued minimum cold cranking specifications for each engine.

NEW RATINGS—Cold Cranking Ampere Rating (CCA):

The requirements for this standard are that the battery be cold soaked until the center of the cell reaches 0°F. (−18°C.) and then discharged for 30 seconds at the rate which will provide at least 1.2 volts per cell at the end of this time. This discharge rate is the "Cold Cranking Amperes."

OLD RATINGS—Ampere-Hour Rating (Amp. Hr.):

This obsolete test for battery capacity was to discharge the battery at 80°F. (27°C.) at the maximum rate which would provide a voltage of 1.75 volts per cell at the end of 20 hours. This amperage was then multiplied by 20 to provide an "Ampere Hour Rating" for the battery.

RECOMMENDATIONS

Experience has shown that the recommendations listed below should be followed to achieve adequate engine cranking performance and meaningful battery comparisons:

1. All batteries must be rated with the new SAE Cold Cranking Ampere (CCA) and reserve capacity ratings.
2. Battery complement must meet or exceed the engine companies' minimum CCA requirement at 0°F. for each engine. Refer to engine company bulletins.

NOTE: For best total system performance, the following must be included.

1. RCCC Recommended Practice 105, Battery Cable Assemblies, must be followed so that cable resistance values are not exceeded.
2. RCCC Recommended Practice 106, 12-Volt Batteries in Parallel, must be followed. (When connecting batteries in series the voltage is additive and the cold cranking amperes remain the same. When connected in parallel the voltage remains the same and the cold cranking amperes is additive.)

BATTERY SPECIFIC GRAVITY TEST

By using a hydrometer, the specific gravity of the electrolyte solution in a battery can be determined. The battery specific gravity is an indication of the battery state of charge. If the state of charge is low, the hydrometer will read low. If the state of charge is high, the hydrometer will read high. As an example, a reading from 1.260 to 1.280 indicates a fully charged battery. A reading from 1.200 to 1.220 indicates a battery that is in a half-charged condition. Reading below 1.200 indicate that a battery is in a discharged condition and cannot give satisfactory service.

The definition of specific gravity is the weight of a liquid compared to the weight of an equal volume of water. The specific gravity of chemically pure water at 80°F is 1. Therefore, by knowing the specific gravity of sulfuric acid, we can accurately measure the ratio of sulfuric acid to water in the battery electrolyte solution.

When a battery is in a full state of charge, the negative plates are basically sponge lead, the positive plates are lead peroxide, and the electrolyte has a maximum acid content and a minimum water content.

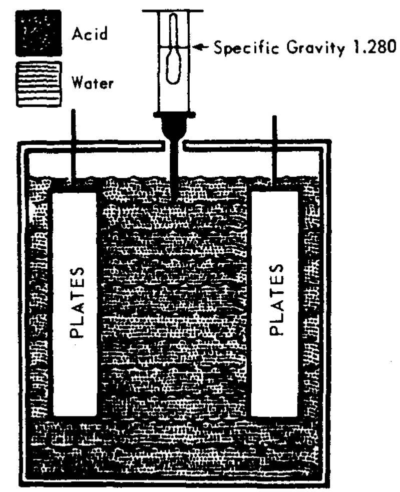
As the battery is discharging, the chemical action taking place reduces the acid content in the electrolyte and increases the water content, while both negative and positive plates are gradually changing to lead sulfate.

When the battery is in a state of discharge, the electrolyte is very weak, since it now has minimum acid content and a maximum water content, and both plates are predominately lead sulfate. The battery now ceases to function because the plates are now basically two similar metals in the presence of water, instead of two dissimilar metals in the presence of an acid.

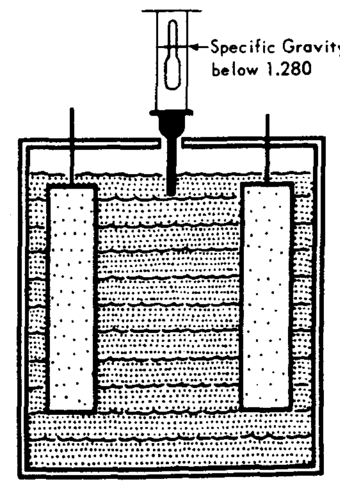
During the charging process, the chemical action that occurred during the battery discharge is reversed. The lead sulfate on the plates is gradually decomposed, changing the negative plates back to sponge lead and the positive plates back to lead peroxide. The acid is redeposited in the electrolyte, returning it to full strength. The battery is now again capable of performing all its functions.

After activating a dry-charge battery, check the specific gravity. The gravity reading should be 1.260 or slightly higher. If the electrolyte level drops shortly after the initial fill, due to the plates and separators absorbing some of the solution, add more electrolyte to bring the solution up to the proper level. When so instructed, charge the battery at 15 amperes for 10 minutes before installing the battery to assure a full charge.

BATTERY SPECIFIC GRAVITY



FULLY CHARGED
Acid in water gives electrolyte specific gravity of 1.280



GOING DOWN
As battery discharges, acid begins to lodge in plates. Specific gravity drops.

TEMPERATURE-CORRECTED HYDROMETER

Hydrometer floats are calibrated to indicate correctly only at 80°F temperature. If used at any other temperature, a correction factor must be applied. The reason for this lies in the fact that a liquid expands when it is heated and shrinks when it is cooled. This will cause a change in the density of the electrolyte solution, which will raise or lower the specific gravity reading.

A thermometer is built into the temperature-compensating-type hydrometer. The scale of this thermometer indicates the temperature of the solution. This reading should be used so that the proper temperature correction factor can be applied.

The table is based on an electrolyte temperature of 80°F. For other temperatures, correct the indicated reading by adding 4 points (0.004) for each 10° above 80°F, and subtracting 4 points for each 10° that the electrolyte temperature is below 80°F.

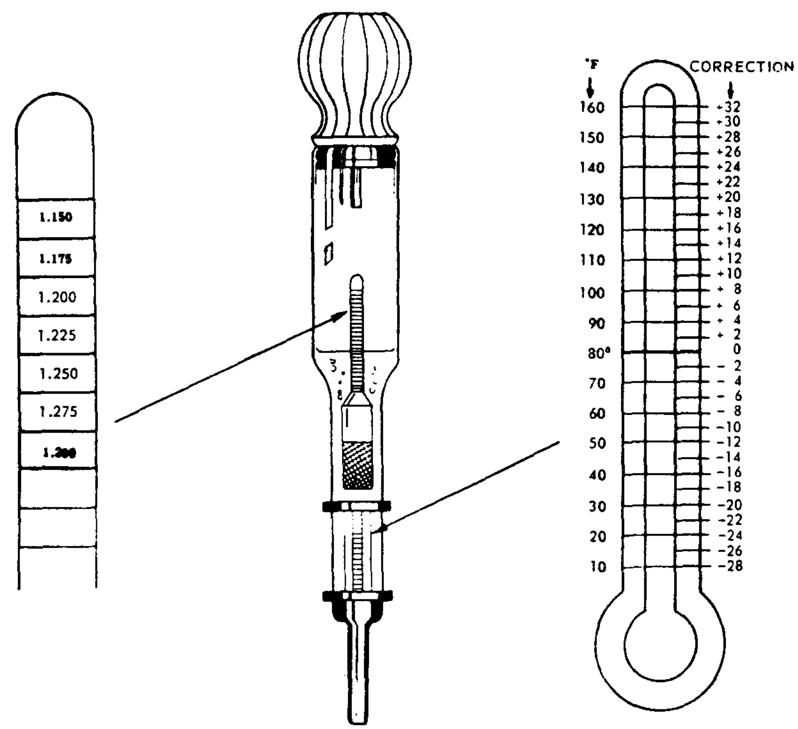
For example, a specific gravity reading of 1.230 is obtained at a solution temperature of 10°F. If the electrolyte temperature is disregarded, the reading of 1.230 may be considered as low but acceptable. When the reading is temperature corrected, the true reading of 1.202 (7 × 4= 28 from 1.230) reveals that the battery is actually very low and definitely in need of charging.

A specific gravity reading of 1.235 is obtained at a solution temperature of 120°F. The reading itself may be interpreted as being rather low, but when temperature corrected the reading is actually 1.251 (4 × 4 = 16 added to 1.235). This specific gravity may be high enough for the battery to be restored to full charge by the car's generator.

These examples indicate the importance of temperature correcting specific gravity readings to accurately interpret the true state of battery charge.

To accurately test the true condition of the battery, a light-load test or a capacity test should be conducted after the specific gravity has been tested.

TEMPERATURE CORRECTED HYDROMETER



SPECIFICATIONS

BCI GROUP SIZE	BATTERY TYPE	RESERVE CAPACITY MINUTES	CRANKING PERFORM-ANCE AT 0°F	PLATES PER BATTERY	20 HR RATE	OVERALL DIMENSIONS*			WEIGHT IN POUNDS		ELECTROLYTE QTS TO FILL
						LENGTH	WIDTH	HEIGHT	DRY CHARGED	WET CHARGED	
PASSENGER CAR — 12 VOLT											
22F	PR-22F	69	280	54	53	9 7/16	6 13/16	8 5/16	20.2	33.5	5.1
	XHD-22F	60	280	54	46	9 7/16	6 13/16	8 5/16	20.2	33.5	5.1
	C-22F	45	220	42	40	9 7/16	6 13/16	8 5/16	20.2	31.4	4.6
24	PR-24	107	360	66	74	10 1/4	6 3/4	8 31/32	26.9	42.3	6.2
	XHD-24	80	305	54	60	10 1/4	6 3/4	8 31/32	22.2	38.0	6.3
	HD-24	69	280	54	53	10 1/4	6 3/4	8 31/32	21.3	36.9	6.3
	C-24	45	220	42	40	10 1/4	6 3/4	8 31/32	21.2	34.9	5.5
24F	PR-24F	107	360	66	74	10 21/32	6 5/8	8 31/32	26.8	42.3	6.2
	XHD-24F	80	305	54	60	10 21/32	6 5/8	8 31/32	22.2	38.0	6.3
	HD-24F	69	280	54	53	10 21/32	6 5/8	8 31/32	21.3	36.9	6.3
	C-24F	45	220	42	40	10 1/4	6 3/4	8 7/8	21.5	35.3	5.6
27	PR-27	126	420	78	90	12 1/32	6 13/16	8 31/32	30.9	49.4	7.3
	XHD-27	107	360	66	74	12 1/32	6 13/16	8 31/32	28.6	46.2	7.0
27F	PR-27F	126	420	78	90	12 17/32	6 13/16	8 31/32	30.9	49.4	7.3
	XHD-27F	107	360	66	74	12 17/32	6 13/16	8 31/32	28.6	46.2	7.0
29NF	HD-29NF	80	300	66	56	13	5 1/2	8 15/16	25.9	39.4	5.5
3EE	HD-3EE	80	295	54	59	19 5/16	4 5/16	8 3/4	31.0	46.3	6.1
42	XHD-42	59	260	66	45	9 9/16	6 27/32	7	23.1	31.7	3.6
60	HD-60	80	305	54	60	13 1/16	6 1/4	8 7/8	28.5	44.7	6.5
22NF	HD-22NF	59	255	54	45	9 7/16	5 1/2	8 15/16	23.1	31.3	3.5
72	PR-72	69	280	54	53	9 7/16	6 27/32	8 3/32	19.6	31.2	4.8
74	PR-74	107	360	66	74	10 1/4	6 27/32	8 27/32	25.9	40.8	6.1
77	PR-77	126	420	78	90	12 1/32	6 27/32	8 27/32	31.4	49.0	7.0
PASSENGER CAR — 6 VOLT											
1	HD-1	134	440	45	92	8 7/8	6 27/32	8 21/32	21.5	33.1	4.8
	C-1	91	330	33	66	8 7/8	6 27/32	8 21/32	17.2	29.3	4.9
2	HD-2	134	330	45	92	10 1/8	6 7/8	8 3/4	22.6	36.2	5.3
19L	HD-19L	110	385	39	80	8 1/4	6 3/4	7 11/32	18.5	26.7	3.3
MARINE SERVICE — 12 VOLT											
24	SU-M84†	120	450	78	84	10 1/4	6 11/16	9 27/32	31.9	46.4	5.8
	PR-M74†	107	360	66	74	10 1/4	6 3/4	9 3/4	31.0	43.2	5.0
	XHD-M60†	80	305	54	59	10 1/4	6 3/4	9 3/4	26.5	39.6	5.2
MAINTENANCE FREE PASSENGER CAR — 12 VOLT											
22F	MF-22F	91	315	66	62	9 7/16	6 13/16	8 5/16	23.9	36.2	5.0
24	MF-24	126	420	78	90	10 1/4	6 13/16	8 31/32	28.6	44.0	6.2
24F	MF-24F	126	420	78	90	10 5/8	6 13/16	8 31/32	28.6	44.0	6.2
27	MF-27	153	485	90	95	12 1/32	6 13/16	8 31/32	31.2	48.8	7.0
27F	MF-27F	153	485	90	95	12 15/32	6 13/16	8 31/32	31.2	48.8	7.0
74	MF-74	126	420	78	90	10 1/4	6 27/32	8 27/32	30.1	44.1	6.2

**DIMENSIONS TAKEN FROM BOTTOM OF BATTERY TO TOP OF POST*

†COMBINATION POST (FOR SAE OR WING NUT CONNECTION) WITH CARRYING HANDLE

BCI GROUP SIZE	BATTERY TYPE	RESERVE CAPACITY MINUTES	CRANKING PERFORM-ANCE AT 0°F	PLATES PER BATTERY	20 HR RATE	OVERALL DIMENSIONS*			WEIGHT IN POUNDS		ELECTROLYTE QTS TO FILL
						LENGTH	WIDTH	HEIGHT	DRY CHARGED	WET CHARGED	
MAINTENANCE FREE COMMERCIAL BATTERIES											
2	MFTC-2	216	545	57	135	10 1/8	6 27/32	8 3/4	29.9	42.7	5.1
3	MFTC-3H	239	550	57	145	11 21/32	6 7/8	9 1/8	33.5	50.0	6.1
4	MFTC-4H	272	655	69	165	12 7/8	6 29/32	9	34.4	50.2	6.8
4	MFTC-4EC	358	820	87	180	12 7/8	6 29/32	9	41.3	55.9	7.1
27	MFTC-27	130	435	90	89	12 1/32	6 13/16	8 31/32	30.2	52.6	7.0
27F	MFTC-27F	130	435	90	89	12 15/32	6 13/16	8 31/32	30.2	52.6	7.0
30H	MFTC-30H	130	380	78	90	13 1/2	6 13/16	8 7/8	40.0	58.0	7.2
5D	MFTC-5D	355	820	81	190	13 1/8	7 1/16	9 1/16	42.7	58.3	6.1
7D	MFTC-7D	415	935	93	230	15 7/8	7 1/16	9 1/16	49.1	68.3	7.5
4D	MFTC-4D▲	325	760	150	190	20 3/4	8 3/4	9 1/2	85.9	119.8	13.2
8D	MFTC-8D▲	415	935	186	240	20 3/4	11	9 1/2	104.0	146.0	16.2
▲ *WITH RUBBER SEPARATORS*											
COMMERCIAL & TRACTOR—6 VOLT											
1	FTC-1	153	410	45	105	8 7/8	6 27/32	8 21/32	21.0	32.6	4.6
1	FTC-1H	187	465	51	120	8 7/8	6 27/32	8 21/32	25.1	36.3	4.4
4	FTC-4	225	550	57	140	12 7/8	6 29/32	9	34.1	53.8	7.6
4EH	FTC-4EH	342	775	87	207	19 5/16	5	9 25/32	45.0	65.0	7.7
COMMERCIAL & TRACTOR—12 VOLT											
24	XHD-24EC	95	305	66	66	10 1/4	6 3/4	8 13/16	35.5	46.6	4.6
30HR	FTC-30HR	90	260	54	80	13 1/2	6 13/16	8 7/8	47.1	62.0	6.0
3ET	FTC-3ET	147	440	78	95	19 5/16	4 5/16	9 13/16	43.0	60.0	6.8
GARDEN TRACTOR SNOWMOBILE—12 VOLT											
U1	FTC-LM9L•	37	220	54	32	7 3/4	5 3/16	7 1/4	15.8	20.3	2.1
U1	FTC-LM9R■	37	220	54	32	7 3/4	5 3/16	7 1/4	15.8	20.3	2.1
GOLF CART—6 VOLT		CAPACITY AT 80°F 75 AMPS TO 5.25V									
GC-2	XHD-88	88 MINUTES		57	185	10 3/8	7 3/16	11 7/32	40.4	59.8	7.1
GC-2	SU-106	106 MINUTES		57	220	10 3/8	7 3/16	11 7/32	47.2	65.1	6.6

**DIMENSIONS TAKEN FROM BOTTOM OF BATTERY TO TOP OF POST*

▲HANDLES MANUFACTURED WITH BATTERIES

•POSITIVE TERMINAL ON LEFT SIDE

■POSITIVE TERMINAL ON RIGHT SIDE

THE CHARGING CIRCUIT

The purpose of the charging system is to supply current for the lights, ignition, radio, heater and other electrical accessories and to maintain the storage battery in a charged condition or to recharge it when it has become discharged. The charging system consists of four important components: battery, generator or alternator, regulator and leads.

The battery performs two important functions. First, it supplies electrical energy for the starting motor and the ignition system until the engine starts. Second, it intermittently supplies current for the lights, radio, heater and other accessories when the electrical demands exceed the output of the generator or alternator.

The generator or alternator converts mechanical energy supplied by the engine into electrical energy. This energy is used to charge the battery and to supply power to the electrical system of the automobile.

The regulator is the control unit for the generator or alternator. Its function is to automatically control generator output to safely meet all conditions of speed and electrical load. The generator regulator assembly usually consists of three units, a cutout or reverse current relay, a voltage limiter and a current regulator. The alternator regulator contains a voltage control unit and may also contain a field relay and/or an indicator light relay.

The cutout relay or circuit breaker is used to open and close the circuit between the generator and battery. When the generator voltage exceeds the battery terminal voltage, the contact points close. This completes the circuit between the generator and battery permitting the generator to charge the battery. If the engine is stopped, is idled or operated at low speed, the contact points open and prevent the battery from discharging through the generator.

The voltage limiter is used to regulate the generator voltage to a predetermined value, thus protecting the battery and all vehicle electrical accessories from the damage of high voltage.

When the generator voltage rises to a value at which the voltage limiter is set, the regulator contacts vibrate thus inserting a resistance in the generator field circuit thereby limiting the generator voltage.

The current regulator is used to limit the generator output to a predetermined value, thus protecting the generator against overload. When the generator output reaches its predetermined safe maximum output, the regulator contacts vibrate inserting a resistance in the field circuit which reduces the voltage and consequently the amperage output of the generator.

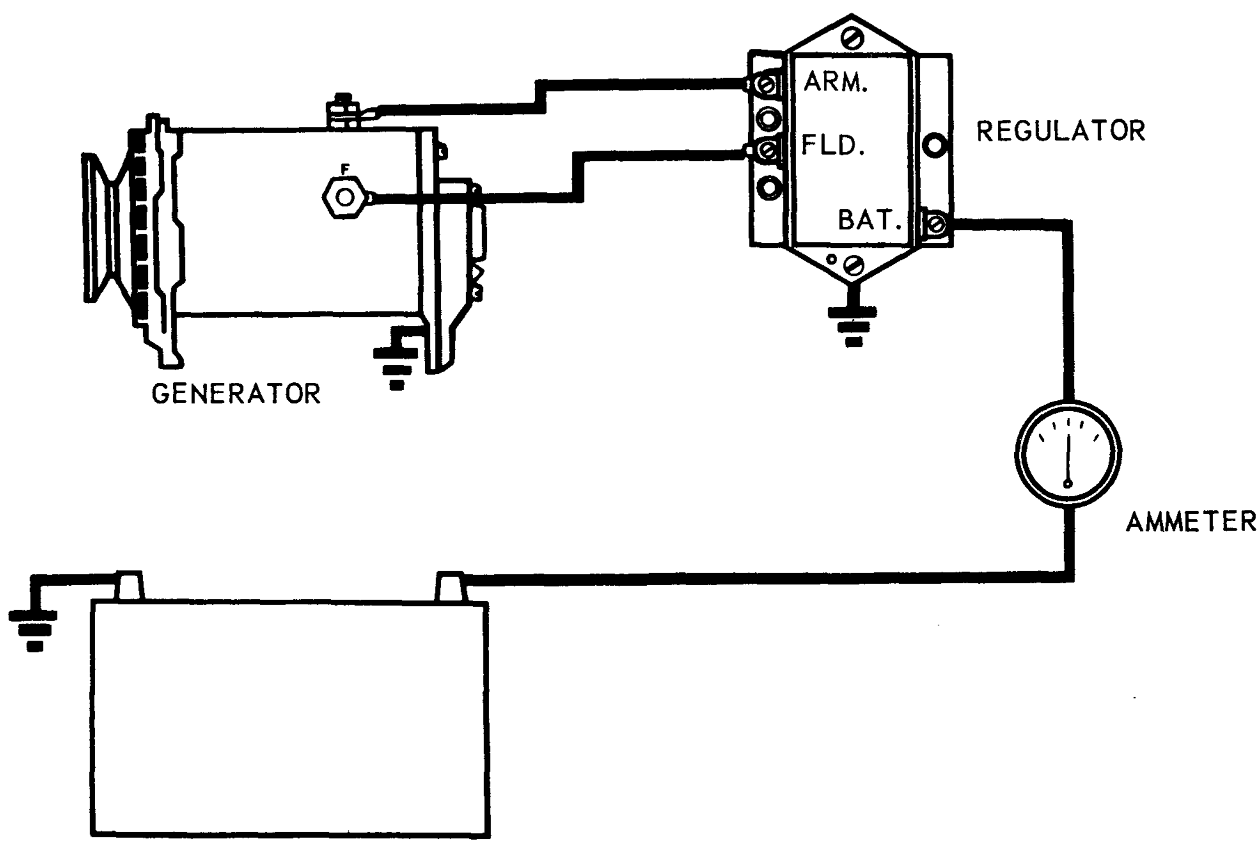
The field relay is used to energize the alternator field coil by connecting the coil to the battery when the ignition switch is turned on. When the ignition switch is turned off, the field relay opens the circuit between the field coil and the battery to prevent battery discharge.

The indicator light relay is used in the alternator-equipped system where a light is mounted on the instrument panel to replace the ammeter. The relay permits the light to go on when the alternator is not producing voltage and causes the light to go out when voltage is produced. Should the light be lit when the engine is running, trouble is indicated.

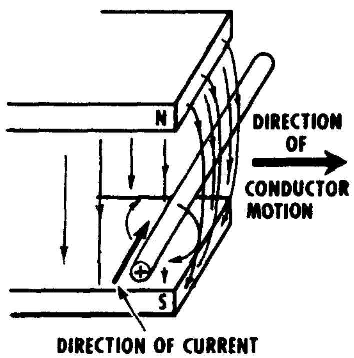
The leads are necessary to complete the circuitry between the charging system components and the vehicle. The wiring insulation must be in good condition. The connections must be clean and tight.

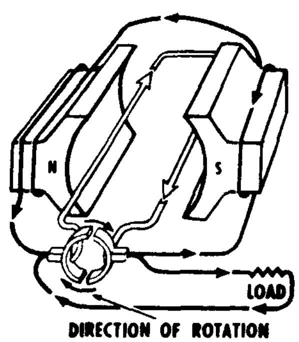
All components in a charging system are equally important. In order for the charging system to function properly, the generator must be capable of producing an output at least equal to its electrical rating. The regulator in turn must be able to limit the generator output at a predetermined setting. The leads should be in good condition and the connections clean and tight. With high resistance in the leads and connections the generator and regulator cannot perform properly.

THE CHARGING CIRCUIT



GENERATOR OPERATING PRINCIPLES





GENERATOR OPERATING PRINCIPLES

Current is developed by the automobile generator by moving wire conductors, in the form of an armature, through a magnetic field generated by current flow through field coils which are wrapped around pole shoes.

When a conductor is moved through a magnetic field, it cuts the magnetic lines of force of the field and induces a voltage in the conductor, causing current to flow in the conductor. The direction in which the current will flow in the conductor is governed by the direction of the movement of the conductor in the magnetic field. As the conductor moves through the field, it causes a distortion of the lines of magnetic force, which tends to cause the lines of force to wrap themselves around the conductor, so to speak. Applying the right-hand rule to this distorted field movement will verify the direction of current flow in the conductor.

Figure No. 55 shows the basic elements of a generator circuit. The armature wire conductor is illustrated as a single loop of wire. Each end of this loop is connected to commutator segments. The function of the commutator is to rectify the alternating current generated by the revolving armature loop into direct current.

As the wire loop is rotated in the magnetic field, voltage is induced in the loop, causing current to flow as previously explained. The current generated flows from the insulated brush through the connected electrical load circuit and back to the generator ground brush, completing the circuit.

A portion of the generator output is shunted through the field coils to develop and sustain the magnetic field in which the armature turns. Generators are identified as *shunt wound* because the field is shunted across the armature.

As the armature is turned faster, more lines of force are cut, resulting in increased generator output. This greater output also results in increased current flow through the field coils. This increases the strength of the magnetic field and consequently increases, still further, generator output. Unless this action is controlled, generator ouput will continue to increase to the point where so much current and heat will be generated that the soldered connections of the armature winding will melt and the generator will be destroyed. To control this condition, a regulator is used, which governs generator output by controlling the strength of the magnetic field.

GENERATOR FUNCTION

With the generator at rest, or operating at low speed, all of the electrical energy is furnished by the battery.

Whenever the electrical load exceeds the output of the generator, then electrical energy is also furnished by the battery to supplement the generator output.

When an electrical load is less than the generator output, the generator supplies all the power for the load and also recharges the battery.

The generator on a vehicle has been carefully selected so that it will meet all the electrical requirements of that vehicle. Its rated output will be high enough to efficiently supply the electrical load of the vehicle and its accessories at varying speeds.

The principle advantage of the alternator over the generator is that the alternator has an output at engine idle which the generator does not have and the alternator also has a higher low-speed output, if it is belted with correct pulley ratios.

GENERATOR TESTING

The charging system like any other system or component on the vehicle, requires periodic service or maintenance to assure top operating efficiency. Should trouble occur in this system, the cause and location of this trouble can readily be determined through a systematic test procedure. To efficiently test charging system components so that proper service operations be performed, it is necessary to have a clear understanding of electrical troubles. Basic malfunctions can be classified into four groups. SHORT circuits, OPEN circuits, GROUNDED circuits and circuits with abnormally HIGH or LOW RESISTANCE.

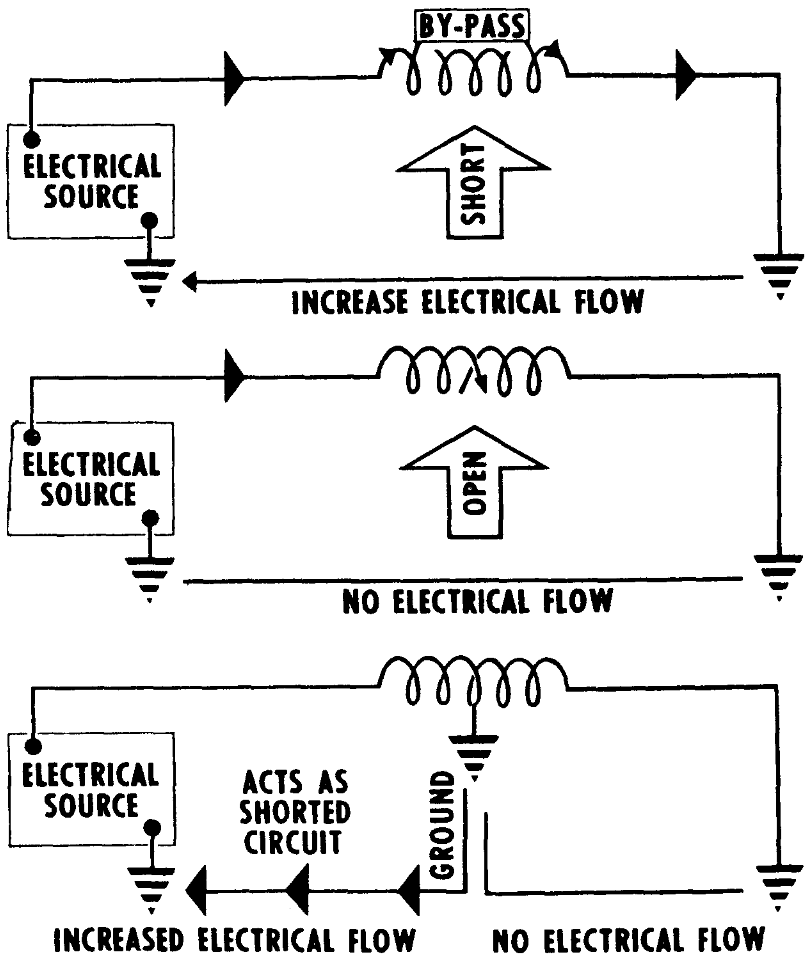
A short circuit is any accidental contact that permits the current to bypass a portion of the electrical circuit. This condition is present when one or more windings on a coil are bypassed due to insulation failure. A short circuit results in a lower than normal circuit resistance thereby permitting a higher than normal current flow.

An open circuit is an undesired break in the circuit. A break can occur in any one of a number of locations in the circuit such as, coil windings, wires or connections, resulting in an inoperative circuit. No current will flow through an open circuit.

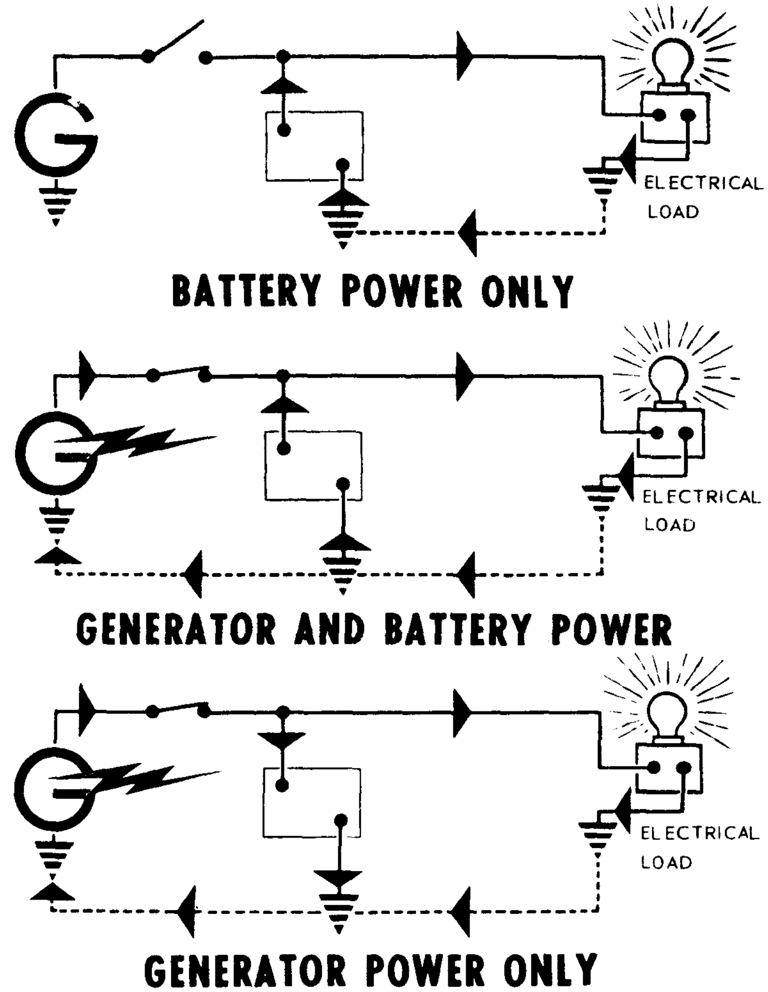
A grounded circuit is an undesired connection that bypasses part or all of the electrical units, from the insulated side to the ground side of the circuit. In a lighting circuit, for example, should a ground occur between the battery and the lamps, the load on the battery would become unreasonably high while the lamps would fail to light. In general, a grounded circuit results in a higher than normal current flow produced by a proportionate reduction in circuit resistance.

A circuit with abnormally high resistance is 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. Should this condition exist, current flow will be less than normal because of the increase in circuit resistance.

GENERATOR TESTING



GENERATOR FUNCTION



CUTOUT RELAY

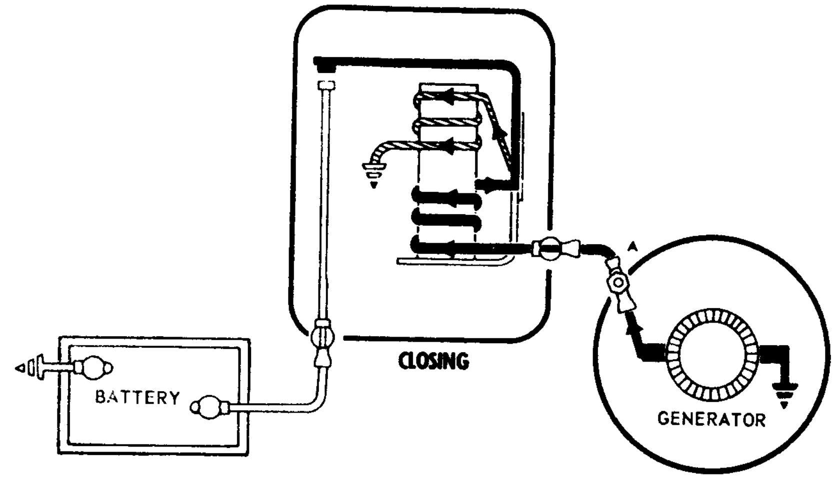
The cutout relay is an electromagnetic switch used to close the charging circuit between the generator and the battery when the generator voltage is higher than battery voltage and to open the circuit when battery voltage is higher than generator voltage. Without the cutout relay the battery would discharge through the generator to ground when the generator was slowed down or stopped. Such a discharge would damage the generator and permit the battery to become discharged.

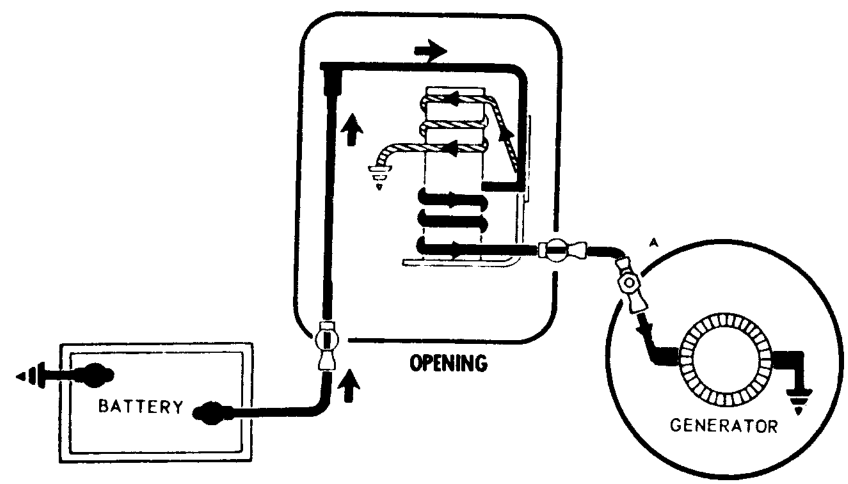
The cutout relay has a coil of fine wire connected in shunt from the generator output lead to ground. This coil is a voltage sensitive winding. The generator voltage creates a magnetic field in this coil of the relay. When sufficient generator voltage is available, it overcomes the spring tension and closes the contact points. Generator current can now flow to the battery. After the contacts have closed, regardless of whether the current flows from the battery or the generator, the coil would maintain the same magnetic polarity. Under these conditions the cutout would not be able to open because the shunt winding would keep the relay energized at all times. To correct this condition, another winding, a current sensitive winding, is added to the relay in series with the generator and battery.

With the generator charging, current is flowing in the same direction in both the series and shunt windings. The magnetic field of both windings combines to hold the cutout points closed. When the generator is not charging, the current reverses in the series winding because the battery voltage is higher. Since the current flow in the windings is now in opposite directions, the magnetic fields cancel each other out, the relay becomes demagnetized, and the spring opens the contact points.

A cutout relay is tested to determine whether it closes at the proper generator voltage, and opens at the proper reverse current value. Unless the cutout relay is operating correctly, a discharged battery and/or damage to the charging system can result.

CUTOUT RELAY





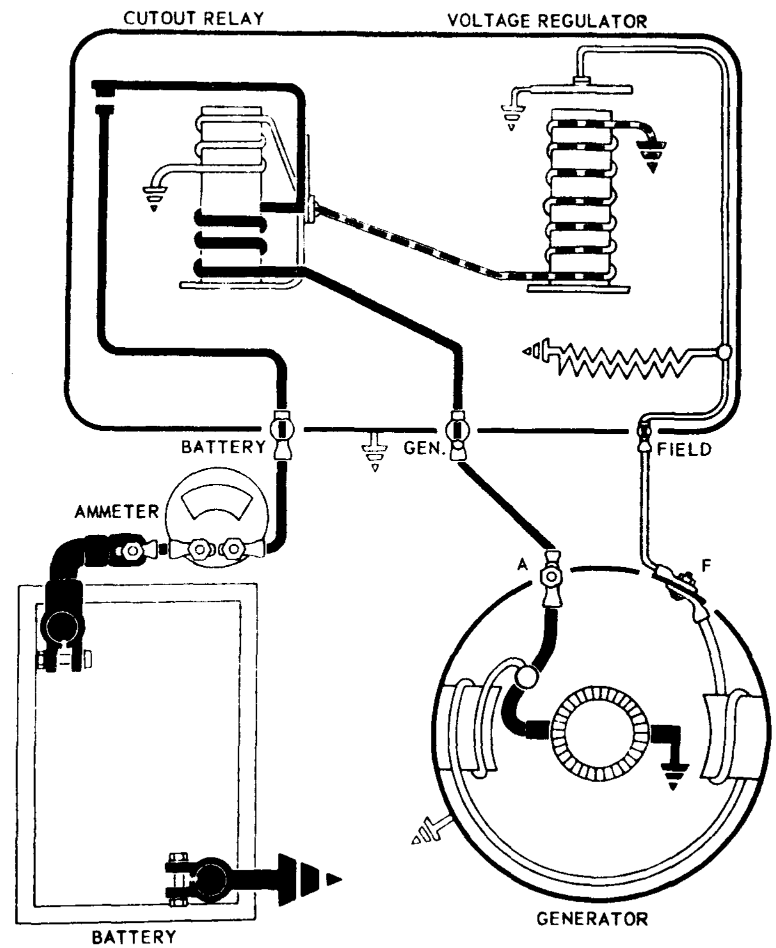
VOLTAGE REGULATOR

The voltage regulator unit is used to prevent the generator from developing an excessively high voltage. The voltage regulator limits the charging voltage to a value which is safe for the electrical accessories and is able to maintain the battery in a state of full charge.

The voltage regulator contacts are installed in series with the field winding. All of the field coil current must flow through the points of the voltage regulator to ground. As long as the voltage regulator points are closed, the field current and the generator output will attain a maximum value for any specific generator speed. The fine wire coil of the voltage regulator relay is connected across the generator output circuit enabling it to sense the output voltage. As the voltage output of the generator reaches the safe maximum limit, the magnetic field of the voltage sensitive regulator coil becomes stronger and will overcome the spring tension and open the points. With the points open, the field coil circuit is then completed through a resistor which lowers the field current flow thereby decreasing generator output. The decreased voltage output of the generator reduces magnetic strength in the voltage regulator coil and the spring closes the contacts completing the field circuit to ground which allows the generator output to rise. The points vibrate at a high frequency of from 50 to 250 cycles per second thereby regulating the generator output voltage to a specified setting.

The voltage regulator setting is controlled by adjusting the spring tension on the regulator armature. This tension must be carefully adjusted to effect unit operation within specified limits. A voltage regulator that permits a high voltage output will cause damage to the electrical units in the vehicle. Also the battery would be overcharged and eventually damaged. A low voltage setting will not permit the generator to bring the battery to its full state of charge also the electrical accessories would not receive the correct voltage for efficient operation.

VOLTAGE REGULATOR



CURRENT REGULATOR

The current regulator unit protects the generator from excessive current output by limiting the current to a value considered safe for the generator. As the generator output reaches the value for which the current regulator is set, the regulator contact points begin to vibrate. This vibration alternately opens and closes the contact points inserting and removing a resistance in the generator field circuit controlling the voltage and thereby limiting the current output of the generator.

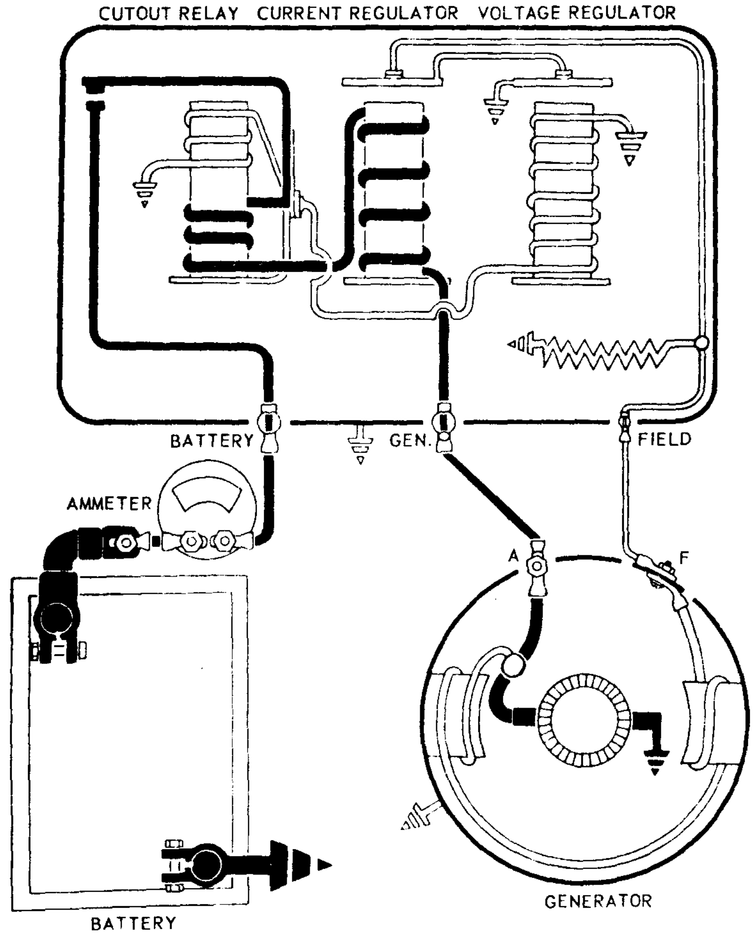
The generator field coils are in series with the current regulator points and the voltage regulator points. The current regulator windings are made of heavy wire and carry the entire output of the generator. When the current output reaches the rated maximum output of the generator, a magnetic field in the heavy windings of the current regulator becomes strong enough to overcome spring tension, opening the contact points which breaks the field circuit. The field current then flows through a resistor to ground reducing the output of the generator. The current flow through the regulator windings also drops, reducing the magnetic field thus allowing the points to close and complete the field circuit to ground. Generator output then rises, the relay magnetic field again opens the points inserting the resistance in the field circuit. This action continues as long as current regulation is required.

The current regulator setting is controlled by adjusting the spring tension on the regulator armature.

Both the voltage regulator and current regulator never operate at the same time. If the electrical load requirements are heavy and the battery is low the system voltage will not be sufficient to cause the voltage regulator to operate. The generator output consequently will increase until it reaches the value for which the current regulator is set at which time the current regulator will observe to protect the generator from overload.

If the electrical load is reduced, or if the battery begins to come up to charge, the system voltage will increase to a value sufficient to cause the voltage regulator to operate. When this happens the generator output is reduced below the value required to operate the current regulator. The current regulator then stops operating and all control is dependent on the operation of the voltage regulator.

CURRENT REGULATOR



DOUBLE CONTACT VOLTAGE REGULATOR

One of the factors that limit generator output is the amount of current that can be carried by vibrating contacts without excessive arcing. The double contact voltage regulator was developed to handle higher generator field current.

When generator speed is low, the first set of contacts on a double contact voltage regulator, control the voltage output in the same manner as in a single contact regulator. When the generator speed increases, these contacts may not effectively control the field current because the generator voltage has become high enough to push sufficient voltage through the resistor to produce a higher than desired output.

When the generator speed and voltage increase to this point, the voltage relay coil will be influenced by an electromagnetic field strong enough to attract the armature to engage the second contact set. These are called the "shorting" contacts. When these points close, the generator field circuit is shorted out. This action practically eliminates all field strength. The generator output drops and the points open. The field current then flows through the resistor. This method of voltage control effectively maintains the generator voltage at a predetermined setting without the tendency of voltage "creep" at high speed.

INDICATOR LAMPS

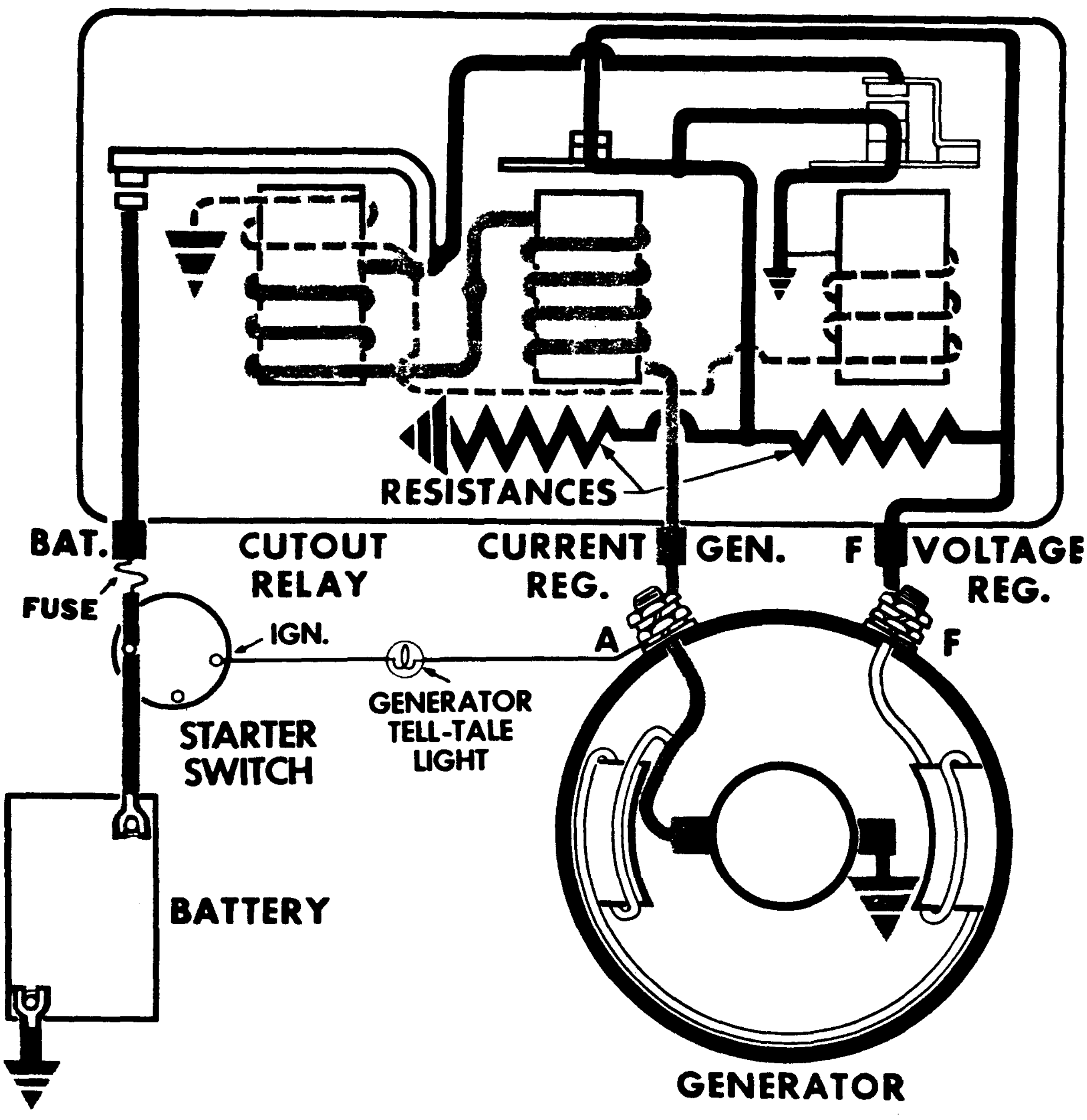
Many late model cars are equipped with a "tell-tale" indicator lamp in the charging circuit instead of an ammeter.

One side of the indicator lamp is connected to a wire that is "hot" when the ignition switch is turned on and the other side of the lamp is connected to a wire that is "hot" when the generator is charging.

When the ignition switch is turned on, battery current flows through the lamp circuit to ground in the generator causing the lamp to light. When the engine is started generator voltage is applied to this same circuit but to the other side of the lamp. Since approximately equal voltage is applied to both sides of the indicator lamp, no current will flow in the circuit and the lamp goes out.

If the indicator lamp does not light when the ignition switch is turned on, the lamp should be tested and the lamp circuit should be checked for open circuit or loose connections. If the lamp stays on after the engine has started, the generator should be checked for output.

DOUBLE CONTACT VOLTAGE REGULATOR



GENERATOR CIRCUITS

There are two types of generator charging circuits; the "A" circuit and the "B" circuit.

In the "A" circuit, current for the generator field circuit starts at the generator insulated brush, flows through the two field coils to the field terminal on the regulator, through the regulator current and voltage regulator points to ground. This field circuit is said to be externally grounded. That is, it is grounded in the regulator. General Motors and Chrysler Corporation frequently use the "A" circuit.

In the "B" circuit, current for the generator field circuit starts in the regulator, flows through the current and voltage regulator points to the field terminal on the regulator, to the generator, through the generator field coils and to ground. This field circuit is said to be internally grounded. That is, it is grounded in the generator. Ford generally uses the "B" circuit.

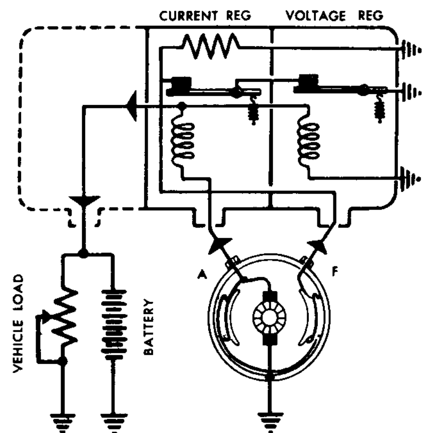
The construction of the "A" circuit and "B" circuit regulators is similar in many details but they are not interchangeable because of the method of field circuit grounding. When replacing voltage regulators, this factor along with polarity and voltage are essential to correct unit replacement.

To determine if the generator is in an "A" or "B" circuit, perform this simple test:

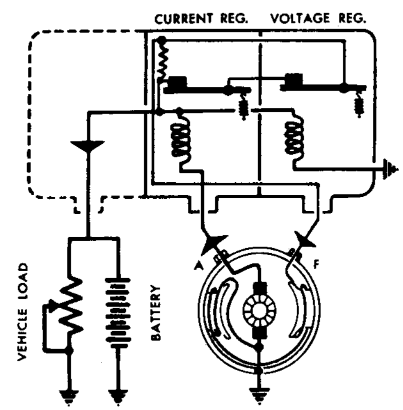
1. Disconnect the field "F" wire from the **generator**. DO NOT allow this wire to touch ground.
2. Connect a voltmeter from the **generator** field terminal to ground.
3. Operate the engine at a fast idle. If a voltmeter reading is indicated, the generator is in an "A" circuit. If no reading is indicated, the generator is in a "B" circuit.

   Note: In the event the generator is dead, there will be no voltage indicated in the "A" circuit test. An output test will quickly detect a defective generator.

GENERATOR CIRCUITS



"A" CIRCUIT



"B" CIRCUIT

GENERATOR POLARITY

The generator will build up voltage that will cause current flow in either direction depending upon the polarity of the residual magnetism in the pole shoes which in turn is determined by the direction of current flow in the field coils. The generator polarity must be in agreement with battery polarity in order for current to flow in the proper direction to charge the battery and to prevent damage to the regulator relay points. Reverse polarity causes these points to flutter, arc and burn and can even cause burning of the generator armature and charging system wiring.

Whenever the leads have been disconnected from a generator or after a generator has been repaired, it must be polarized. It is important that the generator be polarized BEFORE starting the engine. This will insure correct polarity and cause current to flow in the proper direction to the battery. An easily accessible place to polarize the generator is at the voltage regulator terminals.

Circuit "A" generators are polarized by momentarily touching a jumper lead from the regulator battery (B) terminal to the regulator armature (ARM) (Gen) terminal, with the engine stopped. A touch of the jumper is all that is required. Battery current will flow through the generator field coils in the right direction to correctly polarize the generator field coil pole shoes.

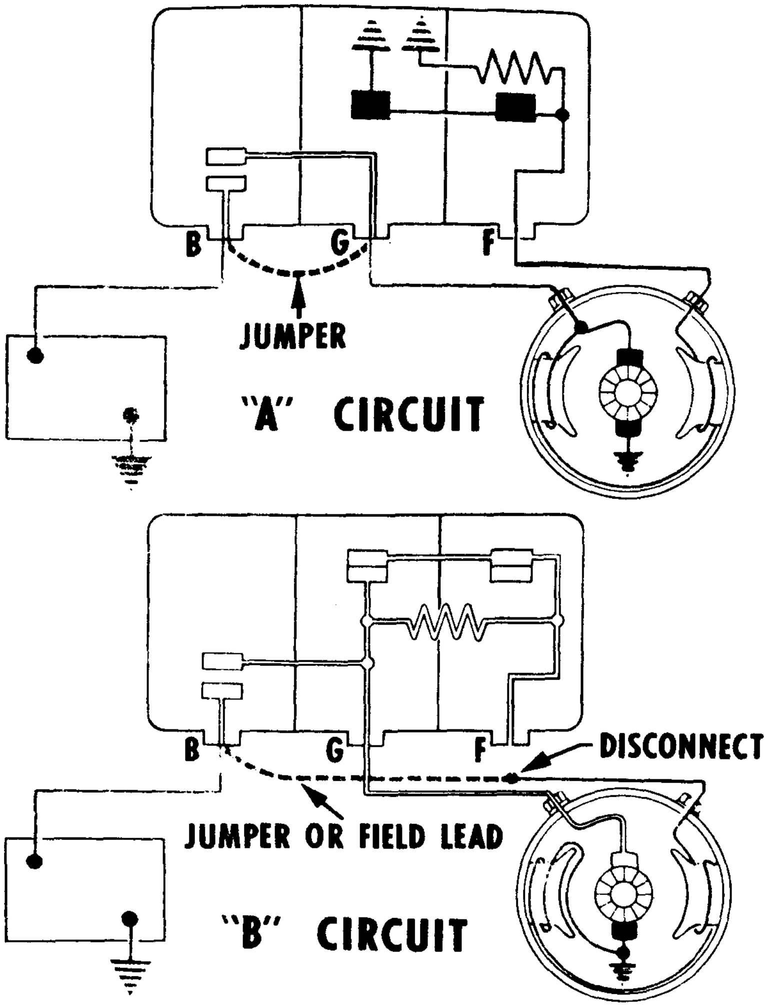
When polarizing generators on cars equipped with double contact regulators disconnect the field lead to prevent damage to the upper regulator contacts.

Circuit "B" generators are polarized by disconnecting the regulator field (F) terminal lead and momentarily touching it to the regulator battery (B) terminal.

The generator field coil resistance will protect the regulator points from even momentary excessive current flow with either method of polarizing. These procedures for polarizing the generator are commonly referred to as "flashing the fields."

Remember – generator polarizing is performed after the regulator leads are connected but BEFORE the engine is started.

GENERATOR POLARITY



GENERATOR AND REGULATOR TESTS

The following generator and regulator ON THE CAR test procedures and test equipment hookups are applicable to most charging systems. However, always use the tester hookups and follow the test procedures recommended by the manufacturer of your test equipment.

The charging system should be tested and adjusted only when the units in the system are at operating temperature.

When adjusting the voltage regulator units, make the adjustment very carefully. A slight change in adjustment makes a considerable change in setting.

Test specifications used in this procedure are only averages. Follow the specifications listed for the particular car being serviced.

GENERATOR OUTPUT TEST

1. Check generator drive belt and adjust as required.
2. Circuit "A" only: Disconnect regulator field lead from regulator F terminal and ground this lead to the regulator base with a jumper.

   Circuit "B" only: Clip a jumper lead from the generator output (Arm) terminal to the generator field (F) terminal.
3. Disconnect the regulator battery lead from the BAT terminal and connect a test ammeter between disconnected lead and BAT terminal.
4. Connect tachometer between distributor primary terminal and ground.
5. Turn on all electrical accessories – bright lights, radio, etc.
6. Start engine and slowly increase engine speed until ammeter reads 35 amperes. Engine speed at this time should NOT exceed 1500 rpm. Return engine speed to idle immediately after making test. If generator does not produce rated output at less than 1500 rpm, the generator is defective.

CUTOUT RELAY TEST

1. Leave all test and meter leads connected as in generator output test.
2. Connect voltmeter from regulator Gen (Arm) terminal to ground on regulator base.
3. Start and slow idle engine. Very slowly increase engine speed while observing meters.

   Highest voltage reading just before ammeter indicates charge, is cutout relay closing voltage.

Relay closing voltage is between 12.0 and 13.0 volts. If voltage does not conform to specifications, remove regulator cover, adjust cutout relay, replace cover and retest. Increasing relay spring tension increases the closing voltage. Decreasing the spring tension decreases the closing voltage.

4. Very slowly decrease engine speed while observing ammeter. Lowest ampere reading below zero, just before meter swings to zero, is relay opening counteramperage. Reverse current should be between 1 to 3 amperes.

   If reverse current does not conform to specification, the relay air gap and point gap opening must be adjusted to specifications.

CURRENT REGULATOR TEST

1. Circuit "A" only: Reconnect regulator field lead to regulator F terminal.

   Circuit "B" only: Remove jumper lead from generator armature and field terminals.

2. Move voltmeter lead from regulator Gen (Arm) terminal to regulator battery (Bat) terminal. Leave other voltmeter lead grounded to regulator base.

3. Connect a variable load (carbon pile) across the battery. Turn the load control to lowest load (open circuit).

4. Operate engine at 1500 rpm and slowly apply load to battery while observing ammeter for highest reading. Generator output should be between 34 and 38 amperes.

   If current regulator setting does not conform to specifications, remove regulator cover, adjust current regulator, replace cover and retest. Increasing the current regulator spring tension increases the current setting. Decreasing the spring tension decreases the current setting.

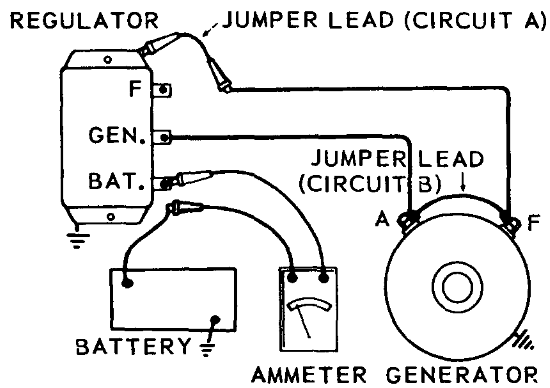
VOLTAGE REGULATOR TEST

1. Remove ammeter and connect a ¼ ohm fixed resistor between the regulator disconnected battery lead and the regulator battery (Bat) terminal.

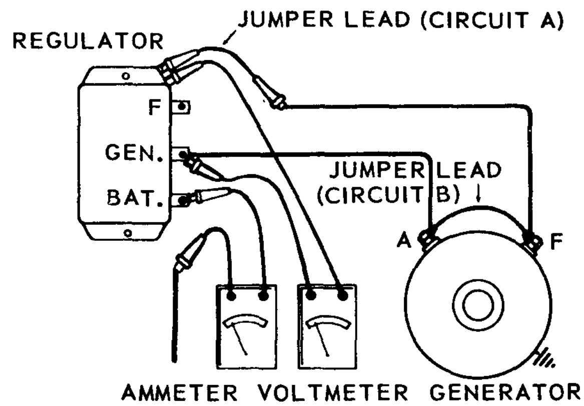
2. Operate engine at 2000 rpm and observe voltmeter. Reading should be between 13.5 volts and 14.7 volts.

   If voltage regulator setting does not conform to specifications, remove regulator cover, adjust voltage regulator, replace cover and retest. Increasing the voltage regulator spring tension increases the voltage setting. Decreasing the spring tension decreases the voltage setting.

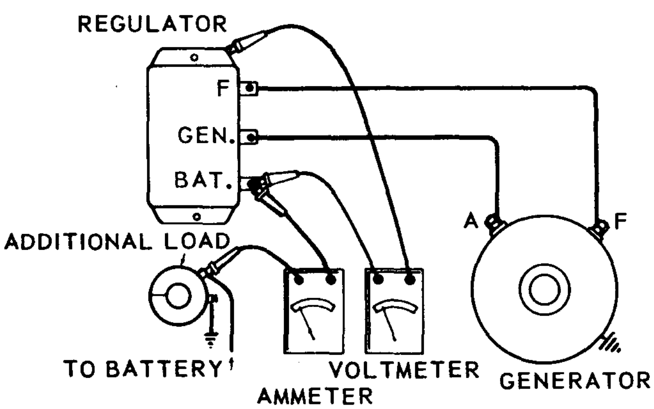
GENERATOR AND REGULATOR TESTS



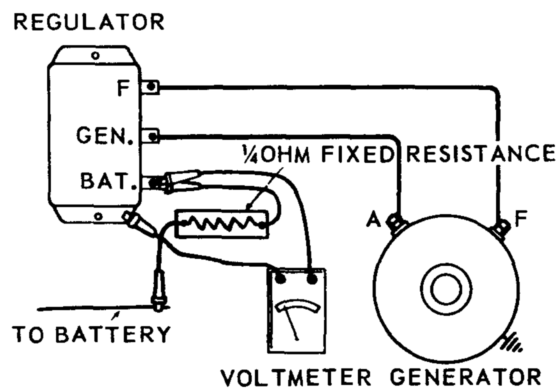
GENERATOR OUTPUT TEST



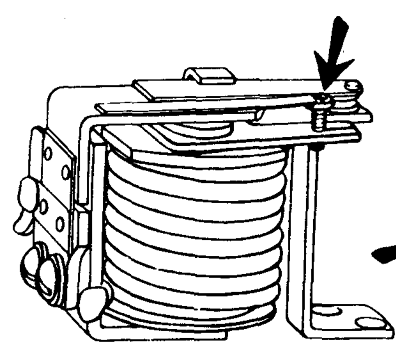
CUTOUT RELAY TEST



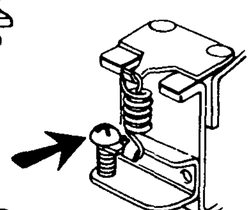
CURRENT REGULATOR TEST



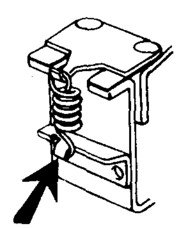
VOLTAGE REGULATOR TEST



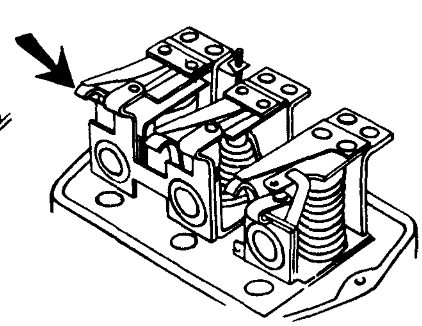
CUTOUT RELAY ADJUSTMENT



ADJUSTING SCREW COIL SPRING



ADJUSTING HANGER COIL SPRING



ADJUSTING ARM FLAT SPRING

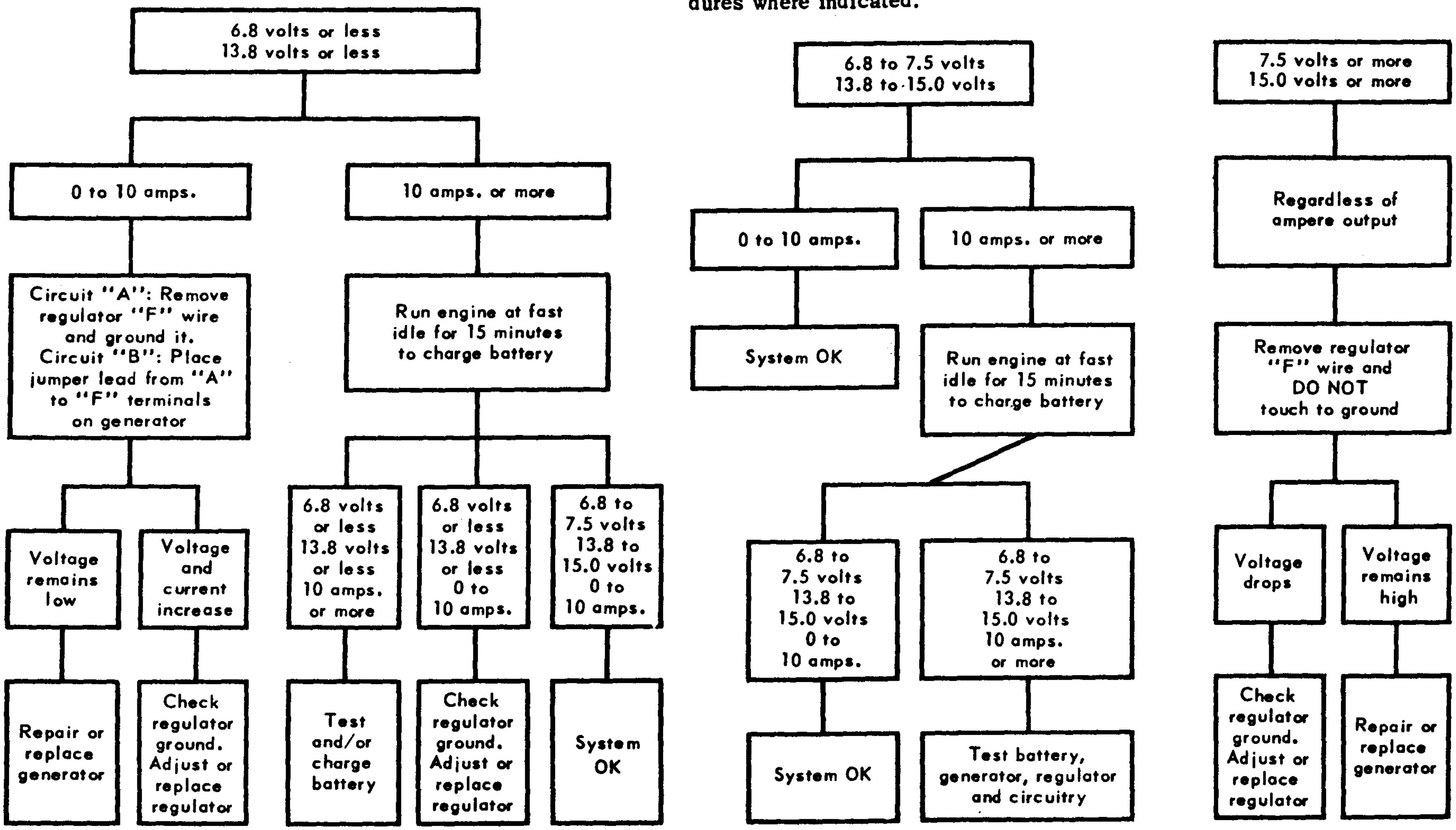
REGULATOR ADJUSTMENTS

GENERATOR AND REGULATOR QUICK CHECKS

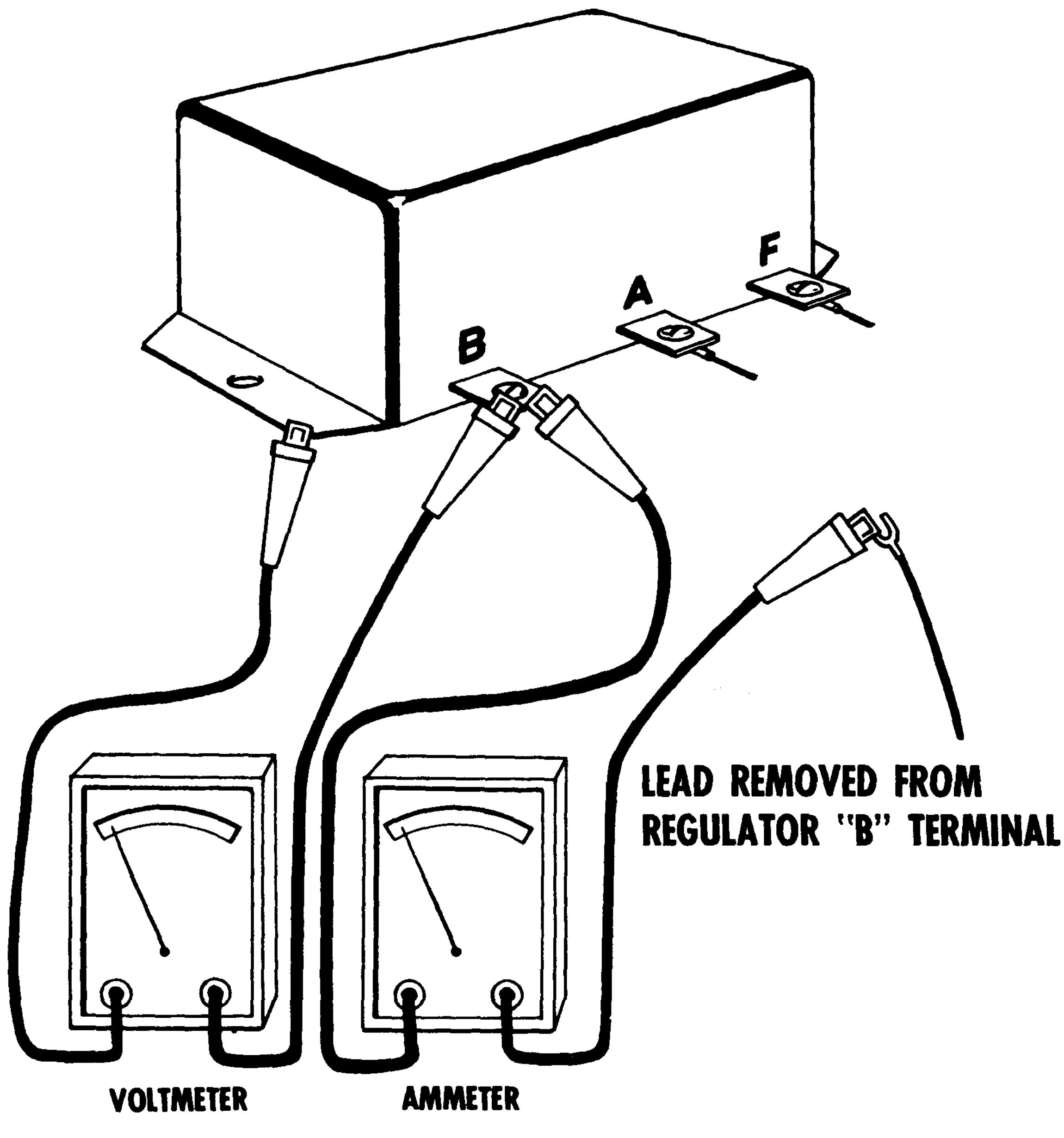
Disconnect regulator battery lead and connect ammeter between disconnected lead and regulator "BAT" terminal. Connect voltmeter from regulator "BAT" terminal to ground. Start engine and set engine speed at 1500 rpm.

Note: Observe differences in Circuit "A" and Circuit "B" test procedures where indicated.

METER READING INDICATIONS



GENERATOR AND REGULATOR QUICK CHECKS



CHARGING SYSTEM RESISTANCE TESTS

The charging system is designed for minimum voltage loss due to resistance in its circuitry. Excessive resistance in any part of the charging system circuit will alter its efficiency proportionately.

The insulated circuit test is made to determine the amount of voltage loss occurring between the armature terminal of the generator and the insulated battery post. The ground circuit test is made to determine the amount of voltage loss between the battery ground post and the generator housing. The regulator ground circuit test is made to determine the amount of voltage loss occurring between the regulator base and the generator housing.

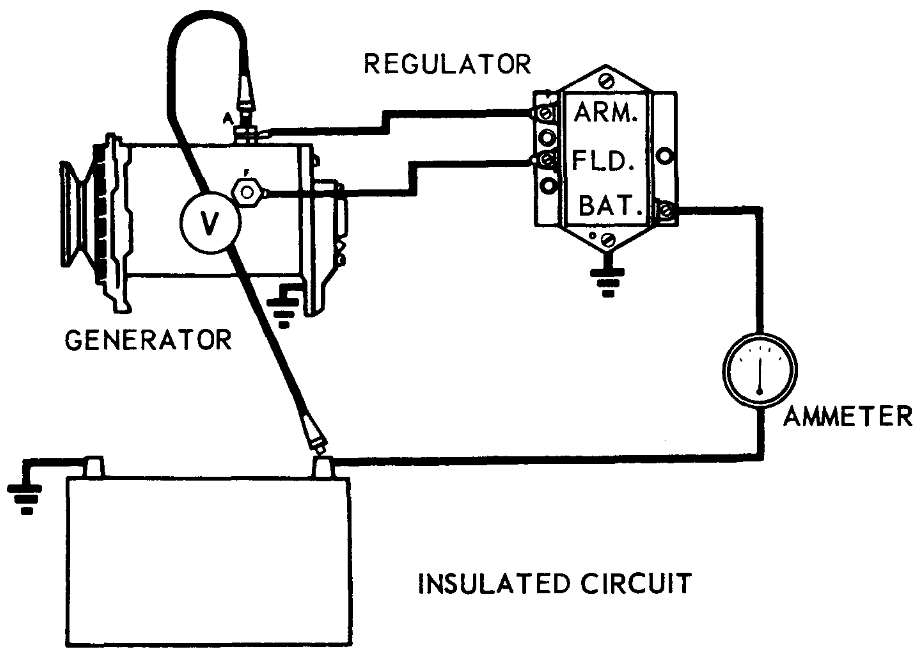
Any voltage loss caused by high resistance in these circuits will reduce the overall charge rate and can lead to eventual battery discharge. High resistance can be present in the form of poor connections or defective wiring. If excessive resistance is indicated by a test, it should be located and corrected.

The maximum permissible voltage loss in the charging system insulated circuit, with a 20 ampere charge flowing, is 1.0 volt. If more than 1.0 volt is indicated, the cause of the excessive resistance should be isolated and corrected permitting only .2 volt for each wire and each regulator terminal in the circuit.

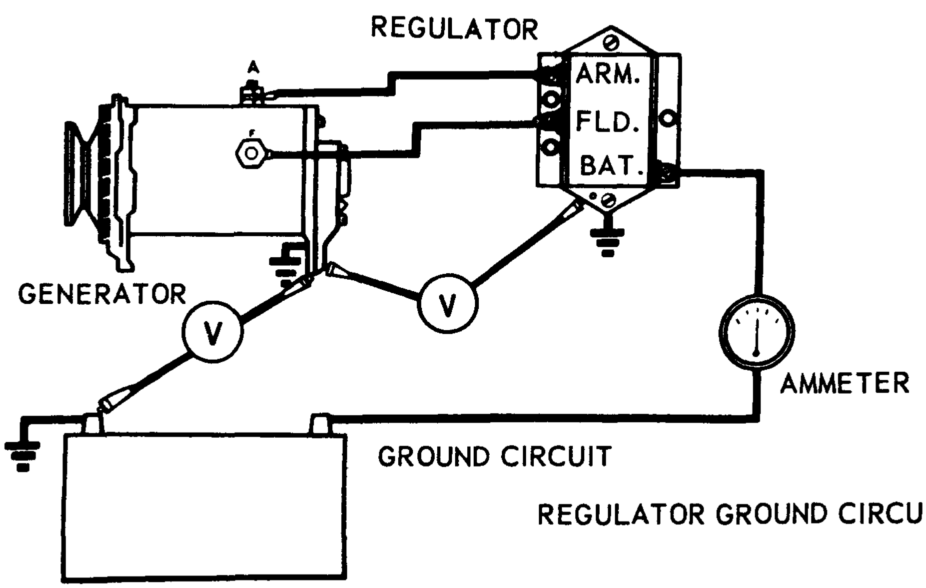
The maximum permissible voltage loss in the charging system ground circuit, with a 20 ampere charge rate flowing, is .2 volt. Higher voltage drop readings indicate a poor ground connection between the battery and the engine or between the generator and the engine.

The permissible voltage drop in the regulator ground circuit, with a 20 ampere charge rate, is .2 volt. Excessive voltage loss due to high resistance will cause the cutout relay and voltage regulator to operate at higher settings than those for which they are actually adjusted. This test is particularly critical because the regulator contact points, the voltage windings on the relays and the resistance units are all grounded in the regulator. A perfect ground circuit for these units is **essential** to proper regulator operation.

CHARGING SYSTEM RESISTANCE TESTS



INSULATED CIRCUIT



GROUND CIRCUIT

REGULATOR GROUND CIRCUIT

ALTERNATOR CHARGING SYSTEM

The alternator charging system has been developed to answer the need for increased generator output necessitated by the addition of electrically-operated accessories on the modern car combined with low-speed driving in congested traffic.

The alternator possesses the ability to produce a current output at engine idle speed and at low car speed. This factor makes it a superior charging unit to the direct current generator which must be rotated at reasonable speed before a current output is developed.

The basic alternator charging system components include the battery, the self-rectifying alternating current generator, a voltage limiting relay and interconnecting wiring. The circuit will include either an ammeter or an indicator light.

Every AC charging system is controlled by a voltage regulator. The battery initially supplies the current for the alternator field coil. At this time, and during idle and low-speed operation, there is no voltage control problem. However, as alternator speed increases with engine speed, the voltage increase developed by the alternator would be imposed on the field coil. This increases the field strength and further raises the voltage output. Unless this voltage rise condition is kept under control, the high voltage developed will result in damage or shortened life expectancy of light bulbs, relay coils, radio tubes, turn signal flashers, breaker points and other voltage-sensitive units.

All alternator voltage regulators are of the double-contact type discussed under generator regulators.

In other alternator systems the regulator may contain, in addition to the voltage limiter, a field relay which is used to complete the field circuit when the ignition switch is turned on. It may also include a lamp relay when an indicator light is used instead of an ammeter.

The cutout relay used in the DC generator system is not used in AC systems because the diode rectifiers used in the AC system permit the flow of current in one direction only. The positive diodes will not allow current to flow from the battery into the alternator. Battery discharge is thereby prevented.

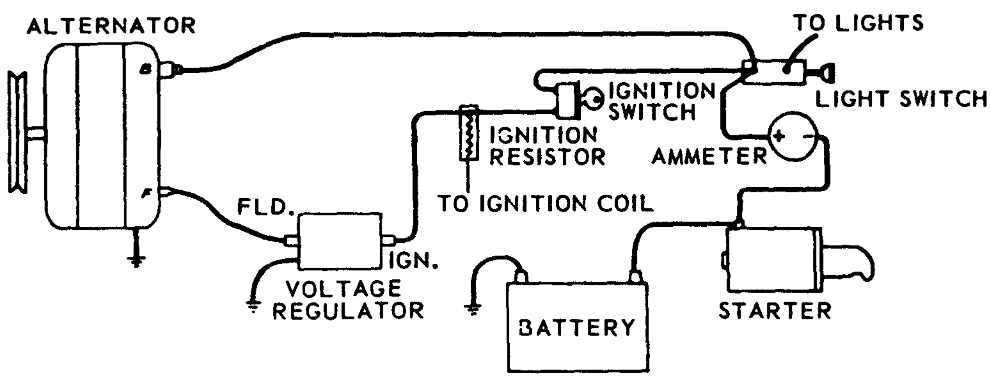
The AC system does not require the use of a current regulator since the alternator is self-limiting in current output as long as voltage control is maintained.

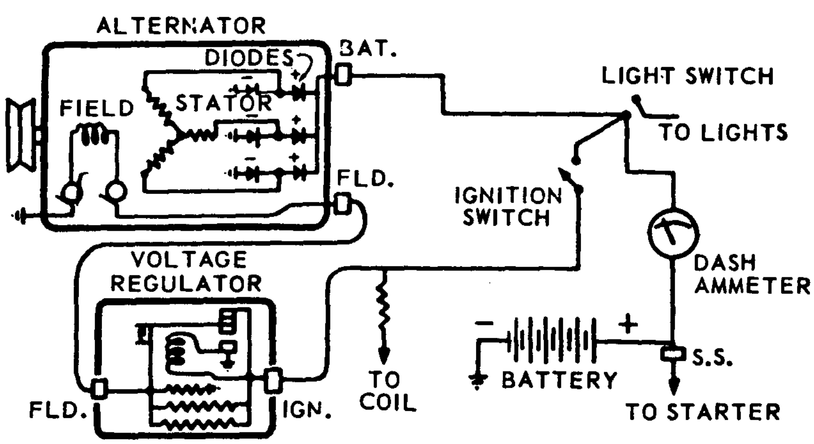
The chart illustrates a schematic arrangement of an AC charging system in common use. The field terminal of the alternator is connected to the field terminal of the regulator. The connection from the ignition terminal of the regulator goes to the ignition switch. Field current must be supplied from the battery, as the rotor of the alternator does not possess residual magnetism. The lead from the output terminal completes the circuit from the alternator to the battery positive terminal.

The car ammeter is in the circuit between the ignition switch and the battery. In that location it will register charge only when the alternator output is greater than the electrical load. The ammeter will register discharge only when the alternator output is less than the electrical load. The ammeter does not register the alternator output. It registers only the current flow into or out of the battery.

The AC charging system illustrated on this chart essentially covers the elements of all AC systems. Individual coverage of specific systems will be covered under testing procedures a little later in this course.

ALTERNATOR CHARGING SYSTEM





ALTERNATOR COMPONENTS

The alternator is composed of a rotor assembly, a stator assembly and two end frame assemblies, one at the drive end of the alternator and one at the slip ring end.

The rotor assembly is composed of a field coil made of many turns of wire wound over an iron core which is contained between two iron segments with interlacing fingers. These fingers serve as magnetic poles. This assembly is press mounted on a steel shaft which turns in prelubricated anti-friction bearings. Two slip rings are mounted on one end of the shaft.

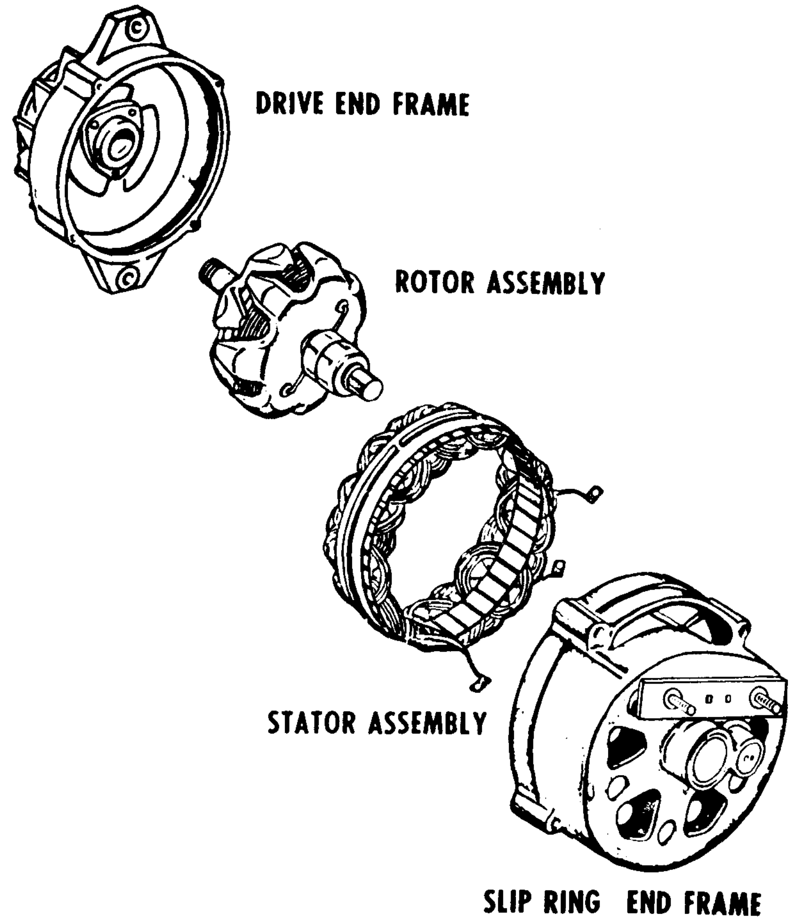
Each end of the field coil winding is connected to one of the slip rings. A brush rides on each slip ring. These brushes conduct battery current to the rotor winding to create the magnetic field required for current generation. This is necessary because the rotor is made of a metal alloy that does not retain residual magnetism and is therefore not self-exciting.

The stator assembly is composed of a laminated iron frame and three sets of windings wound into slots in the frame. The manner in which these windings are wound and connected makes the alternator a three phase unit. Constant voltage can be maintained since each of the three windings reaches its maximum voltage output at a different time. Three voltage impulses are induced for every turn of the rotor with this arrangement whereas one voltage impulse would be induced if a single winding were used. One end of all three windings are connected together while the other end of each winding is connected to a pair of diodes, one positive and one negative.

When assembled, a very small air gap is present between the rotor poles and the stator to keep the magnetic field lines of force as strong as possible. As the rotor spins, the alternate north and south poles of the rotor fingers pass each loop in the stator windings inducing an alternate amperage and voltage in the windings. This alternating current is then rectified by the diodes.

The slip ring end frame contains six diodes, which are electrical rectifying devices. The diodes, three negative and three positive, act as one-way valves permitting current to pass freely in one direction but not in the other. By their combined action, the alternating current generated is rectified to direct current.

ALTERNATOR COMPONENTS



DIODE

As previously stated, the diode is a current rectifying device. It serves as a one-way electrical check valve which permits current to flow readily in one direction but stops its flow in a reverse direction. The silicon die or wafer in the diode possesses this electrical characteristic by virtue of the molecular construction of the metal.

The diode symbol is an arrow indicating the direction of current flow allowed by the diode. The bar indicates a one-way "gate" or block to current flowing in the opposite direction.

The cross-sectional view illustrates the position of the silicon wafer in the bottom of the diode case. The case is made of rather heavy metal to serve both as a protection for the rather brittle silicon wafer and to effectively dissipate the heat, induced by the current flow through the diode. The case is tightly sealed during manufacture to prevent the entrance of moisture into the diode which would result in short circuiting of the unit. Moisture is readily drawn into any unit that operates at a temperature since it "breathes" as it heats and cools.

In all negative ground alternator charging systems the negative (case) diodes are pressed into the alternator grounded end frame and the positive (case) diodes are pressed into a holder called a heat sink. The heat sink is usually made of die-cast aluminum because it possesses high heat dissipating qualities. It is mounted in, but electrically insulated from, the end frame. The end frame also serves to absorb the heat developed by the passage of current through the diodes.

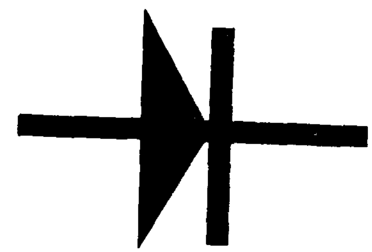
A negative diode is properly identified as a negative case diode meaning the diode case is negative polarity and the diode lead is positive polarity. A positive case diode will have a positive polarity case and a negative polarity lead. Diodes are color coded for polarity identification. The part number of the diode is printed with a red dye on the positive diode and with a black dye for the negative diode. When part numbers are not used, a dab of red or black dye on the diode case identifies its polarity. Diodes used in heavy-duty application are identified with a + (plus) or a - (minus) sign.

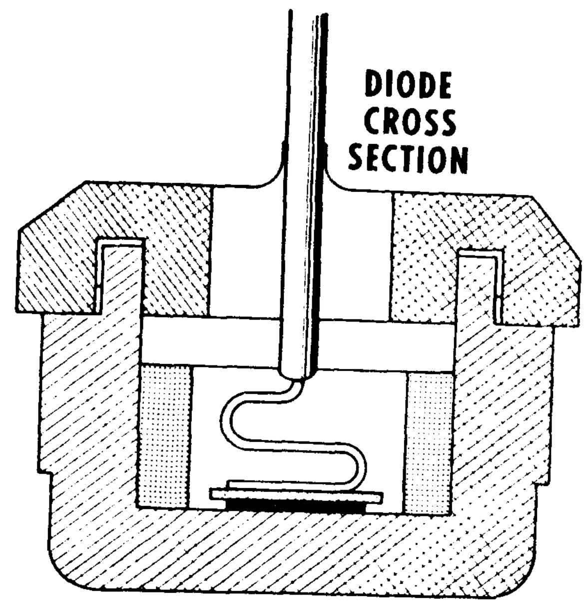
The Zener diode is used in many transistorized ignition systems and voltage regulators. Its basic function is to protect the transistors in the circuit from the harmful effects of high voltage. When a predetermined voltage is reached, the Zener diode "breaks down" and permits the passage of current in the opposite direction by providing a shunt circuit for the high-voltage current. This breakdown voltage does not harm the Zener diode since it is designed to perform in this manner. When the voltage drops below the predetermined voltage, the Zener diode again blocks current.

Since the breakdown voltage of the Zener diode is lower than the voltage value that would damage the transistor, the transistor is thereby protected. The Zener diode can be constructed to "break down" at varying voltages.

DIODE

DIODE SYMBOL





DIODE CROSS SECTION

TRANSISTORS

A transistor is a device which acts as an electrical switch but has no moving parts. Current flow through the transistor can be controlled mechanically by a set of contacts or electrically by reversing the circuit polarity.

A transistor is made up of three small sections of material fused together like a wafer or sandwich and placed in a container. The sections are referred to as "N" or "P" type material. The arrangement of the sections determines the transistor's polarity. The transistor may be known as a PNP transistor or as a NPN transistor according to the positions of the wafers. The middle wafer serves as the base and therefore dictates the polarity.

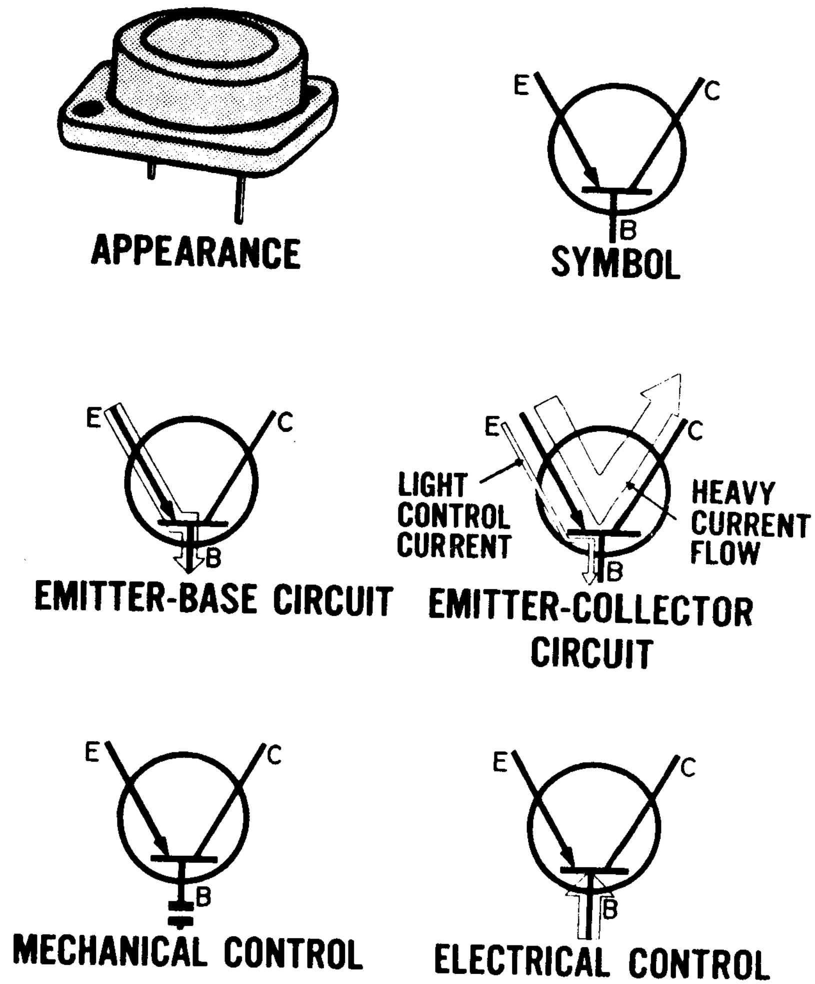
The transistor symbol is illustrated on the chart. The circle represents the container. The letters represent the three elements of which the transistor is composed – E is the Emitter; C is the Collector; and B is the Base. The arrow on the Emitter symbol indicates the direction of current flow through the transistor.

There are two important factors relative to the manner in which the transistor works. First: the Emitter-Collector circuit is the main current-carrying circuit. Second: current flow through the Emitter-Collector circuit is possibly ONLY when there is current flow through the Emitter-Base circuit. Although the current flow in the Base circuit may be only a fraction of the current flow in the Collector circuit, the Collector circuit cannot exist without the Base circuit. It follows then, that an interruption of the light current flow in the Base circuit will cause a stoppage in the heavy current flow in the Collector circuit. In this manner the Base circuit "triggers" the transistor and turns it ON or OFF.

As previously stated, the transistor is electrically controlled through the base circuit. A set of mechanical contact points, in series in the Emitter-Base circuit, can readily carry the light current flow in this circuit and serve to "make" and "break" the Base circuit.

Another method of electrical control is performed by reversing the current flow in the Base circuit. The Base circuit will carry current only when the proper voltage range and polarity is applied. When incorrect voltage or reversed polarity is applied the Base circuit is turned OFF and current flow in the Collector circuit is consequently stopped.

TRANSISTORS



DIODE-RECTIFIED OUTPUT

This chart illustrates how the diodes rectify the alternating current flowing in either direction through any two stator windings so that direct current is always available at the output or battery terminal of the alternator.

Voltage induced in the windings "A" and "C" cause current to flow from the "A" coil of the stator through its positive diode, out of the "Bat" terminal of the alternator and to the battery. The return circuit is from the battery, to the alternator ground terminal, through the negative diode connected to the "C" coil of the stator and back to the "A" coil where it started, completing the circuit.

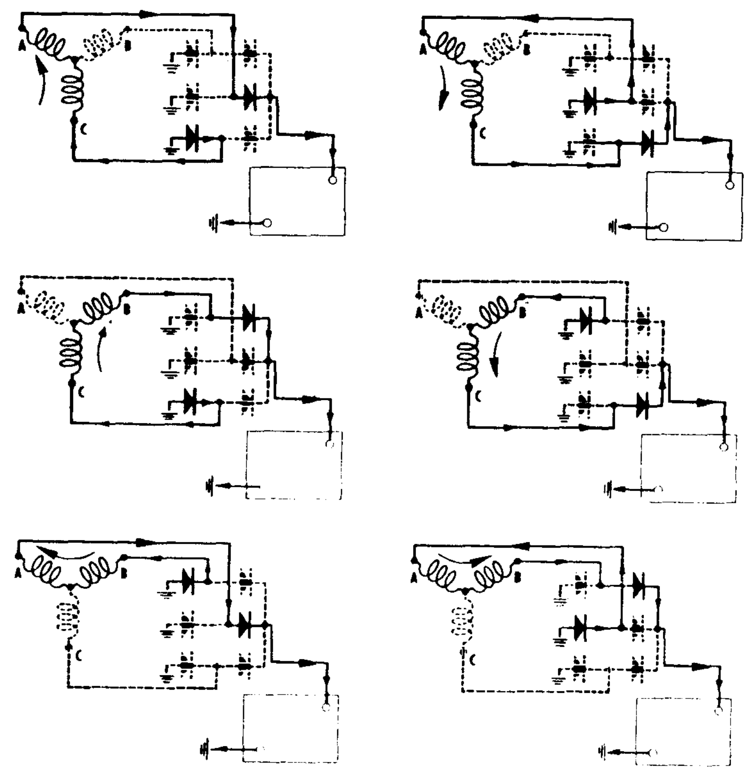
When the alternating voltage induced in these windings is reversed, current will flow out of the "C" stator coil of the alternator, through its positive diode, out of the "Bat" terminal of the alternator and to the battery. This rectified direct current flows to the battery in the same direction as it did previously. The return circuit is from the battery, to the alternator ground terminal, through the negative diode connected to the "A" stator coil and back to the "C" coil where it started, completing the circuit.

Current flow, in either direction, through the stator windings in the other illustrations can be traced by following the arrows from the stator coil windings, through the positive diode, to the battery, from the battery through the negative diode, and through the stator windings back to its source.

These illustrations clearly show that by the action of the diodes, direct current is always flowing into the battery regardless of which stator windings are inducing the voltage or the direction of the current flow through the windings.

Occasionally a diode is used in an alternator for a function other than current rectification. An example is the isolation diode used in the Motorola alternator. Its function is to serve as a load relay to essentially disconnect the alternator from the battery when the ignition switch is turned off. In a sense it is serving the same function as a cutout relay in a DC charging system. When the vehicle is not in use, this diode eliminates the possibility of electrical leakage over the insulators.

DIODE-RECTIFIED THREE PHASE OUTPUT



AC CHARGING SYSTEM (With Ammeter)

A typical AC charging system equipped with an ammeter is illustrated on this chart.

When the ignition switch is closed, a connection is established between its battery and ignition terminals. Battery current now flows to terminal "2" of the regulator, through the field relay shunt winding, to ground and back to the battery through the ground circuit.

The magnetic field created around the field relay core attracts the relay armature thereby closing the relay points. Battery current now flows to terminal "3" of the regulator, across the field relay points, across the lower voltage regulator points, from the field terminal on the regulator to the field terminal on the alternator, through the field coil to ground and back to the battery. Some current also flows through the shunt winding on the voltage coil. With the rotor field coil energized, the alternator is ready to produce current as soon as the rotor is turned.

With the field relay closed, current is supplied directly to the alternator field coil from the battery instead of through the ignition switch and ignition primary resistance wire.

When the engine is started, the alternator rotor spins and the magnetism created in the field coil by the field current induces an alternating current in the stator windings. The diodes rectify the alternating current generated into direct current as previously explained.

As the vehicle is put in motion, the alternator speed is increased resulting in a greater voltage being induced on the current flow in the field circuit. Since the shunt winding on the voltage coil is also subjected to this increased voltage, a greater magnetic field is created around the voltage coil. This strong field attracts the voltage regulator armature causing the lower contact points to separate.

Field current must now flow through the resistor on its way to the field coil. Field current is reduced from approximately 2 amperes to about ¾ ampere by the resistor. The reduced field current results in an immediate reduction in alternator output with an associate drop in voltage applied to the voltage regulator coil. The voltage regulator armature spring closes the lower contacts thereby re-establishing full field current flow. This cycling action of inserting and removing the resistor from the field circuit limits the voltage developed by the alternator to a safe value.

If the vehicle is driven at high speed and the accessory and battery demands are low, a higher voltage of .1 to .3 volt is induced on the shunt coil of the voltage limiter. This results in the upper armature being attracted to the relay core thereby closing the upper contacts. At this time, both ends of the field coil are grounded with the result that there is no current flow through the coil. With a "dead" field coil, alternator voltage decreases permitting the upper contact points to open. Field current now flows through the resistor to the field coil. As the voltage again increases, the upper relay contacts are again closed. The cycling that takes place limits the field current between ¾ ampere and no current at all. By this action, alternator output is safely limited regardless of how fast the vehicle may be driven or how long the speed is sustained.

The function of the condenser used in the alternator is to dampen the high voltage surges developed in the stator windings or any transient high voltage impulses generated anywhere in the charging system. The condenser also serves as a noise suppression unit.

AC CHARGING SYSTEM
With Ammeter

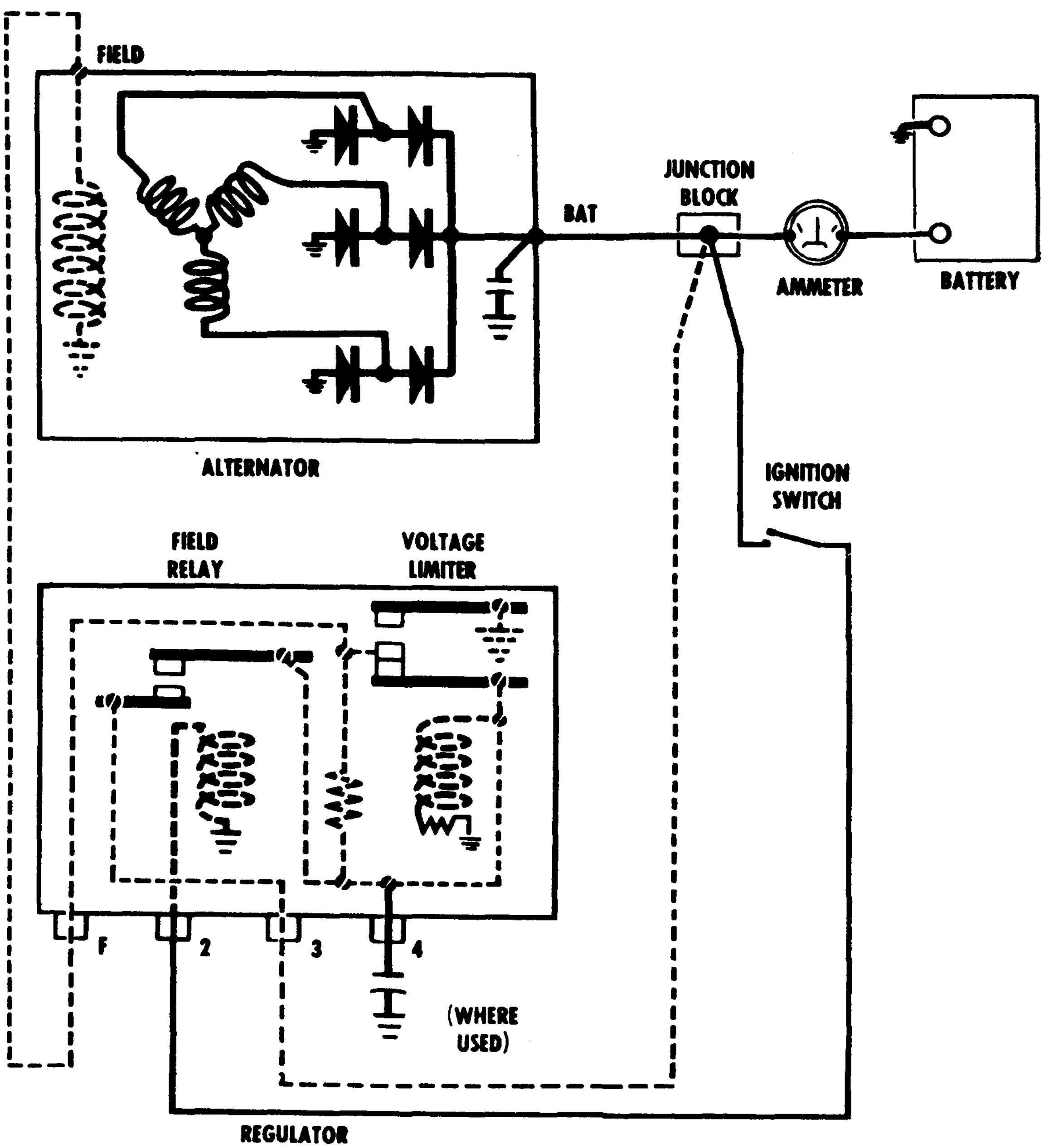


Chart No. 67

AC CHARGING SYSTEM (With Indicator Lamp).

A typical AC charging system equipped with an indicator lamp is illustrated on this chart.

When the ignition switch is closed, battery current flows through the indicator lamp to the "L" terminal on the regulator, across the closed relay contacts and to ground. This completes the indicator lamp relay circuit permitting the lamp to light.

Also energized by the closing of the ignition switch is the field relay. Battery current flows from the switch to the "SW" terminal on the regulator, through the field relay voltage coil, to ground and back to the battery. The magnetic field created around the field relay core attracts the relay armature closing the relay points. Battery current now flows from the junction block terminal to the "V" terminal on the regulator, across the field relay points, across the lower voltage regulator points, from the "F" terminal on the regulator to the alternator, through the field coil to ground and back to the battery.

When the engine is started, the alternator rotor spins and the magnetism created in the field coil by the field current induces an alternating current in the stator windings. The diodes rectify the alternating current generated into direct current as previously explained.

As soon as the alternator starts operating, current flows from the alternator "relay" terminal to the "R" terminal on the regulator, through the voltage coil on the indicator lamp relay to ground and back to the alternator. This current flow magnetizes the light relay core which attracts the relay armature thereby opening the relay points. This opens the indicator lamp circuit, and the lamp goes out. This circuit arrangement provides a light which serves as a warning when lit with the engine running, that trouble exists in the charging system.

As the vehicle is put in motion, the alternator speed is increased resulting in a greater voltage being induced on the current flow in the field circuit. Since the shunt winding on the voltage coil is also subjected to this increased voltage, a greater magnetic field is created around the voltage coil. This strong field attracts the voltage regulator armature causing the lower contact points to separate. Field current must now flow through the resistor on its way to the field coil. Field current is reduced from approximately 2 amperes to about ¾ ampere by the resistor. The reduced field current results in an immediate reduction in alternator output with an associate drop in voltage applied to the voltage regulator coil. The voltage regulator armature spring closes the lower contacts thereby re-establishing full field current flow. This cycling action of inserting and removing the resistor from the field circuit limits the voltage developed by the alternator to a safe value.

If the vehicle is driven at high speed and the accessory and battery demands are low, a higher voltage of .1 to .3 volt is induced on the shunt coil of the voltage limiter. This results in the upper armature being attracted to the relay core thereby closing the upper contacts. At this time, both ends of the field coil are grounded with the result that there is no current flow through the coil. With a "dead" field coil, alternator voltage decreases permitting the upper contact points to open. Field current now flows through the resistor to the field coil. As the voltage again increases, the upper relay contacts are again closed. The cycling that takes place limits the field current between ¾ ampere and no current flow at all. By this action, alternator output is safely limited regardless of how fast the vehicle may be driven or how long the speed is sustained.

AC CHARGING SYSTEM
With Indicator Lamp

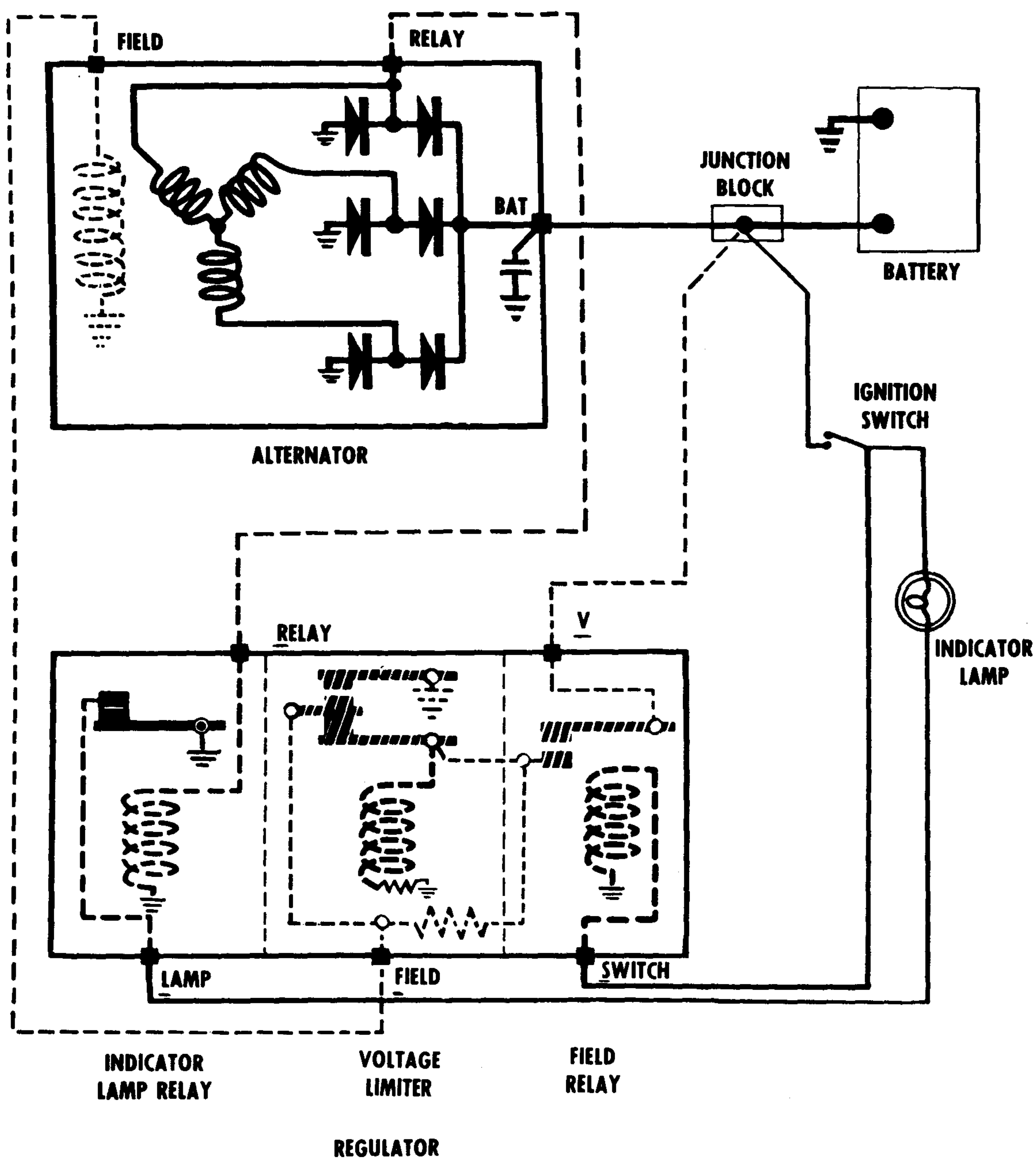


Chart No. 68

AC CHARGING CIRCUIT INDICATOR LAMPS

The upper circuit diagram illustrates the use of an indicator lamp and a separate indicator lamp relay.

When the ignition switch is turned on, battery current flows through the indicator lamp, to the indicator lamp relay No. 3 terminal, across the relay armature and the closed upper relay points to ground. This completes the circuit permitting the indicator lamp to light.

As soon as the engine starts, alternator voltage from the relay terminal is impressed on the indicator lamp relay No. 2 terminal. The current flows through the relay winding creating a magnetic field which attracts the relay armature pulling it down and closing the lower contacts.

When this occurs, not only is the circuit ground denied to the indicator lamp but alternator output voltage is now applied to both sides of the lamp at the same time. As a result, current flow stops and the light goes out.

The rest of the charging system functions are as previously explained.

The lower circuit diagram illustrates the use of an indicator lamp without the use of an indicator lamp relay.

When the ignition switch is turned on, battery current flows through the indicator lamp to the regulator No. 4 terminal, across the closed lower voltage regulator points, to the regulator "F" terminal and to the alternator field coil. This complete circuit permits the indicator lamp to light.

As soon as the engine starts, alternator voltage is impressed on the alternator relay terminal causing current to flow to the regulator No. 2 terminal and through the shunt winding in the field relay. The magnetic field created by this current flow attracts the field relay armature closing the field relay circuit. System voltage impressed on the regulator No. 3 terminal is now also impressed on the No. 4 terminal. This results in system voltage being applied to both sides of the indicator lamp at the same time. With no current flow through the lamp, the light goes out.

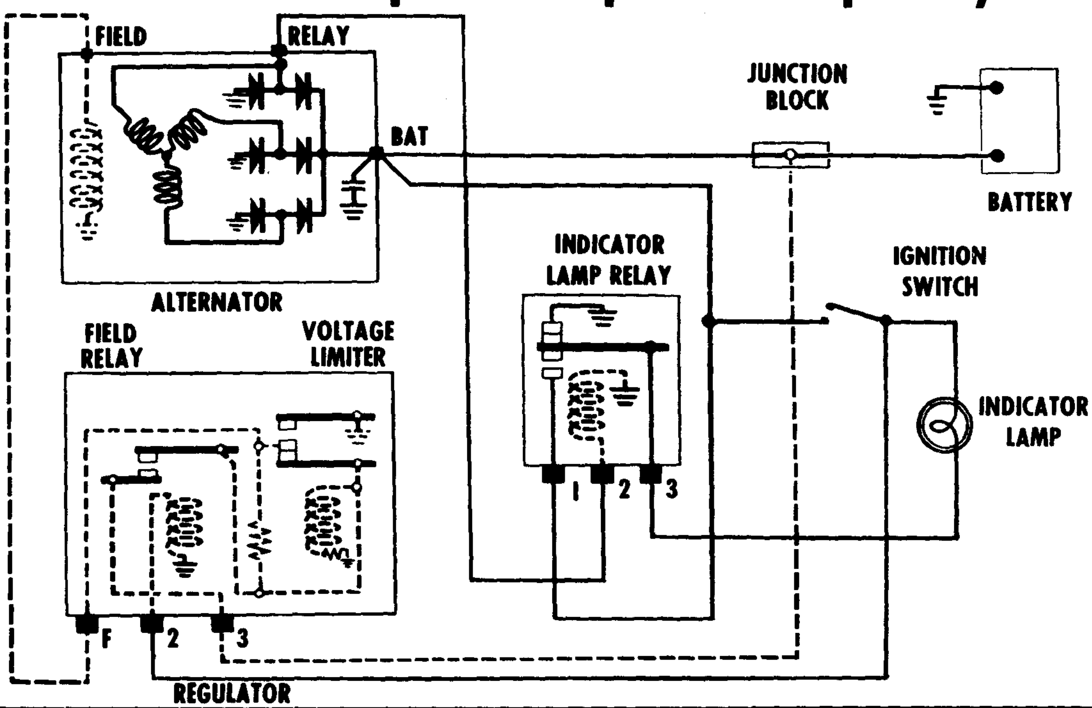
In this regulator circuit, it may be said the field relay has a dual function. It not only completes the field circuit directly from the battery to the alternator field instead of through the ignition switch and primary resistance wire but it also serves as an indicator light relay.

The rest of the charging system functions as previously explained.

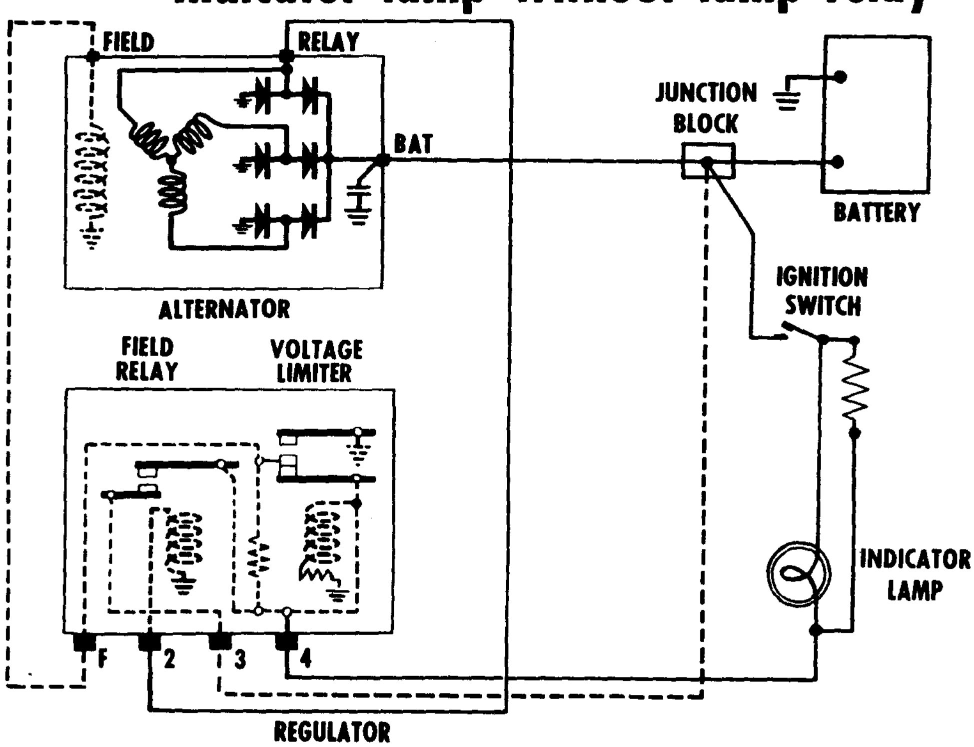
Chart No. 68

AC CHARGING CIRCUIT INDICATOR LAMPS

Indicator lamp with separate lamp relay



Indicator lamp without lamp relay



ALTERNATOR TESTING FACTORS

Failure of the AC charging system to function normally is revealed by an indicator lamp that does not light when the ignition switch is turned on; by a lamp that stays lit after the engine starts running; by a slower than normal cranking speed; or by a battery being in a state of undercharge or overcharge.

An alternator with a faulty diode can put out enough current to supply the ignition system demands and yet be incapable of keeping the battery fully charged especially when the lights and accessories are used.

When an alternator diode is defective, an obvious indication is a whine or hum with the engine idling or operating at low speed. Since the alternator is a 3-phase machine, when one diode is defective the machine is out-of-phase, soundwise, resulting in a whine. This condition is usually the result of a shorted diode. When a diode is open, the condition is generally indicated by noisy operation of the alternator. This noise is caused by the physical unbalance of the unit which has been created by the electrical unbalance, so to speak. If this condition is allowed to persist, the antifriction rotor shaft bearings in the diode end frame may be damaged.

By far, the greatest percentage of alternator trouble is diode trouble. But usually this trouble is created by improper test procedures, reverse current connections, removing alternator leads while the alternator is in operation, reversing battery connections and other abuses.

When an AC charging system complaint is expressed, a few checks and tests should be made before the alternator is condemned or disassembled.

1. Check the tension of the drive belt and inspect its condition. Stretched, frayed or oil-wetted belts should be replaced. The smaller alternator drive pulley has less wraparound drive belt action making belt tension particularly critical. Further, since the alternator has an output even at idle, it is possible for the belt to be slipping at idle speed. Care must be exercised when adjusting belt tension so that the aluminum alternator housing is not crushed by the pry bar. Rest the bar only on the heavy front section of the housing.

2. Test the condition of the battery. A sulphated or internally defective battery will resist being charged even when the charging system is functioning normally.

3. Excessive resistance in the charging circuit can cause a lower than normal charge rate and result in a discharged battery. To isolate the point of high resistance with your test equipment, test both the insulated circuit and the ground circuit.

4. Make an alternator field current draw test and an output test.

5. Test the regulator. A malfunctioning field relay may be restricting field current thereby reducing alternator output. A low voltage regulator setting can also be responsible for an undercharged battery condition.

If the above checks and tests do not reveal any defective conditions, complete tests of the alternator should be conducted before the unit is disassembled.

Starting with the 1972 models, be sure the heater/air condition blower motor is disconnected, along with all the other electrical accessories, before conducting an alternator output test. Pulling the air conditioner fuse is a quick way to cut the power to the blower motor.

To avoid the hazzard of instant, accidental fogging of the windshield, the blower motor operates continuously at low speed unless regulated otherwise. Failure to disconnect the blower motor before testing will result in a lower then specified output since as much as 10 amperes can be flowing in the blower circuit. This reduced ammeter reading may be misinterpreted as a lack of sufficient output even though the charging system is functioning properly. The discrepancy occurs because part of the alternator output is going through the blower motor circuit without passing through the test ammeter since the two circuits are in parallel.

Chart No. 69

TRANSISTOR REGULATORS

The transistorized voltage regulator controls the alternator voltage output electronically by using transistors, diodes, resistors and a capacitor. Some transistorized regulators employ a vibrating contact field relay to control the transistor which carries the field current. A vibrating voltage limiter relay may also be used in conjunction with a transistor. When the regulator design eliminates the use of relays and employs full transistor control, the regulator is called a "solid state" regulator.

The chart illustrates the elements of a simplified alternator charging system. In the regulator control circuit is housed the thermistor, a temperature-compensating voltage control device; a Zener diode, a voltage sensing unit; a driver transistor, which controls the output transistor; resistors and a capacitor. All these units function together to control the alternator field current and consequently alternator output.

When the ignition switch is closed, battery voltage is applied to the emitter-collector circuit of the transistor and to the alternator field circuit. The emitter-collector circuit is completed because the emitter-base circuit is also completed through the regulator control circuit. Alternator voltage builds up as soon as the engine starts, supplying all the activated circuits with current and charging the battery. As the vehicle is put in motion, alternator voltage builds up to the value for which the regulator has been set. The regulator control circuit then applies a higher voltage (or reverse voltage) to the base circuit of the transistor thereby turning the transistor "Off." The resultant loss of current flow in the emitter-collector circuit causes a stoppage of current flow in the alternator field circuit with a resultant drop in alternator output.

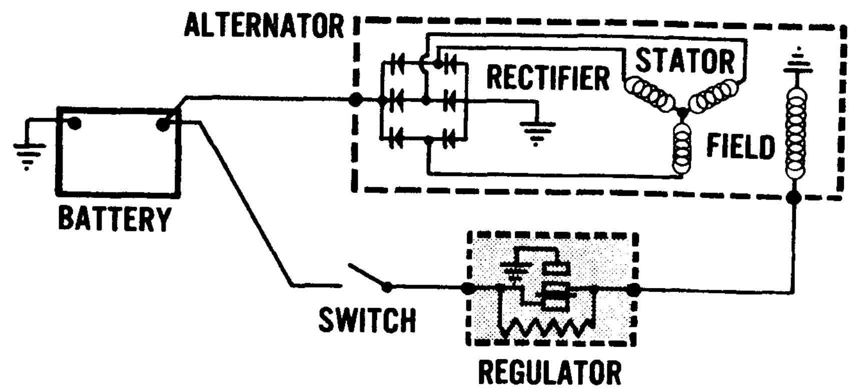
The regulator control circuit now places a lower voltage on the base circuit of the transistor allowing the transistor to be turned "On" again. Current flow in the emitter-collector circuit and in the alternator field circuit is reestablished and alternator output voltage again builds up to the value of the voltage regulator setting. The regulator control circuit again reverses the voltage applied to the transistor base circuit turning the transistor "Off." In this manner, the transistor is switched "On" and "Off" regulating the alternator output to match the electrical demands of of the vehicle and the charging requirements of the battery.

The vibrating contacts of the mechanical voltage limiter relay vibrate from 75 to 250 cycles per second. The "On" and "Off" cycles of the transistor may occur as frequently as 7,000 cycles per second.

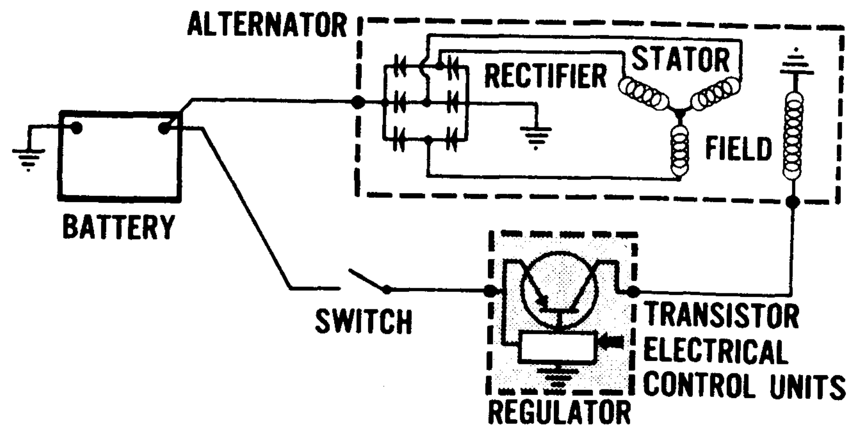
Some transistor regulators are equipped with an external method of adjustment while others are nonadjustable.

Chart No. 69

TRANSISTOR REGULATORS



VIBRATING POINT REGULATOR



TRANSISTOR REGULATOR

Chart No. 72

MICRO-CIRCUIT VOLTAGE REGULATORS

The recently introduced miniature solid-state micro-circuit voltage regulators make possible combining some regulators with the alternator into one compact unit. With the elimination of the conventional regulator unit the standard wiring harness between the two units has also been eliminated.

Although construction and design varies, the micro solid-state regulator is basically composed of transistors, diodes and resistors all fabricated within a single piece of silicon crystal measuring about 1/8 inch square. The parts are interconnected by means of very small aluminum conductors and the entire assembly may be fully encased in high-temperature thermosetting plastic for trouble-free, long-life service. Terminals built into the regulator housing, supply the alternator circuit connecting points. Being factory precision adjusted, the miniature voltage limiter does not need, nor is any provision made for, periodic adjustment. Failure to conform to test specifications, calls for unit replacement.

Several benefits have been attributed to the new regulator design.

1. Advanced technology has miniaturized the voltage regulator for assembly on or inside the alternator. The alternator housing has been finned to provide adequate cooling for both the alternator and the regulator.
2. Simplified circuitry reduces the number of individual components in the charging system.
3. Since the conventional wiring harness between the alternator and regulator has been dispensed with, all wiring and connections are contained within the alternator housing. This arrangement reduces the possibility of voltage loss in the charging system due to loose or poor wiring connection.
4. The regulator solid-state circuitry provides improved voltage control because moving parts as the conventional vibrating contacts have been eliminated. The voltage setting now remains precise for the life of the unit without maintenance or adjustment.
5. The solid-state control sensors are unaffected by shock, vibration, moisture or aging and the long life and inherent accuracy of the semiconductor elements make this type of circuitry particularly adaptable to the automotive charging system.
6. By maintaining positive and precise control over the alternator output at all temperatures, the battery will be kept charged at all times and increased lamp life will also be realized.

The micro-circuit transistorized Electronic voltage regulator introduced on some 1969 Chrysler Corporation vehicles is mounted on the firewall. If the unit is replaced it is important that the same screws that retained the original regulator be used to secure the new unit. The screws are designed for a special "biting" action to assure a definite electrical ground to the firewall. The charging system will fail to function if an effective ground is not secured at the regulator.

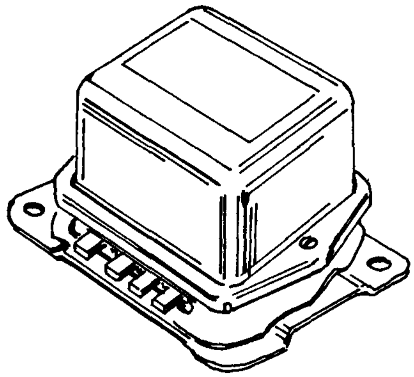
Consistent with the policy of regulator nonadjustment is the conventional charging system regulators used on many models of Ford Motor Company products starting with the 1968 models. Although not of micro-circuit design the regulators have the cover riveted to the regulator base. To further identify these regulators as nonadjustable, the covers are painted a blue color. Any regulator that does not test to a specified tolerance should be replaced, not serviced.

Starting with the 1969 Ford products, some models were equipped with the micro-electronic integral regulator which is externally mounted on the alternator rear end housing. Also starting with some 1969 models,General Motors introduced the Delcotron CSI (Charging System Integral) in which the miniature integrated regulator is internally housed in the rear upper section of the alternator.

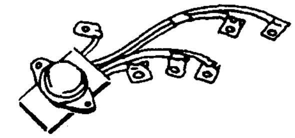
This policy of nonadjustment is predicated on the fact that regulator tailored voltage adjustments that were necessary on dc charging systems are not required on ac charging systems. It was therefore decided that a factory-adjusted regulator, in conjunction with an alternator, will satisfactorily maintain the battery in a state of charge over a wide range of operating conditions.

Chart No. 72

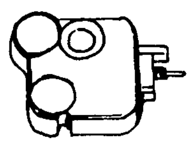
MICRO-CIRCUIT VOLTAGE REGULATORS



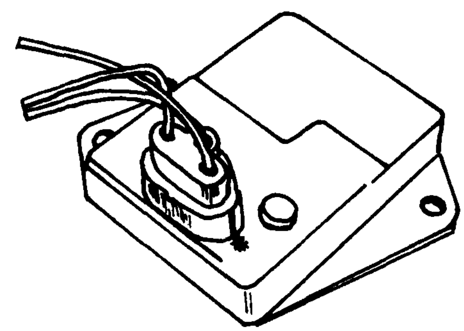
CONVENTIONAL REGULATOR



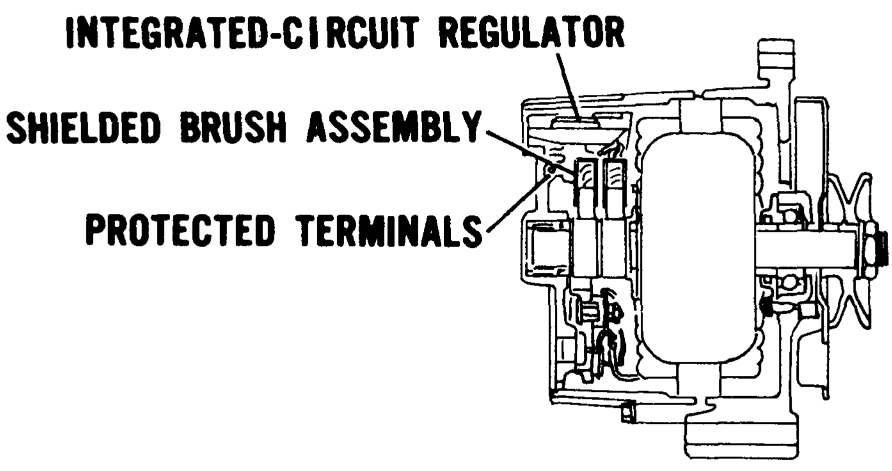
GENERAL MOTORS UNIT



FORD MOTORS UNIT



CHRYSLER CORPORATION
(FIREWALL MOUNTED)



INTEGRATED MICRO-CIRCUIT REGULATOR
(MOUNTED IN ALTERNATOR HOUSING)

Chart No. 76

DIODE TESTS

Due to the manner in which the three stator windings are connected, two windings are always being used at any one time. Only two diodes are being used at any one time. If any diode is defective, causing one phase of the 3-phase winding to be missing, alternator output is decreased by approximately two-thirds because any single missing phase undesirably influences both of the other phases.

The diodes on some makes of alternators can be tested with the alternator assembled and on the engine. Other makes have to be disassembled for diode testing.

Diodes can be readily checked using a Diode Tester. When using this test instrument follow the manufacturer's instructions.

Diodes may also be tested with a **12-volt** test lamp. Touch the prods of the test lamp leads to the diode case and diode lead and then reverse the test lamp prods as previously explained. If the diode is good, the test lamp will light in only one test. If the lamp fails to light in both tests or lights in both tests, the diode is defective.

Another method of checking diodes is with an ohmmeter. After the stator leads have been disconnected, each diode can be tested for shorts and opens. Touch one ohmmeter prod to the diode case and the other prod to the diode lead and observe the ohmmeter reading. Then reverse the ohmmeter prods and again observe the meter readings. A diode in good condition will have one high reading and one low reading. If both readings are very low, or if both readings are very high, the diode is defective. Push and pull the diode lead **gently** while testing it to detect loose connections. Test all six diodes in the same manner. The readings of the diodes in the insulated heat sink will be opposite from those in the grounded heat sink or end frame.

When a diode is found defective, it is advisable to replace all three diodes in the end frame or heat sink using the correct procedure and the proper removal and installation tools. Diodes must never be hammered into position as the impact can easily crack the silicon wafer. Be sure to test the condenser as it may also be damaged.

Recently, the alternator rectifier bridge was introduced. The bridge contains all 6 diodes. This new design further simplifies the diode replacement operation. The bridge also contains the fins that are necessary for cooling the heat sink in which the diodes are mounted.

Chart No. 76A

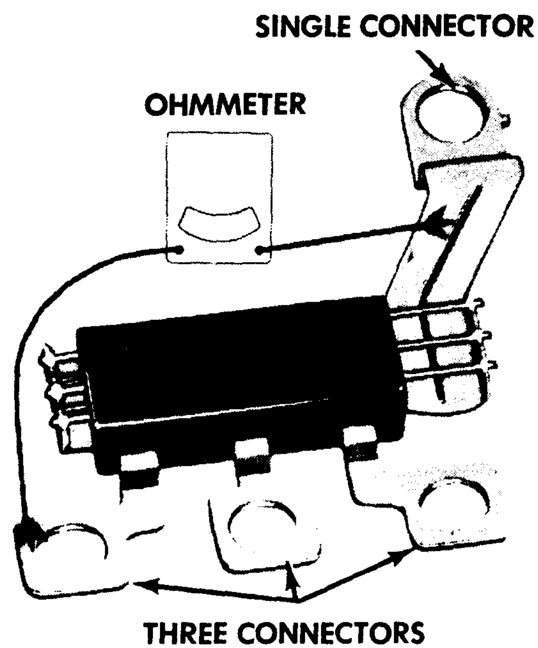
THE DIODE TRIO

Some late model alternators use, in addition to the regular diode assembly or rectifier bridge, a diode trio. It consists of three diodes contained in a single package, as shown, and is used to supply field current to the rotor. This unit is mounted internally in the alternator and must be removed for testing.

Testing is best accomplished with an ohmmeter as shown in the illustration. Connect one ohmmeter lead to the single connection on the end and then touch each of the three other connections. The reading should all be the same, either infinitely high or very low. Then reverse the ohmmeter leads and repeat the test. These readings should be the opposite of the first group. If the ohmmeter gives the same reading with both connections, the diode trio is defective.

Chart No. 76A

THE DIODE TRIO



TESTING A DIODE TRIO

FIELD WINDING TESTS

The rotor field winding may be checked electrically for open circuit, ground circuit and short circuit.

To check for open circuit, touch a 110-volt test lamp prod to each slip ring. If the lamp fails to light, the field winding is open.

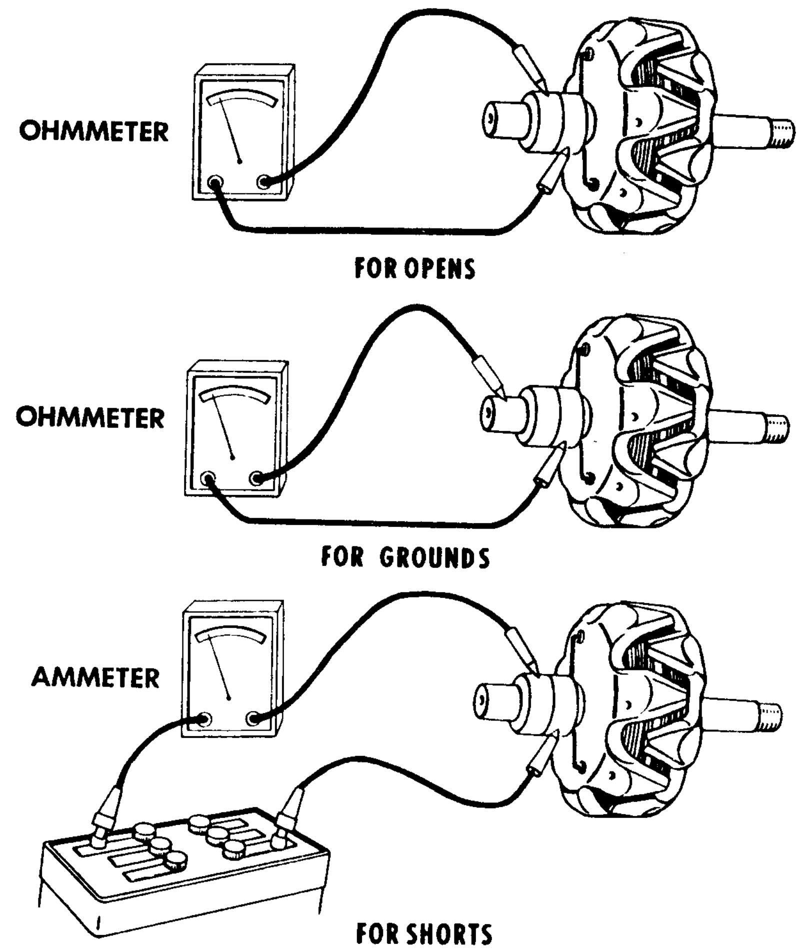
To check for ground circuit, touch one 110-volt test lamp prod to either slip ring and the other test lamp prod to the rotor shaft. If the lamp lights, the field winding is grounded.

To check for short circuit, connect a 12-volt battery and an ammeter in series with the two slip rings. The ammeter should indicate approximately 2 amperes. An ammeter reading above this value indicates a shorted field coil winding. High output alternators will have a higher field current draw.

If an ohmmeter is available, these three tests can be conducted by measuring resistance values.

Chart No. 77

FIELD WINDING TESTS



STATOR WINDING TESTS

Stator windings are checked for open circuit, ground circuit, and short circuit.

To check for open circuit, touch the prods of a 110-volt test lamp to the stator winding terminals as illustrated. If the lamp does not light, the stator winding is open. To complete the test, move one test lamp prod to the other stator winding terminal.

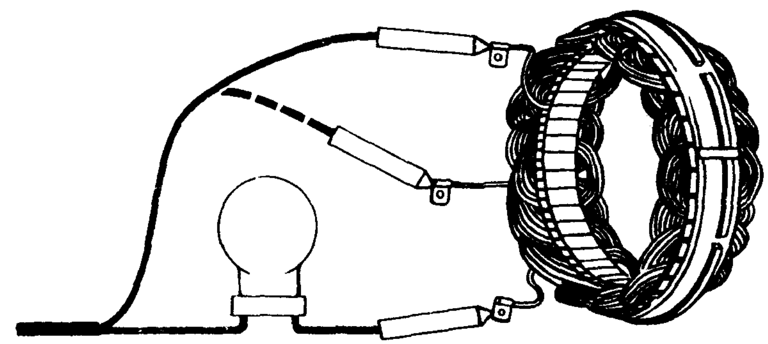
To check for a ground circuit, touch one prod of the 110-volt test lamp to the stator frame and the other test prod to any of the stator winding terminals. The test lamp should not light. If it does, the stator winding is grounded.

If an ohmmeter is available, these tests may be conducted by measuring resistance values.

A visual inspection for charred winding insulation should also be conducted at this time.

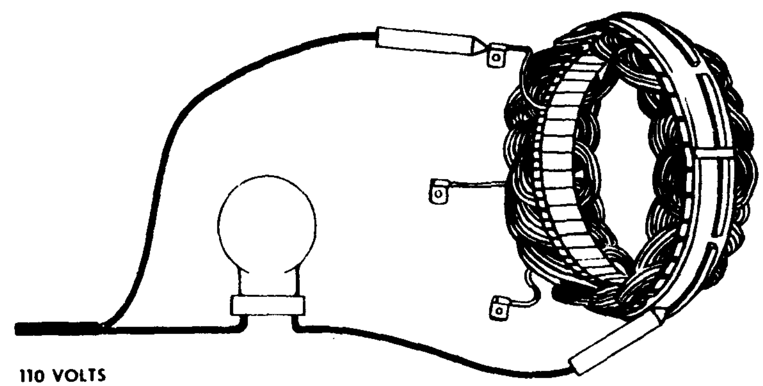
Chart No. 78

STATOR WINDING TESTS



110 VOLTS

FOR OPENS



110 VOLTS

FOR GROUNDS

Chart No. 70

ALTERNATOR AND REGULATOR TESTS

In the event different test procedures are suggested, it is advisable to follow the instrument hook-up and test procedure recommended by the manufacturer of your test equipment.

1. Check alternator drive belt and adjust as required.
2. Remove lead from alternator output (Bat) terminal and connect ammeter negative lead to disconnected alternator lead and ammeter positive lead to alternator output (Bat) terminal.
3. Connect voltmeter positive lead to alternator output (Bat) terminal and voltmeter negative lead to ground.
4. Connect tachometer between distributor primary terminal and ground.
5. Start and operate engine at 1500 rpm.
6. Observe meters. Voltmeter should read between 13.5 volts and 15 volts. Ammeter should read approximately 10 amperes.

If the voltmeter reading is less than 13 volts, disconnect the field lead from the alternator being careful not to touch it to ground. Connect a jumper from the alternator field terminal to the alternator output (Bat) terminal. If a higher voltage and amperage is obtained, a defective regulator is indicated. If voltage remains low, the alternator is defective.

If voltmeter reading is more than 15 volts, disconnect the field lead from the alternator being careful not to touch it to ground. If voltmeter reads 12 volts (battery voltage) and the ammeter reads zero amperes, the regulator is defective.

The alternator charging system circuitry is tested similarly to the DC charging system for insulated, ground and regulator ground resistance. In addition, a field circuit resistance test is also conducted. When testing alternators, regulators and charging system circuitry, always follow the meter hook-up and test procedure recommended by the manufacturer of your test equipment.

Regulator Adjustment Precautions:

When removing or replacing the regulator cover, the ignition switch must be turned off to avoid accidental shorting.

Regulator settings must be made with an insulated bending tool. Make regulator adjustments very carefully. A slight change in adjustment makes a considerable change in setting.

Final voltage limiter settings must be checked with the regulator cover in place.

ALTERNATOR AND REGULATOR TESTS

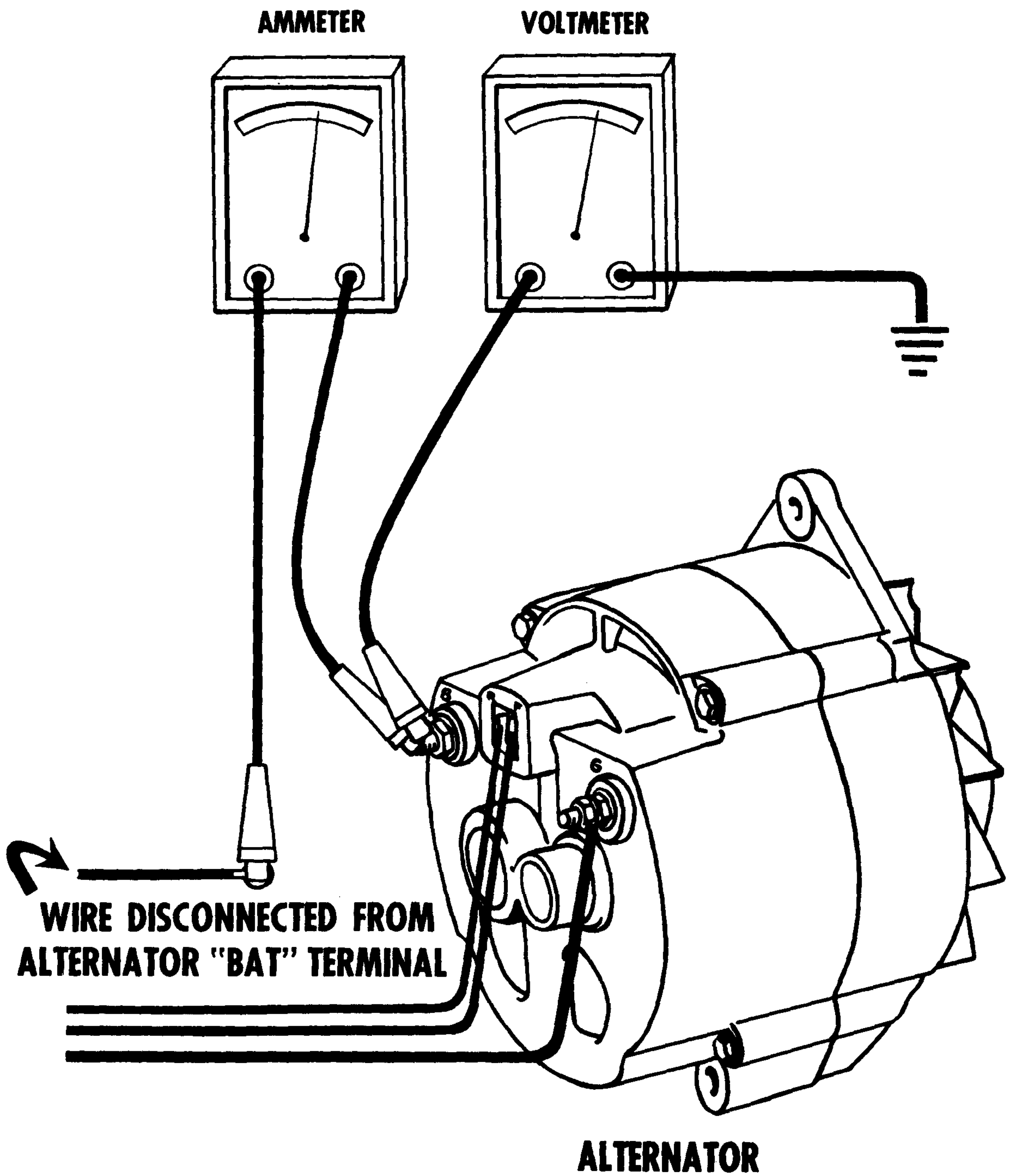


Chart No. 79

AC SYSTEM SERVICE PRECAUTIONS

Alternators are designed and constructed to give long periods of trouble-free service with minimum maintenance. To avoid accidental damage to the alternator, regulator or charging system wiring, the following precautions should be observed:

1. Always be **absolutely sure** that the battery ground polarity and the charging system polarity are the same, when installing a battery.

   If a battery is hooked-up backwards, it is directly shorted across the alternator diodes. The high current flow can damage the diodes and even burn up the wiring harness. If battery post identification is not obvious, use a voltmeter across the posts to identify their polarity.

2. **Do not** polarize an alternator.

   The reason a DC generator is polarized is to excite the generator field to insure that the generator and battery will have the same polarity. Since the alternator develops voltage of both polarities, which the diodes automatically rectify, there is no need to polarize an alternator. In fact, damage to the alternator, regulator or circuits may result from an attempt to polarize the alternator.

3. **Never** short across or ground any of the terminals on either the alternator or the regulator.

   Care should be exercised when working in the engine compartment to avoid accidental shorting of the alternator or regulator terminals. Shorting or grounding of the alternator or regulator terminals, either accidental or deliberate, can result in damage to the diodes, the regulator and/or the wiring. Grounding of the alternator output terminal (Bat) even when the engine is not running can result in damage since battery voltage is applied to this terminal at all times. Care should also be exercised when adjusting the voltage regulator to prevent accidental shorting.

4. **Do not** operate an alternator on open circuit.

   Operating the alternator while it is not connected to the battery or to any electrical load will cause the voltage developed to be extremely high. This high voltage can damage the diodes.

5. Booster battery **must be** correctly connected.

When the booster battery is used to assist in engine starting, it must be connected to the car battery in proper polarity to prevent damage to the diodes. The positive cable from the booster battery must be connected to the car battery positive terminal and the negative cable from the booster battery must be connected to the car battery negative terminal. Positive to positive and negative to negative is the proper hookup.

6. Battery charger **must be** correctly connected.

Battery charger leads must be correctly connected to the battery, the positive charger cable to the positive battery post and the negative charger cable to the negative battery post. Failure to observe this precaution may also result in damage to the diode rectifiers.

When charging a battery, disconnect the battery cables before connecting the charger leads to the battery to prevent possible damage to the alternator.

A fast battery charger should **never** be used as a booster for starting the engine in a car equipped with an alternator.

7. **Always** disconnect the battery ground cable before replacing or servicing electrical units.

Disconnecting the battery ground cable is always advisable when replacing electrical units or servicing electrical components. This precaution will prevent accidental shorting which may result in damage to the diodes, regulator or wiring. Remember, too, that if the battery ground cable is not disconnected, **make sure** the ignition switch is turned off when servicing the regulator since the alternator field circuit is connected to the battery through the ignition switch.

Chart No. 79

AC SYSTEM SERVICE PRECAUTIONS

1- Always be *absolutely sure* that the battery ground polarity and the charging system polarity are the same, when installing a battery.

2 - *Do not* polarize an alternator.

3 - *Never* short across or ground any of the terminals on either the alternator or the regulator.

4 - *Do not* operate an alternator on open circuit.

5 - Booster battery *must be* correctly connected.

6 - Battery charger *must be* correctly connected.

7 - *Always* disconnect the battery ground cable before replacing or servicing electrical units.

Chart No. 71

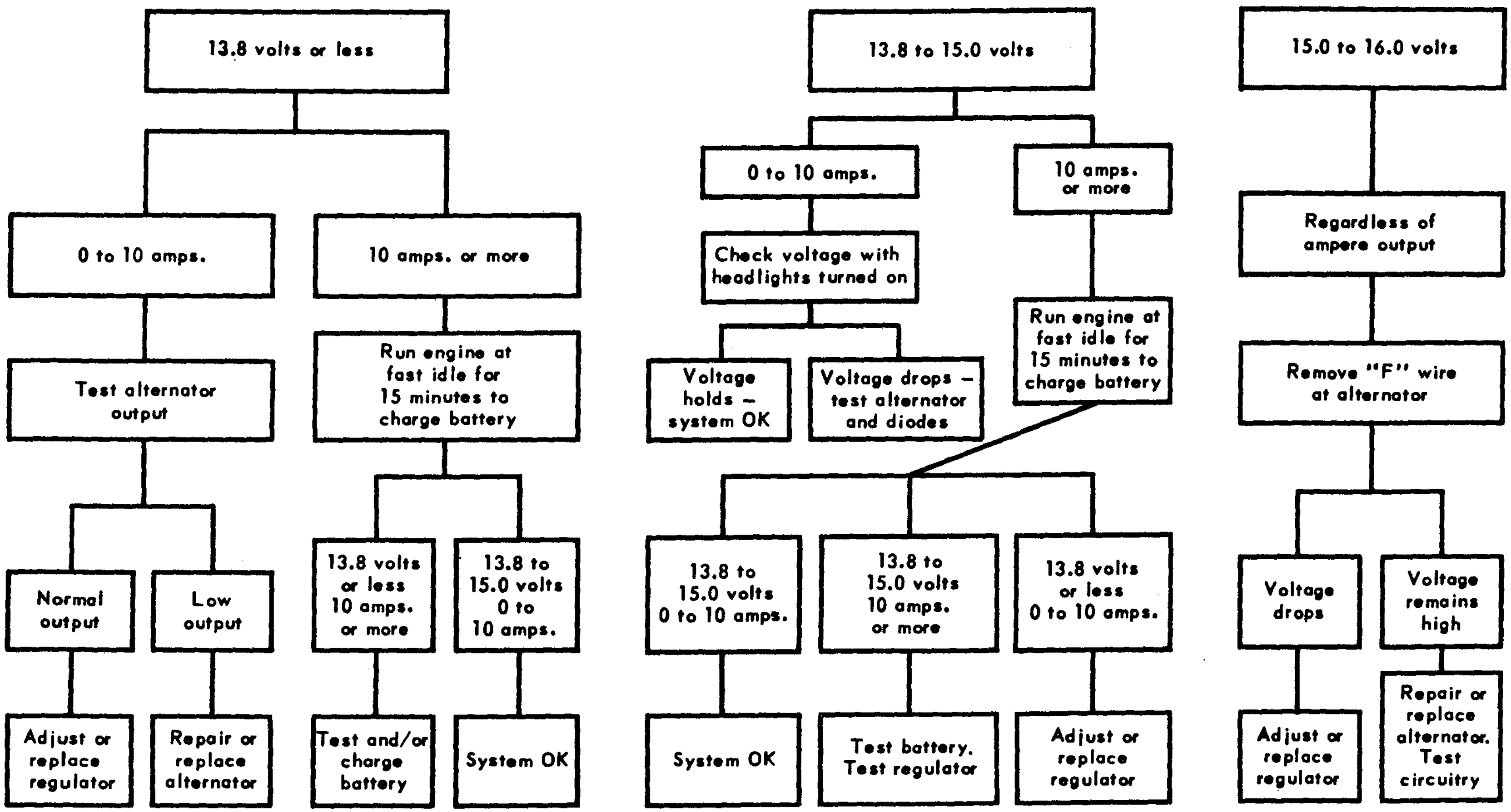
ALTERNATOR AND REGULATOR QUICK CHECKS

Disconnect alternator output "BAT" lead and connect ammeter between disconnected lead and alternator "BAT" terminal. Connect voltmeter to alternator output "BAT" terminal and ground. Start engine and set engine speed at 1500 rpm.

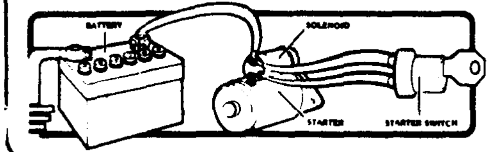
Caution: DO NOT allow voltage to exceed 16 volts. If voltage appears as though it would easily exceed 16 volts, check ammeter connections.

Alternator MUST NOT be operated without a load connected to the output terminal.

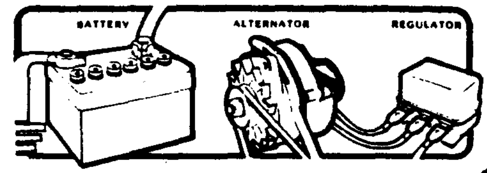
METER READING INDICATIONS



SUN VAT–40/28



STARTING AND CHARGING SYSTEM TEST REPORT



Customer Name ____________________ Phone ____________ Date ____________

Address ____________________ City/State ____________ License ____________

Make/Year/Model ____________________ Mileage ________ Mileage Since Tune-Up ____________

Engine ____________ Transmission — Auto ☐ Std ☐ Air Conditioning Yes ☐ No ☐

Carburetor ____________ Ign. Type ____________ Battery Age ____________

Reason For Tests ____________________ Tested By ____________

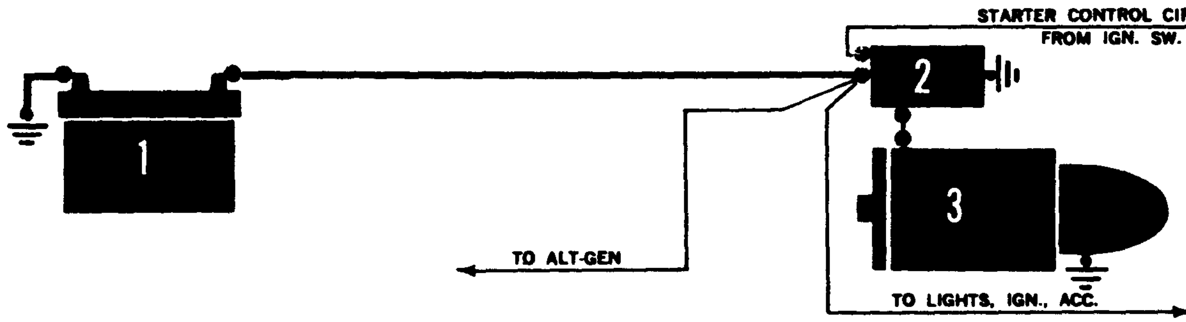
VISUAL INSPECTION	COMMENTS	GO	NO GO
BATTERY CASE/HOLDDOWN			
WATER LEVEL/SPECIFIC GRAVITY			
CABLES AND TERMINALS			
ALTERNATOR/ACCESSORY BELTS			
ALTERNATOR AND REGULATOR WIRING			

BATTERY RATING CHECK	READ	BATTERY SPECIFIED FOR VEHICLE	BATTERY IN VEHICLE	GO	NO GO
AMPERE HOUR RATING (20 HOUR)	SPEC. CARD				
COLD CRANKING AMPS AT 0° F.	SPEC. CARD				

STARTING AND CHARGING SYSTEM TESTS

TEST MODE	TESTS	READ	ENTER SPECIFICATIONS	TEST RESULT	GO	NO GO
#1 BATTERY AND STARTING SYSTEM	BATTERY LOAD	AMMETER				
	LOAD VOLTAGE	VOLTMETER				
	STARTER CURRENT	AMMETER				
	CRANKING VOLTAGE	VOLTMETER				
#2 CHARGING SYSTEM	ALTERNATOR (GENERATOR) OUTPUT	AMMETER				
#2A (IF #2 IS NO GO) CHARGING SYSTEM WITH FIELD JUMPER	ALTERNATOR (GENERATOR) OUTPUT WITH VOLTAGE REGULATOR BYPASSED	AMMETER				
#3 VOLTAGE REGULATOR	VOLTAGE REGULATION	VOLTMETER				
#4 DIODE-STATOR	DIODES AND STATOR CONDITION	D/S SCALE	OK BAND			
#5 BATTERY DRAIN	SHORTS IN ELECTRICAL SYSTEM	AMMETER	ZERO			

TYPICAL STARTING SYSTEM

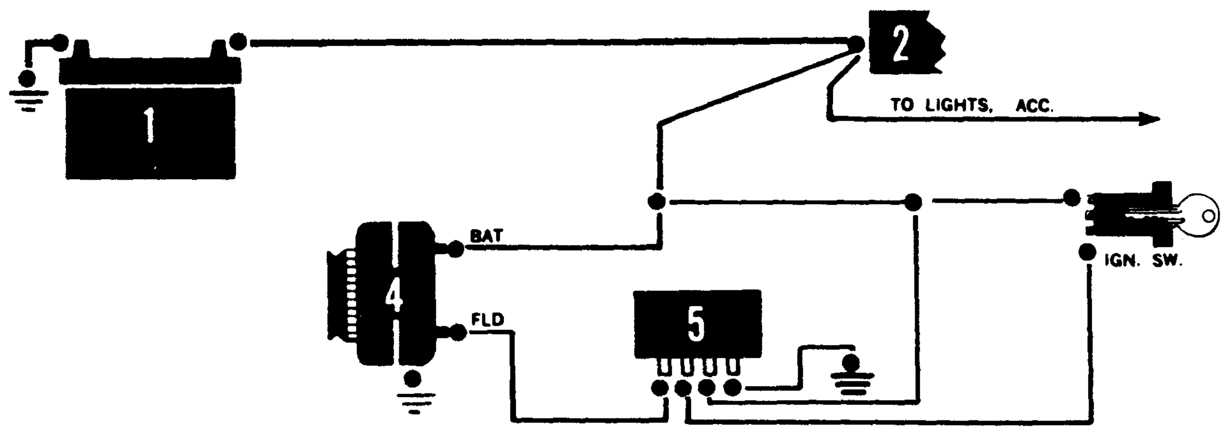


1. BATTERY
2. STARTER SWITCH
3. STARTING MOTOR

— CABLES

(CONNECTIONS INDICATED BY ●)

TYPICAL A. C. CHARGING SYSTEM



1. BATTERY
2. STARTER SWITCH
4. ALTERNATOR
5. VOLTAGE REGULATOR

— CABLES & WIRING

(CONNECTIONS INDICATED BY ●)

SERVICES REQUIRED

VISUAL INSPECTION
OK ☐ NEEDS ____________________

STATE OF CHARGE
OK ☐ NEEDS ____________________

BATTERY RATING
OK ☐ NEEDS ____________________

STARTING SYSTEM
OK ☐ NEEDS ____________________

CHARGING SYSTEM
OK ☐ NEEDS ____________________

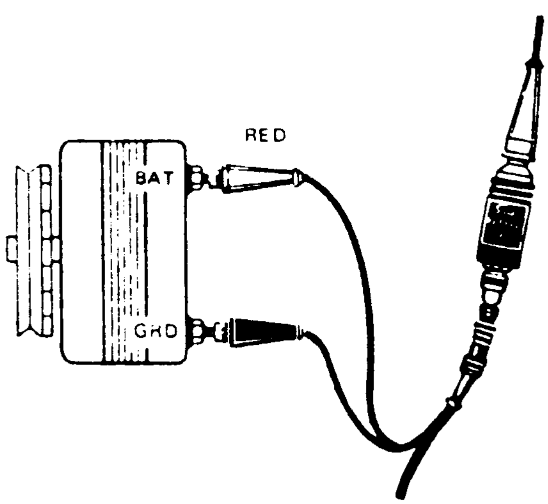
BATTERY DRAIN
OK ☐ NEEDS ____________________

ALTERNATOR DIODE-STATOR TEST

ALTERNATOR DIODE-STATOR TEST

An oscilloscope, when used properly, can be useful for purposes other than analyzing ignition systems. One such use is checking alternator rectifier diodes and the stator. The alternator need not be removed from the engine for this test since the test is performed with the alternator operating under normal conditions. However, if defective stator or diodes are indicated the alternator must be removed, diodes tested and either diode or stator replaced.

This test does not replace the charging system output and voltage test. Final charging system tests should be accomplished using a Sun Volts Ampere Tester.



TEST PROCEDURE

1. Turn Pattern Selector to Display position.
2. Turn Circuit Selector to Primary negative (-) or positive (+), depending on the vehicle battery ground polarity.
3. Set Primary Pattern Height control to the 40 V position.
4. Adjust trace to 0 line.
5. Tester to Alternator connections. (neg.grd. vehicle) Blue Cable.
   a. Connect red Primary pickup to the alternator output (BAT) terminal.
   b. Connect black ground clamp to alternator ground terminal.

   Red Cable;
   a. Connect Timing pickup to number one spark plug.
6. Start engine and run at 1500 RPM (approx.).
7. Apply electrical load to Alternator by turning on headlights to high beam.
8. Adjust Pattern Length control for full waveform coverage between the vertical lines of the scope screen.
9. Adjust brightness and focus as required.
10. Observe waveform and compare with those indicated below.

Results and Indications

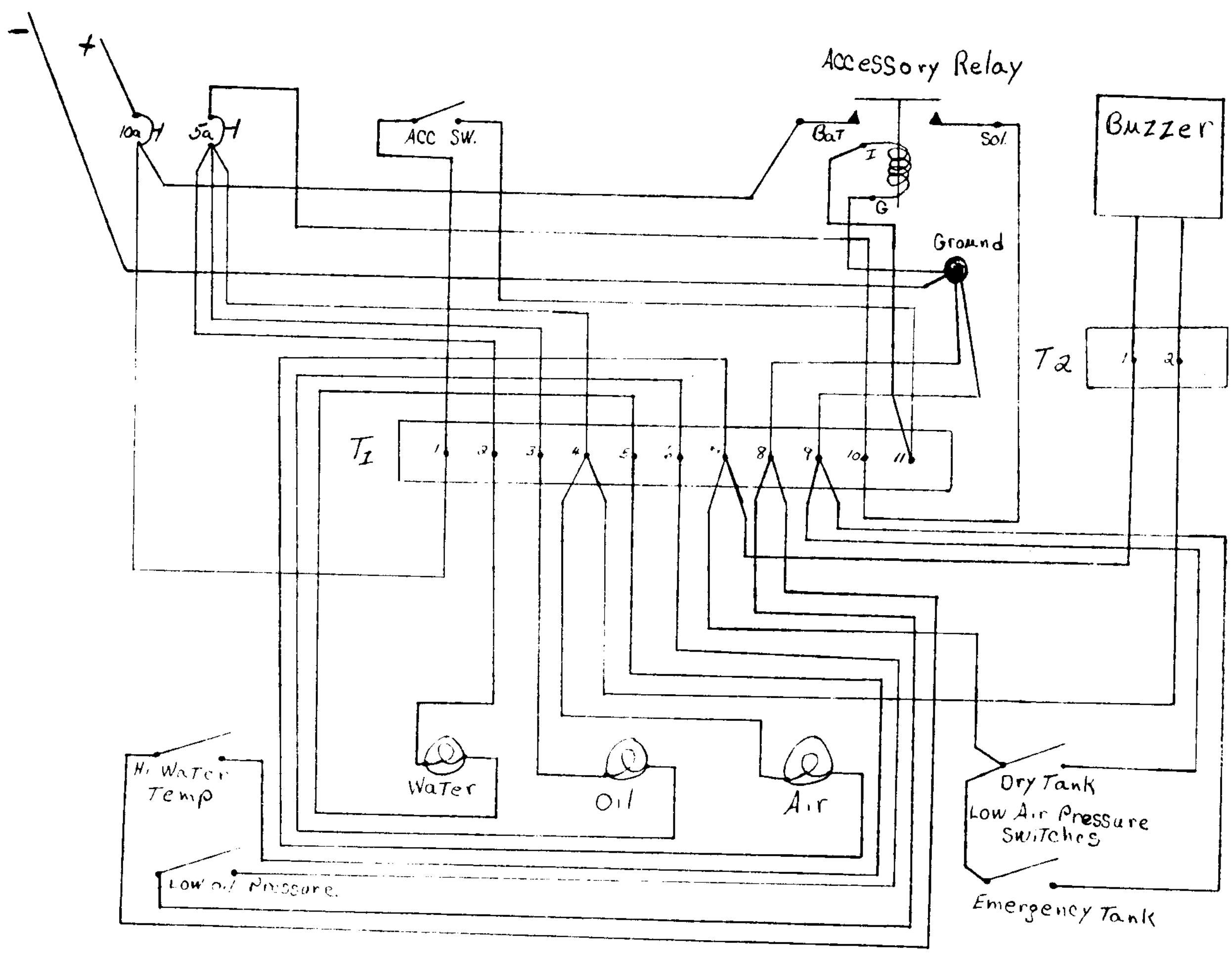
NORMAL

OPEN DIODE

SHORTED DIODE

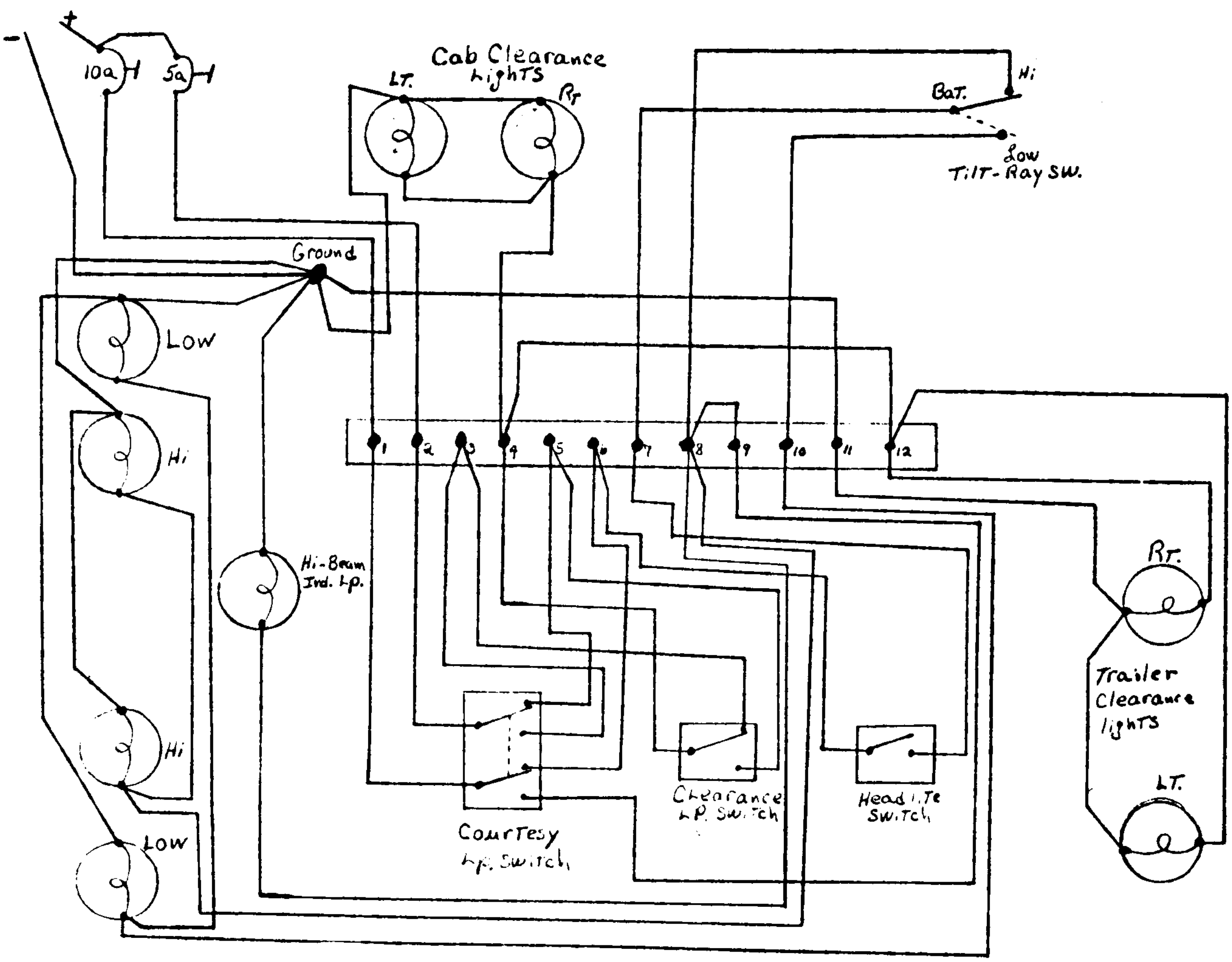
OPEN STATOR

SHORTED STATOR


-
+
10a
5a
ACC SW.
Accessory Relay
Bat
Sol.
I
G
Ground
Buzzer
T2
1
2
T1
1
2
3
4
5
6
7
8
9
10
11
Hi Water Temp
Water
Oil
Air
Dry Tank
Low Air Pressure Switches
Low oil Pressure
Emergency Tank

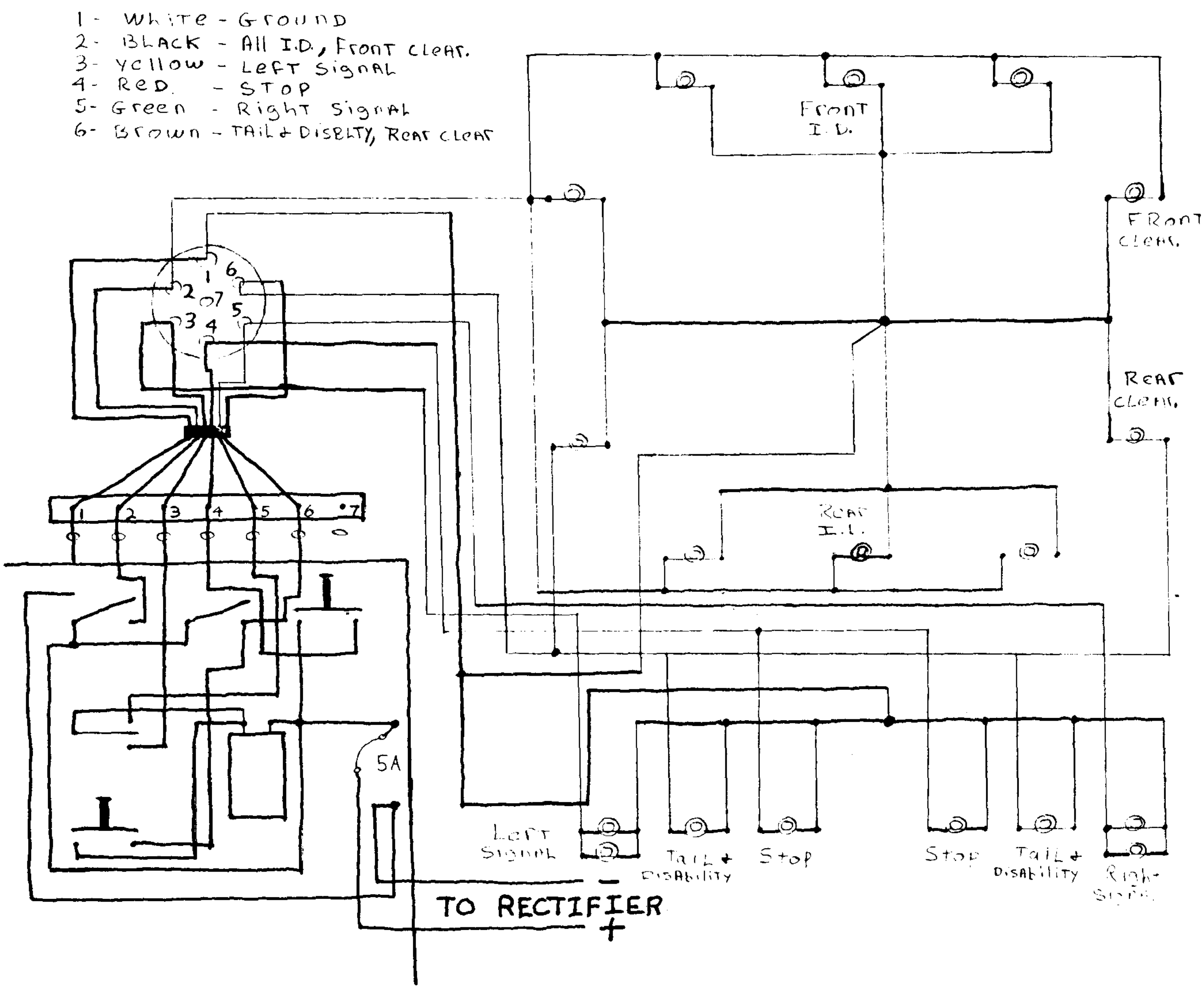
BOX 200

ELECTRICAL TROUBLESHOOTING

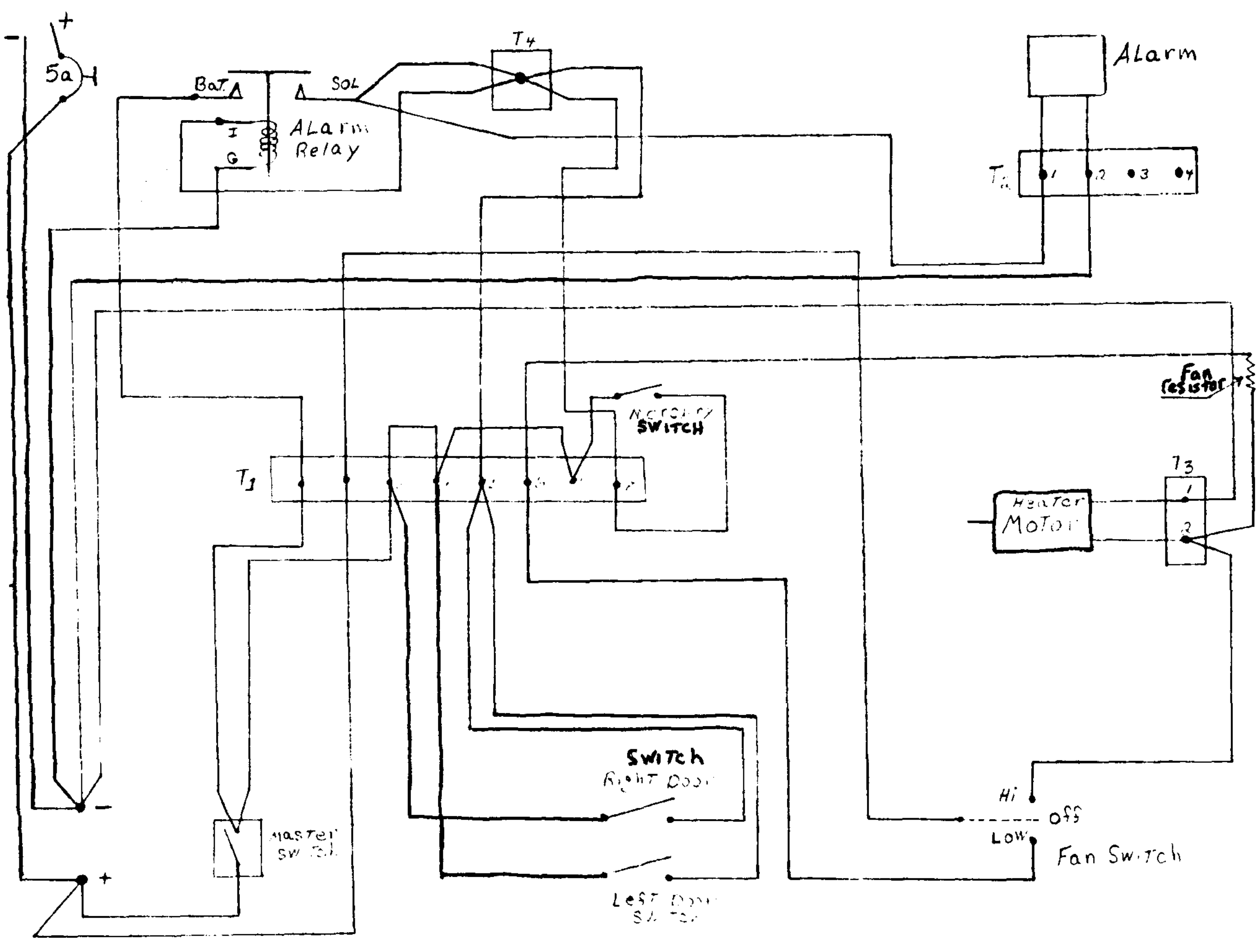


BOX 210

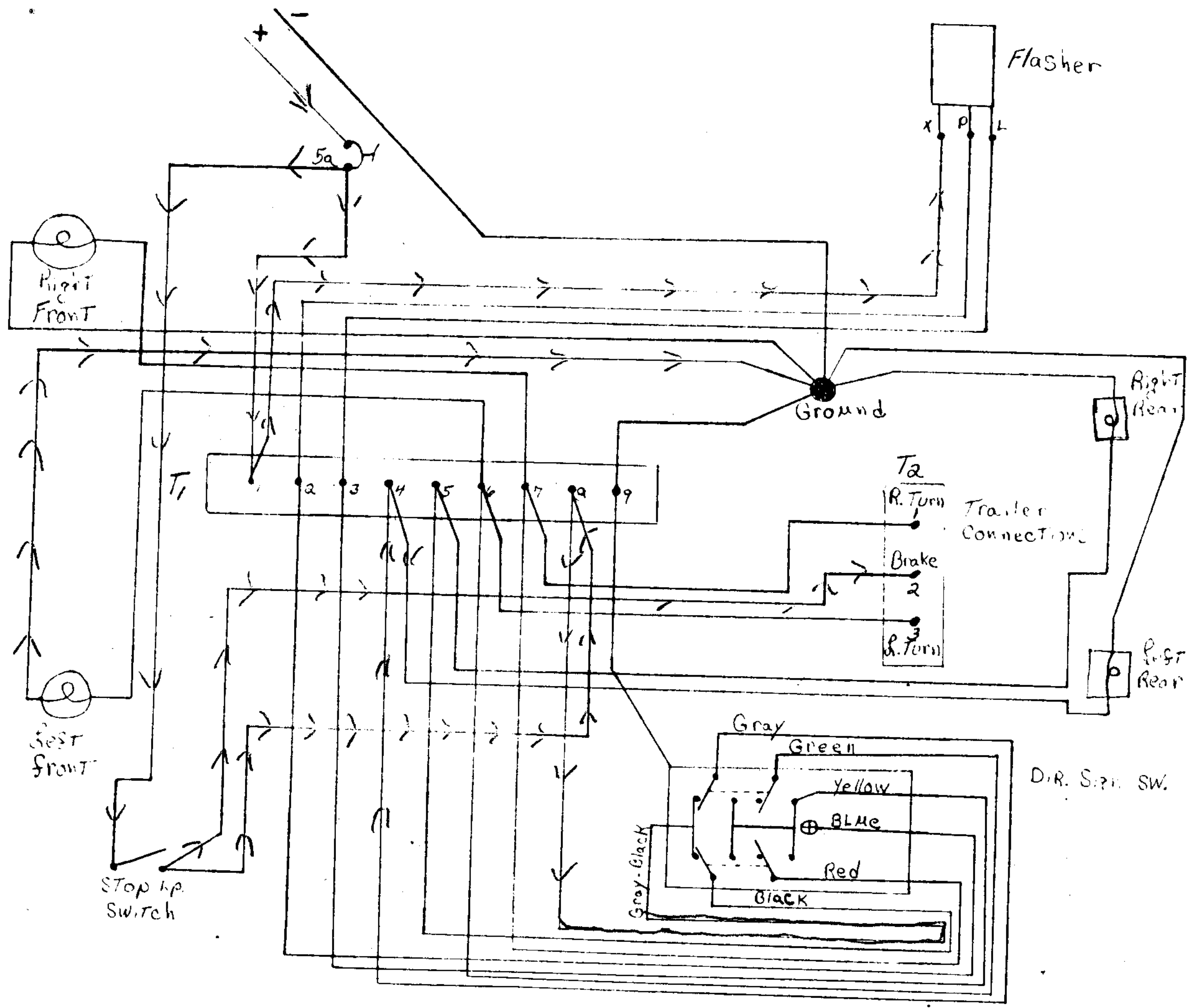
ELECTRICAL TROUBLESHOOTING



BOX 220


5a
BaT
SOL
T4
Alarm
Alarm Relay
I
G
T2
1
2
3
4
Fan resistor
Switch
T1
T3
Heater Motor
Switch Right Door
Master Sw
Hi
Off
Low
Fan Switch
Left Door Switch

BOX 230



Flasher
X
P
L
5a
Right Front
Left Front
Ground
Right Rear
Left Rear
T1
T2
R. Turn
Brake
L. Turn
Trailer Connections
Gray
Green
Yellow
Blue
Red
Black
Gray-Black
Dir. Sig. SW.
Stop Lp. Switch

BOX 240

Delco Remy

Operation and Maintenance of
Low Weight Splashproof

SERIES-PARALLEL AND COMBINED SERIES-PARALLEL AND MAGNETIC SWITCHES

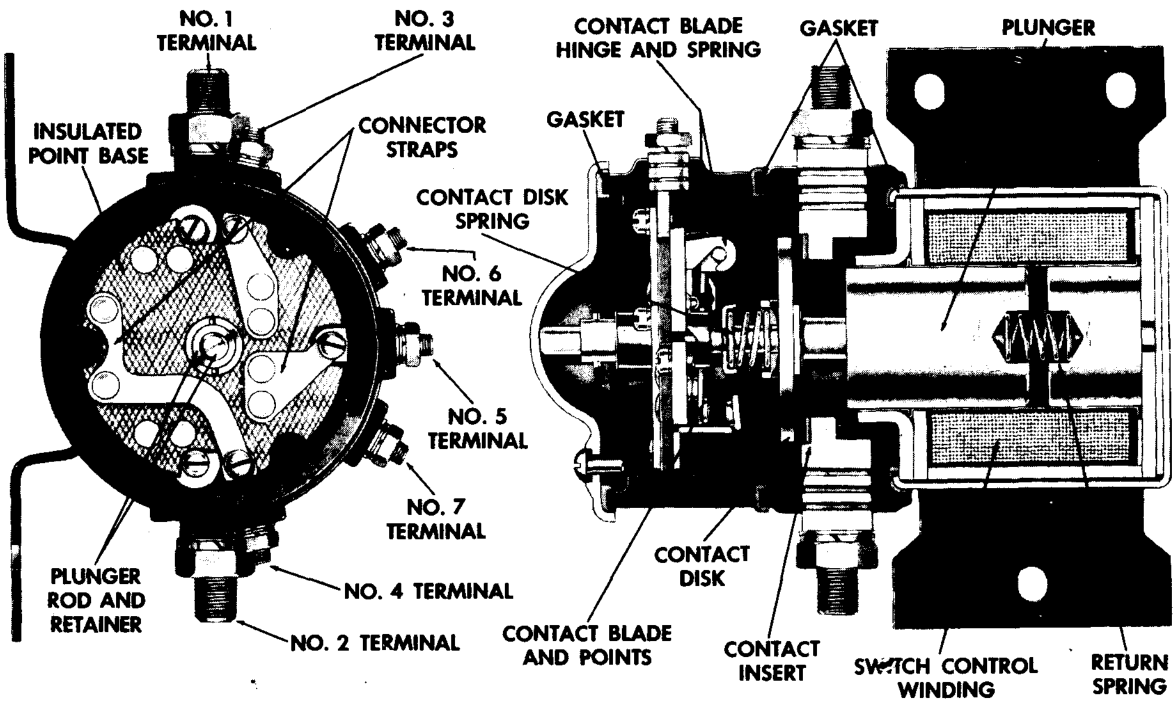


Figure 1—End and sectional view of solenoid-operated series-parallel switch.

INTRODUCTION

Series-parallel switches are used to connect two 12-volt batteries in series for 24-volt cranking, and to connect the same two batteries in parallel for 12-volt charging.

In Figure 1 is illustrated a low weight, splashproof, series-parallel switch that can be used with either a solenoid or separate magnetic switch controlled motor. In Figure 2 is shown a combined series-parallel and magnetic switch that is used with a Bendix drive or inertia drive type of motor. A third type of switch incorporating splashproof features that can be used with either a solenoid or magnetic switch is shown in Figure 3. This switch when properly assembled should have the large contact disk located as shown by turning the shaft nut as required (Fig. 4).

OPERATING PRINCIPLES

A wiring circuit of the series-parallel system using a series-parallel switch with a solenoid operated motor during cranking is shown in Figure 5.

The series connection between the two batteries and the cranking motor is shown in solid red. The cranking motor solenoid circuit is shown in solid blue. The sequence that takes place as the switch closes is as follows: As the starting switch is closed, the solenoid coil within the series-parallel switch is energized (shown in dashed red) creating sufficient magnetic force to attract the series-parallel switch plunger. Movement of the plunger then closes the two main switch terminals and connects the two batteries in series with the cranking motor. At the same time, the cranking motor solenoid coil circuit is completed by a set of points mechanically closed by the series-parallel switch plunger. This completes the battery to cranking motor circuit and allows cranking to take place.

After cranking has been accomplished and the starting switch is released, the two batteries again become connected in parallel with the series-parallel switch in its "at rest" position. This allows operation of the rest of the vehicle electrical equipment at a system voltage of 12 volts. Note that there are two circuit breakers or fuses in the circuit of the "B" battery.

SERIES-PARALLEL SWITCHES

1S-135 Service Bulletin

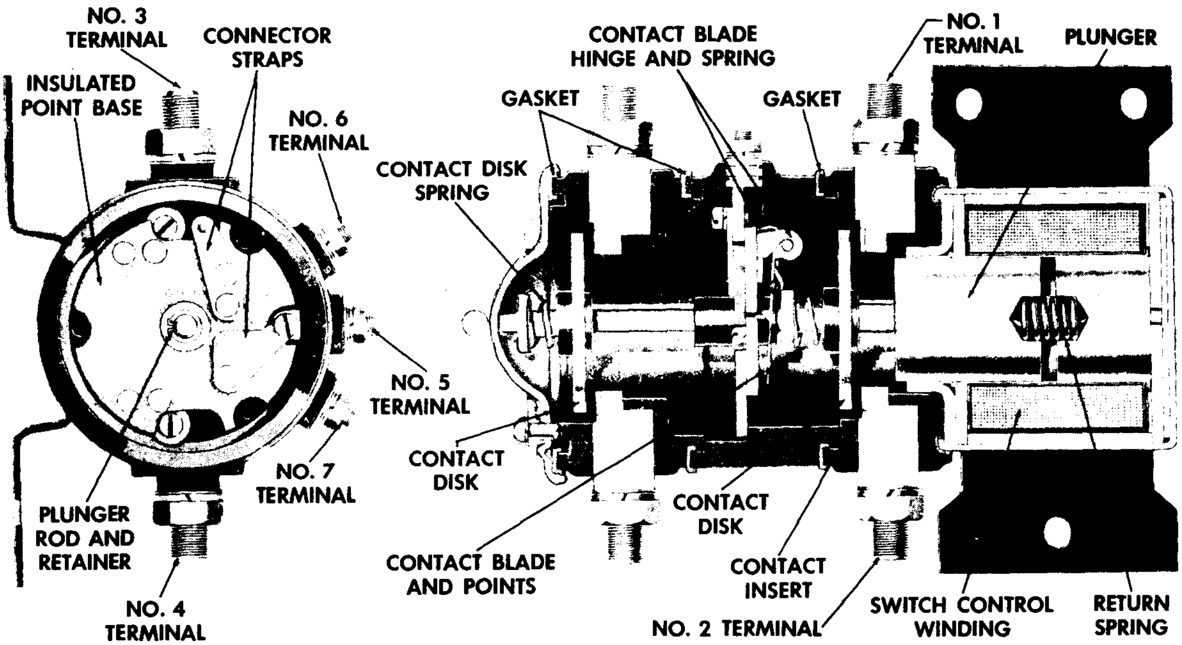


Figure 2—End and sectional view of solenoid-operated combined series-parallel and magnetic switch.

In Figure 6 is illustrated a circuit with the series-parallel switch used with a magnetic switch operated motor. The switch is shown in the charging or "at rest" position. The current from the generator divides at the terminal of the series-parallel switch, half of it going to the "A" battery (as shown in solid red) with the other half of the current going to the "B" battery through the series-parallel switch (as shown in dashed red). Note also that an optional ammeter, as indicated, may be located in either of two positions. The preferred location is shown since this circuit carries only the charging current while the other circuit must also carry the magnetic switch energizing current. An ammeter sufficiently heavy to carry the magnetic switch current is generally unsatisfactory for reading small charging currents. In either position the ammeter will indicate how much current is entering the battery to the right, and if this is subtracted from the total shown on the main ammeter, the difference will be that which is entering the battery to the left.

Figure 7 is the schematic wiring circuit of the combination series-parallel magnetic switch used in conjunction with a magnetic switch operated cranking motor equipped with a Bendix type drive. As the starting switch is closed, the solenoid coil within the series-parallel switch is energized (shown in dashed red) creating sufficient magnetic force to attract the series-parallel switch plunger. The movement of the plunger then connects the two sets of large terminals (shown in solid red). This connects both batteries in series with the cranking motor in order that 24 volts can be supplied for cranking motor operation.

Figure 8 shows the same switch after the starting switch is released and the

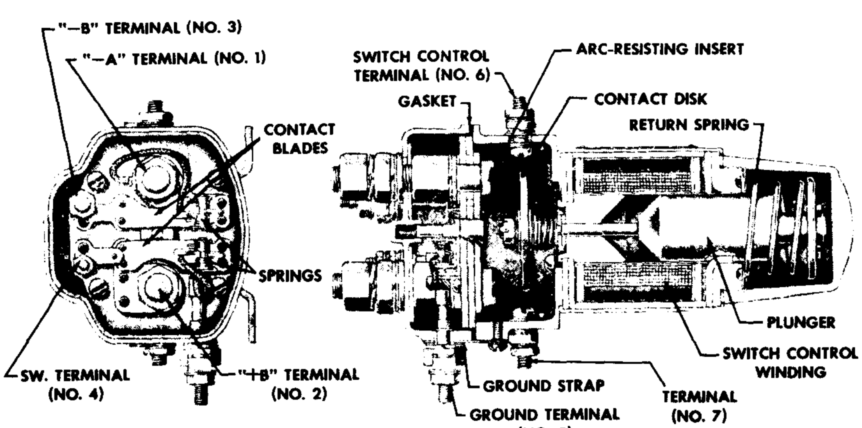


Figure 3—End and sectional views of solenoid-operated series-parallel switch.

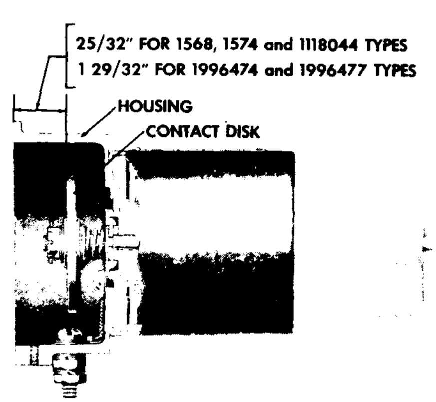


Figure 4—Adjustment of contact disk.

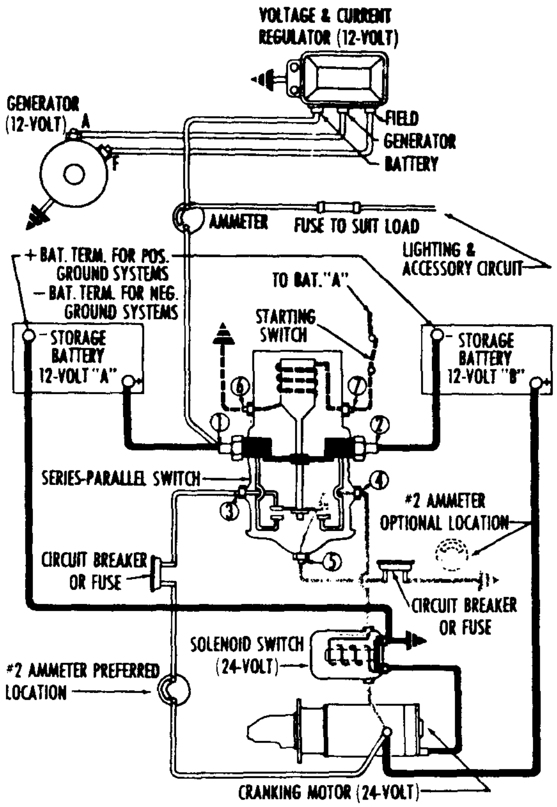


Figure 5—Circuit diagram of series-parallel system with switch completing series connections between batteries for 24-volt cranking motor operation. The cranking motor is operated and controlled by a solenoid.

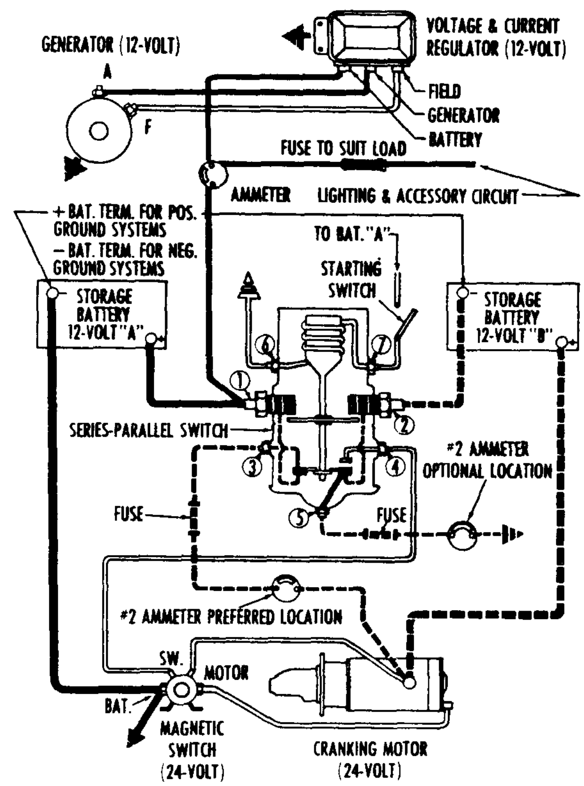


Figure 6—Circuit diagram of series-parallel system with switch completing parallel connections between batteries for normal operation of vehicle electrical equipment at 12 volts. The cranking motor is operated and controlled by a separately mounted magnetic switch.

series-parallel switch is in its "at rest" or charging position. The solid red path indicates the charging circuit of the left-hand or "A" battery. The dashed red shows the path of the charging circuit to the right-hand or "B" battery.

Figures 9, 10, and 11 show alternate methods of making connections within the series-parallel system. Although some of the connections may be different, the circuit still operates in the manner just described.

An Integral Charging System may be used in place of the d.c. generator previously illustrated. This system is shown in Figures 12 and 13 with the series-parallel switch connected to four batteries and a cranking motor with a solenoid for shifting the pinion into mesh with the ring gear. The cranking and charging circuits are shown, and the operation is explained as follows:

When the starting switch is closed, current supplied by the "A" batteries flows through the series-parallel switch winding, and the switch plunger is attracted into the core. As a result, the switch No. 1 and No. 2 terminals are connected together and the No. 4 and No. 5 terminals are connected together.

With this arrangement, the batteries are connected in series to the 24-volt motor to provide 24-volt cranking. The cranking circuit is shown in red in the diagram. Note that the solenoid winding current, shown in blue, flows through the No. 4 and No. 5 terminals on the switch. Also note that the "A" batteries are in parallel with each other and the "B" batteries are in parallel with each other.

After the cranking cycle has been completed and the starting switch is opened, the return spring in the series-parallel switch causes the contact disk to move away from the Nos. 1 and 2 terminals. At the same time, spring-loaded contacts in the switch close to connect the Nos. 1 and 3 terminals together, and the No. 2 and No. 5 terminals together. With the switch plunger and contacts in this position, the batteries are connected in parallel for 12-volt charging. The charging circuit is shown in red with current from the generator being supplied to the No. 2 terminal on the series-parallel switch. Half of the current then flows through the "A" batteries to ground, with the other half flowing through the switch No. 2 and No. 5 terminals, through the "B" batteries, and then through the switch Nos. 1 and 3 terminals to ground. Since the charging circuit through the "B" batteries is more lengthy and contains more connections than the "A" batteries, it is especially important to maintain the "B" battery connections and wiring, along with all

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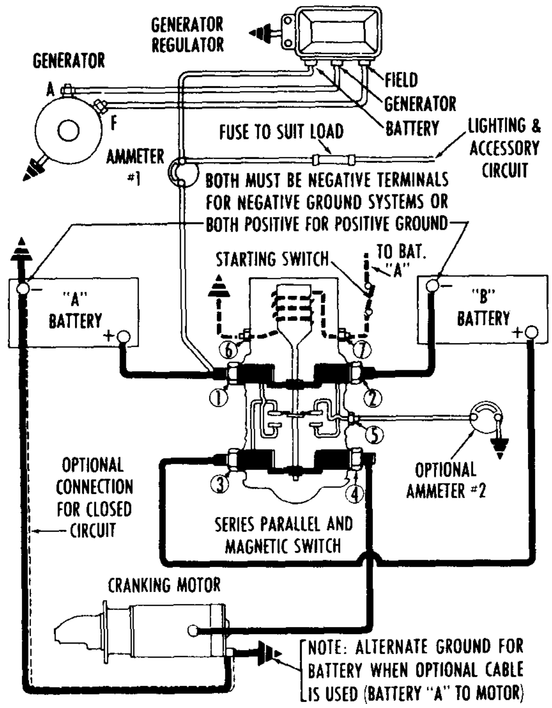


Figure 7—Circuit diagram of combination series-parallel and magnetic switch completing series connections between batteries for 24-volt cranking motor operation.

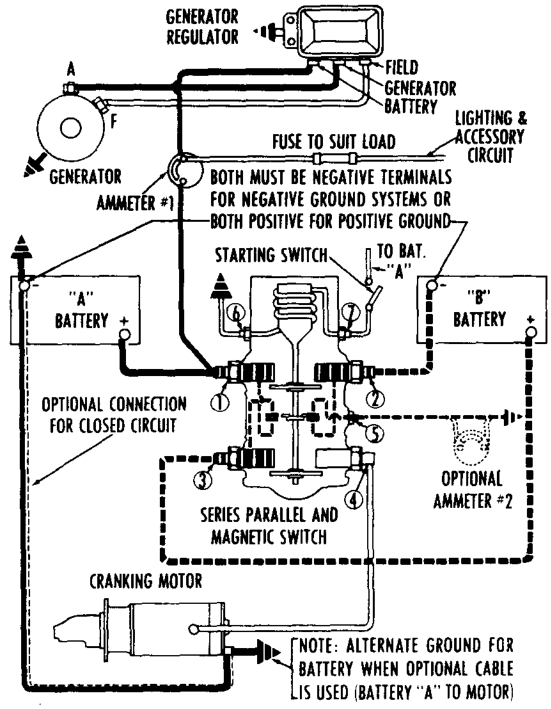


Figure 8—Circuit diagram of combination series-parallel and magnetic switch completing parallel connections between batteries for normal operation of vehicle electrical equipment at 12 volts.

others, in good condition to prevent an unbalanced state of charge condition in the batteries. If the "B" batteries tend to remain in a lower state of charge than the "A" batteries with satisfactory lead connections, the batteries may be interchanged for maximum life.

SERVICE PROCEDURES

Some of the problems that may be encountered in series-parallel systems are covered below.

Blown Fuse or Open Circuit Breaker

A complete check of the entire circuit should be made for evidence of shorts, grounds, or improper connections. Also, the fuse or circuit breaker, where used, should be checked for correct capacity. The fuse capacity should be 60 amperes or 55% of rated generator output, whichever is greater. The minimum circuit breaker rating should be 40 amperes or 55% of rated generator output, whichever is greater.

A pinion and ring gear tooth abutment on some types of solenoid-operated cranking motors can cause a fuse to blow or a circuit breaker to open if the start switch is held on for an excessive period of time (Fig. 5). With the tooth abutment condition preventing the contact disk from connecting the solenoid "BAT" and "MOT" terminals, the high solenoid winding current can cause the circuit to open. To prevent this occurrence, the start switch should be immediately opened when a tooth abutment condition is encountered. If the pinion or ring gear teeth are badly burred, an abnormal tooth abutment condition may occur with can cause an open circuit.

A cranking motor that is grounded internally will cause the fuses or circuit breakers to open when the switch is in the charging position (Fig. 6), since both batteries will be short circuited through the fuses or circuit breakers. The large contactor in the solenoid and the cranking circuit wiring will be severely damaged with the solenoid plunger in the crank position (Fig. 5).

One other condition that can cause the fuses or breakers to open is an improperly positioned contact disk in solenoids of the type shown in Figures 3 and 4. If the disk contacts the No. 1 and No. 2 terminals before the other internal circuits have opened, the batteries are directly shorted through the fuses or breakers and they will open.

An Oscillating Solenoid

Undercharged batteries can cause the cranking motor solenoid to oscillate when the system voltage decreases during cranking to the point where the solenoid hold-in winding can no longer hold the solenoid contacts closed. When the contacts open the cranking circuit is interrupted, the voltage increases and the cycle then repeats to cause oscillation and heavy damage to the contacts. Also, an open hold-in winding can cause the solenoid to oscillate.

Excessive resistance in the solenoid or series-parallel switch coil winding circuits, such as corroded contacts or connections, has the effect of lower-

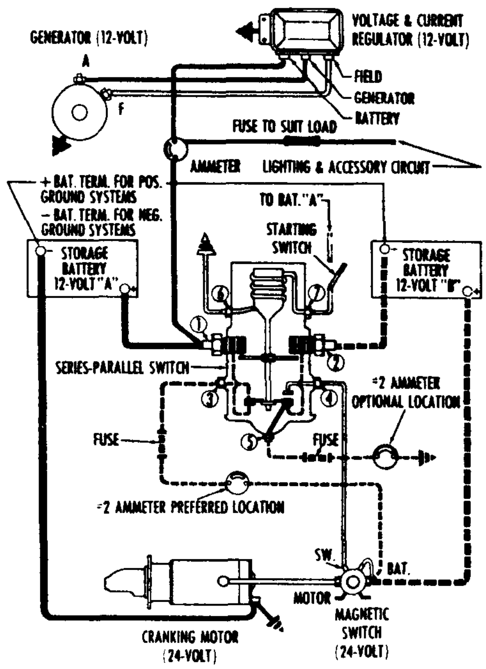


Figure 9—Alternate connections to magnetic switch and motor.

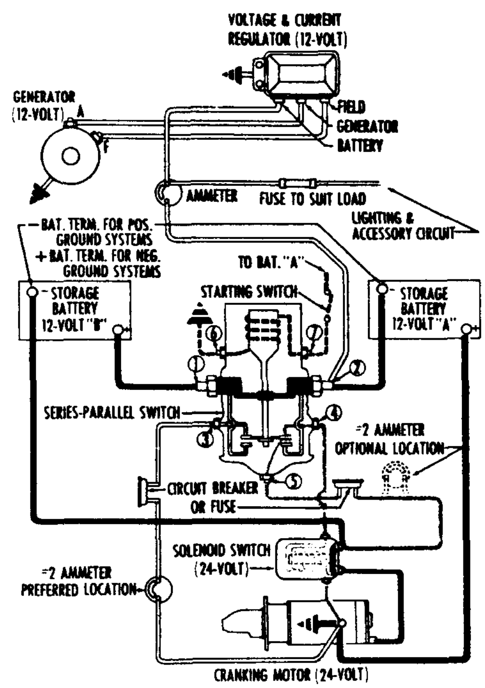


Figure 10—Alternate connections to solenoid switch and motor.

ing the voltage to the coil and causing the plunger to oscillate. This condition is aggravated by undercharged batteries.

An Undercharged "B" Battery

Using Figure 6 as an example, it should be noted that the "A" battery uses heavy cranking motor circuit cables during charging, and that the charging circuit for the "B" battery is much longer through the various contacts and connections in the series-parallel switch. With higher circuit resistance, it is normal for the "B" battery to tend somewhat toward undercharge. Maintaining clean and tight circuit connections, using batteries of the same type, size, and age, and occasionally switching the positions of the two batteries will alleviate this problem. Referring to Figure 6 as an example, one method of checking electrically for excessive resistance in the "B" battery charging circuit is to proceed as follows:

1. Start engine and operate at moderate speed.
2. Connect a voltmeter capable of reading in tenths of a volt directly across the "B" battery terminals, and observe the reading.

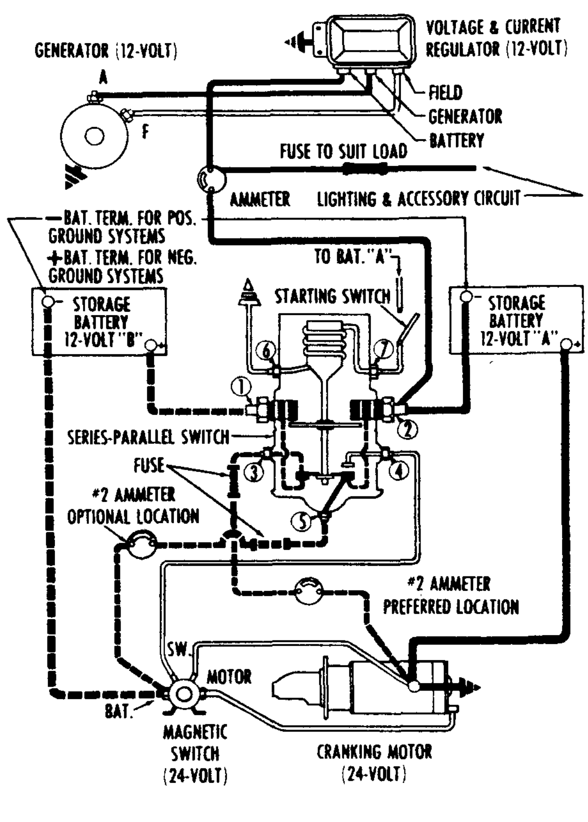


Figure 11—Alternate connections to batteries, magnetic switch, and motor.

3. Connect a heavy jumper cable from the series-parallel No. 1 terminal to the "B" battery ungrounded terminal, and observe the voltmeter.
4. An appreciable voltage increase, say .5 volt or more, indicates excessive resistance in the circuit consisting of the series-parallel No. 1 and No. 3 terminals and contacts, the fuse or breaker and ammeter, and the motor terminal. No exact voltage can be specified due to different wiring sizes and lengths; a judgment based on experiences with the particular system involved must be made.
5. If only a very small voltage increase is obtained, connect the jumper cable from the "B" battery grounded terminal to a good ground on the engine, and observe the voltmeter.
6. An appreciable voltage increase indicates excessive resistance in the circuit consisting of the series-parallel No. 2 and No. 5 terminals and contacts, the fuse or breaker and optional ammeter if used.

SUMMARY

In order to obtain satisfactory service in series-parallel systems, it is important to maintain all wiring and connections in good condition. Some of the effects of excessive resistance have been covered in the previous paragraphs. The other units, generator, regulator, batteries and cranking motor, are covered in separate Delco Remy service bulletins.

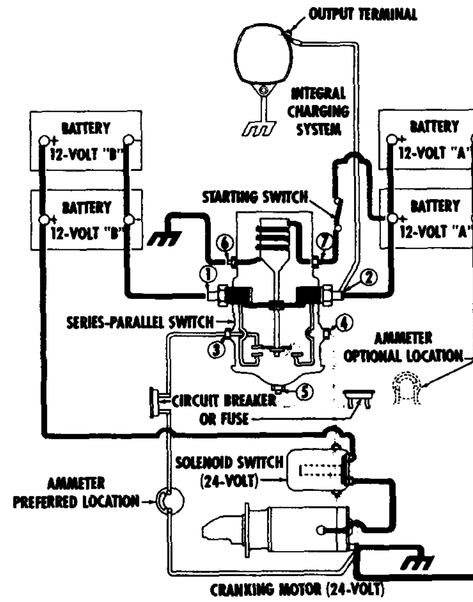


Figure 12—Cranking circuit, with Integral Charging System and solenoid-operated motor.

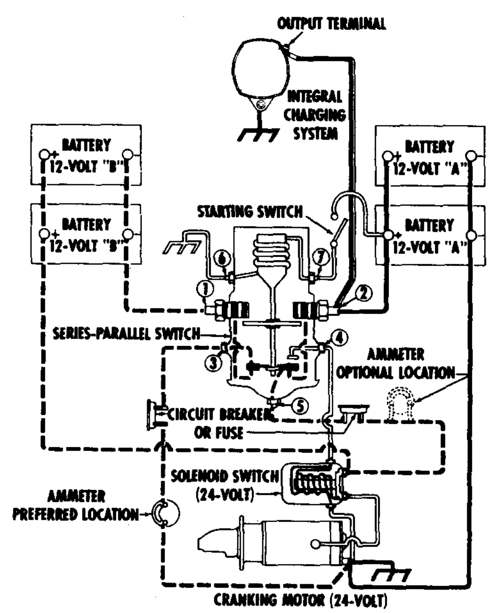


Figure 13—Charging circuit, with Integral Charging System and solenoid-operated motor.

Delco-Remy

ANDERSON, INDIANA, U.S.A.

SERVICE BULLETIN

Bulletin 1R-273

TESTS AND ADJUSTMENTS OF
TRANSISTOR REGULATORS

Shaded blocks indicate changes from or additions to last printing.

(12, 24, 30, AND 32 VOLT, NEGATIVE GROUND, POSITIVE GROUND, AND INSULATED)

(30-RD SERIES, 250 TYPE)

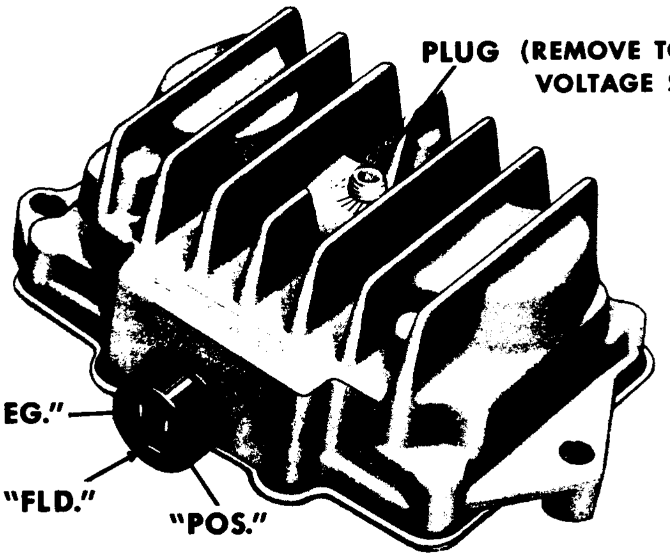


Figure 1—Typical transistor regulator.

The transistor regulator illustrated in Figure 1 and Figure 2 is an assembly composed principally of transistors, diodes, capacitors, and resistors. These components form a completely static electrical unit containing no moving parts.

The function of the regulator in the charging circuit is to limit the generator voltage to a preset value by controlling the generator field current.

The voltage at which the generator is limited is determined by the regulator adjustment. Once adjusted, the generator voltage remains practically unchanged, since the regulator is relatively unaffected by such factors as length of service, changes in temperature, or by changes in generator output and speed.

Transistor regulators of the type illustrated may be used in any one of six different charging circuits and with different types of Delcotron® generators. The type circuit used is the choice of the vehicle manufacturer. Each of these six circuits listed below, three negative ground and three positive ground, is shown on the following pages, along with a brief explanation of operating principles. Insulated circuits are identical to those illustrated, except wiring is substituted for ground returns.

A. These circuits use *separate* light and field relays. The light relay winding is connected to the battery when the switch is closed.
   1. Negative ground circuit (Fig. 3)
   2. Positive ground circuit (Fig. 4)

B. These circuits also use *separate* light and field relays and are identical to Figures 3 and 4, except the light relay winding is connected to the "R" terminal on the generator.
   1. Negative ground circuit (Fig. 5)
   2. Positive ground circuit (Fig. 6)

C. These circuits use a single *combination* light and field relay.
   1. Negative ground circuit (Fig. 7)
   2. Positive ground circuit (Fig. 8)

For a more detailed description of the operating principles of typical transistor regulator circuits, refer to Delco-Remy Training Chart Manual DR-5133L, entitled "Transistor Regulators."

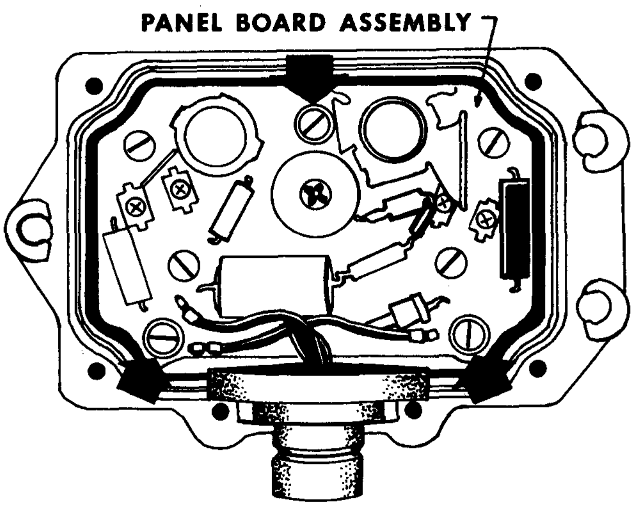


Figure 2—Underneath side of regulator with bottom plate removed. Arrows identify panel mounting screws.

OPERATING PRINCIPLES

A. Circuits containing light relay and field relay with light relay connected to the battery:

The negative ground circuit shown in Figure 3, and the positive ground circuit shown in Figure 4, can be identified by the use of two separate relays with an indicator light—the field relay and the indicator light relay. An ammeter may be employed in this type of circuit instead of an indicator light, in which case the indicator light relay is not used.

In the negative ground circuit illustrated in Figure 3, when the switch is closed and the engine is not running, the indicator lamp lights because its circuit from the battery is completed to ground through the indicator light relay contacts, which are normally closed. Also with this switch closed, the winding on the field relay is energized. This causes the field relay contacts to close, which connects the winding on the indicator light relay to the battery. If the battery has been charged recently and is not loaded, the indicator light relay contacts may separate, causing the light to go out. Thus, the light will flash on and then go out when the switch is closed. However, if the battery is in a discharged condition or has been standing for some time without being charged, the light will not go out until the higher voltage from the generator causes the light relay contacts to separate. If the charging system should fail to operate properly, the system voltage will decrease, the relay contacts will close, and the lamp will light to indicate trouble in the circuit. If the light stays on for more than 10 minutes with the engine running at moderate or high speed, trouble in the system is indicated.

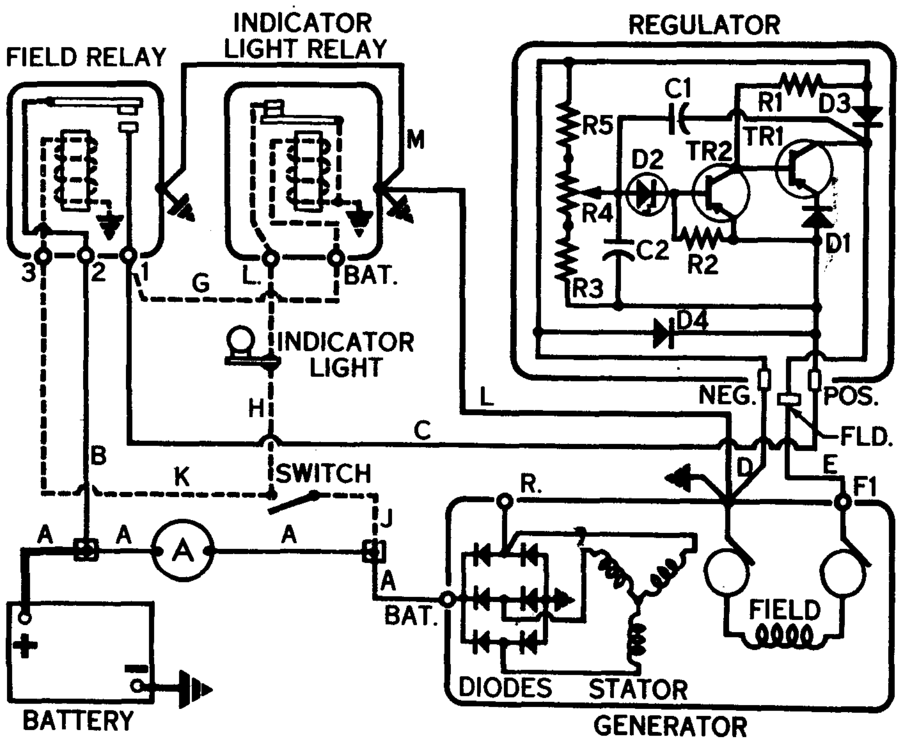


Figure 3—Negative ground circuit with light relay winding connected to battery when switch is closed.

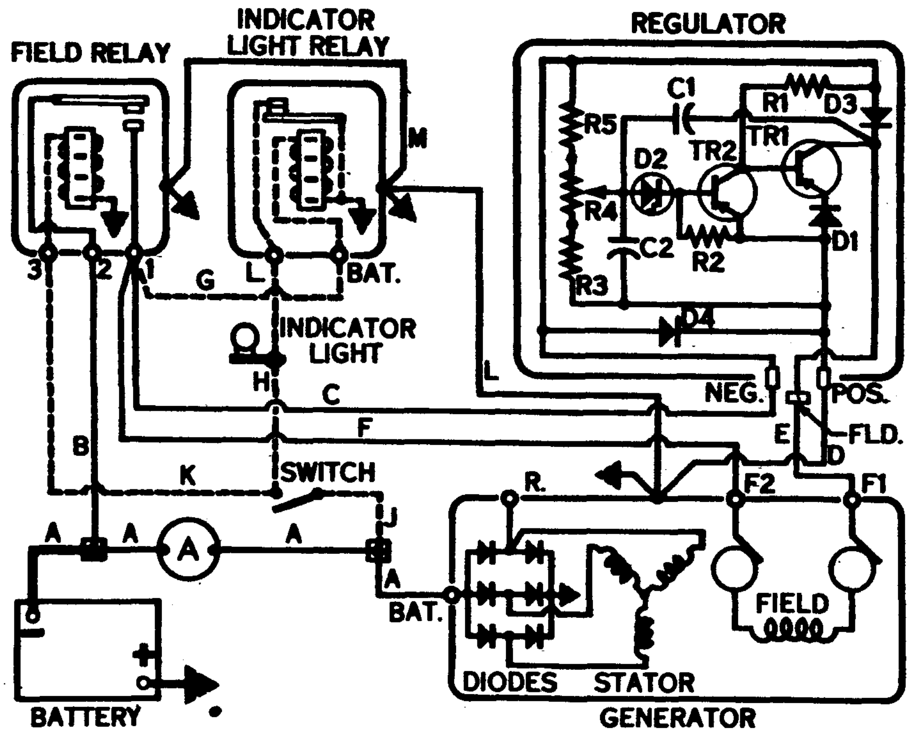


Figure 4—Positive ground circuit with light relay winding connected to battery when switch is closed.

With the field relay contacts closed and the engine not running, generator field current can be traced from the battery through the relay contacts to the regulator "POS" terminal. Current then continues through diode D-1 and transistor TR-1 to the regulator "FLD" terminal, and then through the generator field winding to ground, completing the circuit back to the battery.

When the generator begins to operate, a.c. voltages are induced in the stator windings. These voltages are changed, or rectified, to a d.c. voltage which appears at the output, or "BAT," terminal on the generator. The generator then supplies current to charge the battery and operate vehicle accessories.

As generator speed increases, the voltage reaches the pre-set value and the components in the regulator cause transistor TR-1 to alternately "turn off" and "turn on" the generator field voltage. The regulator thus operates to limit the generator output voltage to the pre-set value.

In the positive ground circuit shown in Figure 4, when the switch is closed and the engine is not running, field current can be traced from the battery positive ground to generator ground, and then to the regulator "POS" terminal. The current continues through diode D-1 and transistor TR-1 to the regulator "FLD" terminal, and then through the field winding and field relay contacts back to the battery, thus completing the circuit. Except for this primary difference, this circuit operates in the same manner as that described for the negative ground circuit in Figure 3.

B. Circuits containing light relay and field relay with light relay connected to generator:

These two circuits (Figs. 5 and 6) are identical to the circuits in Figures 3 and 4, except the winding on the indicator light relay is connected to the "R" terminal on the generator instead of to the terminal on the field relay. In this type of circuit, the indicator light relay contacts will not separate to cause the light to go out until the generator is in operation. If the generator should fail to operate properly, the relay contacts will close and the lamp will light to indicate trouble in the circuit.

C. Circuits with a combination light and field relay:

The negative ground circuit shown in Figure 7, and the positive ground circuit shown in Figure 8, are identified by a resistor connected in parallel with the indicator light and by a single relay which serves as a combination light and field relay.

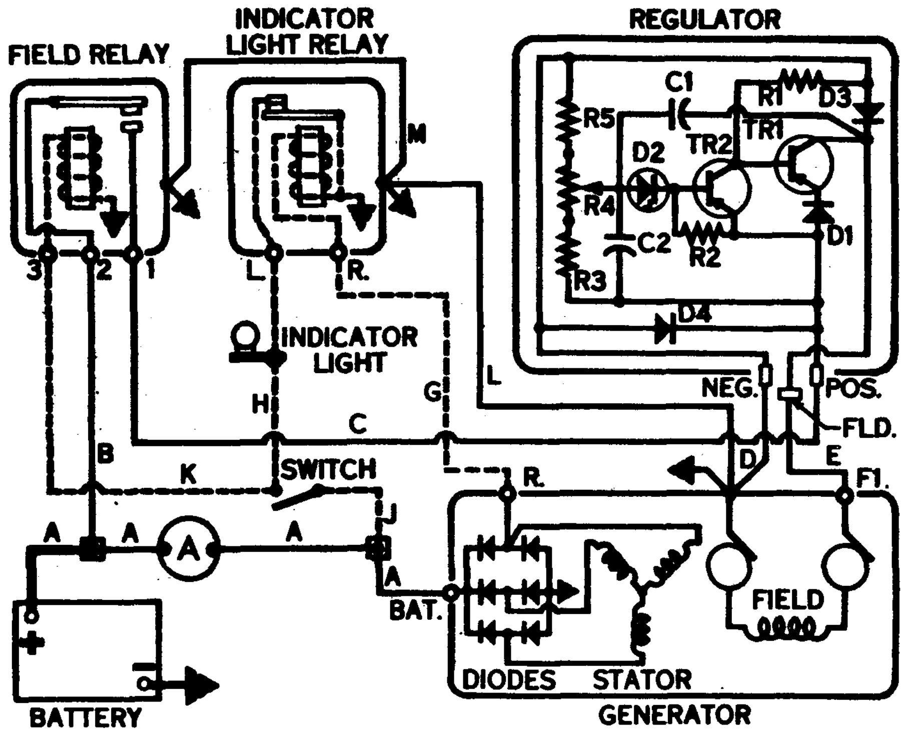


Figure 5—Negative ground circuit with light relay winding connected to "R" terminal on generator.

In Figure 7, with the switch on and the engine not running, current flows from the battery through the switch and indicator light and resistor to the "POS" terminal on the regulator. The current continues through diode D-1 and transistor TR-1 to the regula-

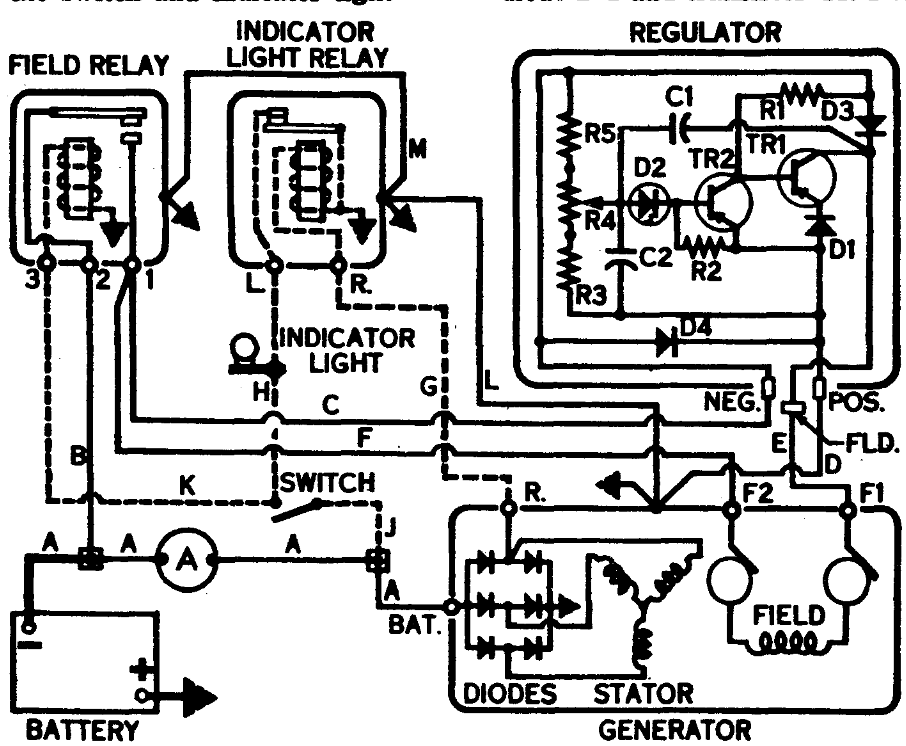


Figure 6—Positive ground circuit with light relay winding connected to "R" terminal on generator.

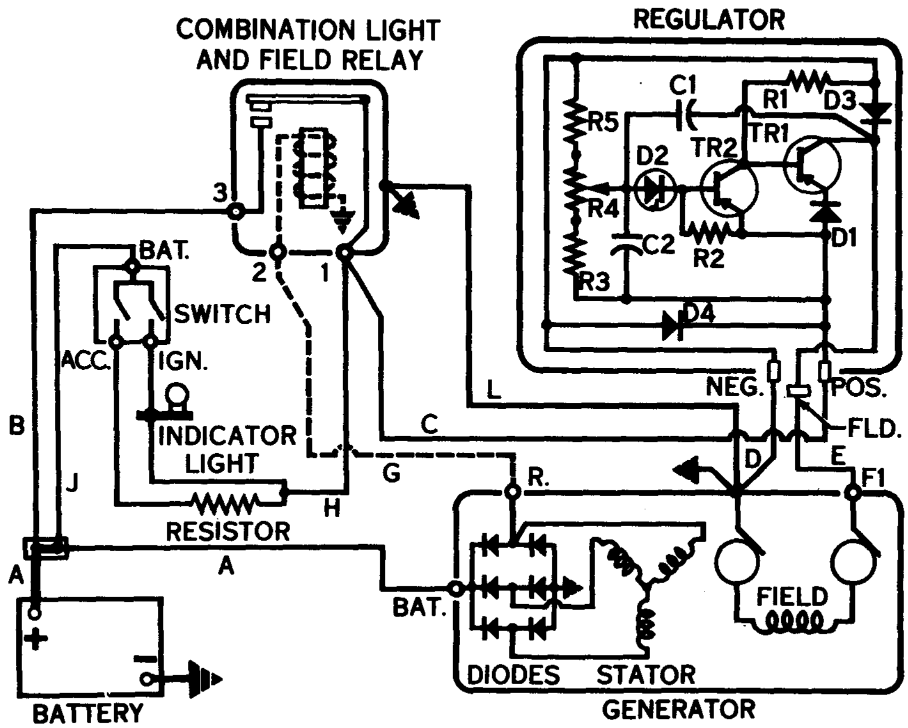


Figure 7—Negative ground circuit with combination light and field relay.

tor "FLD" terminal, and then through the generator field winding to ground, completing the circuit back to the battery. Thus, before the engine is started, the indicator light is on, and the generator field winding is energized.

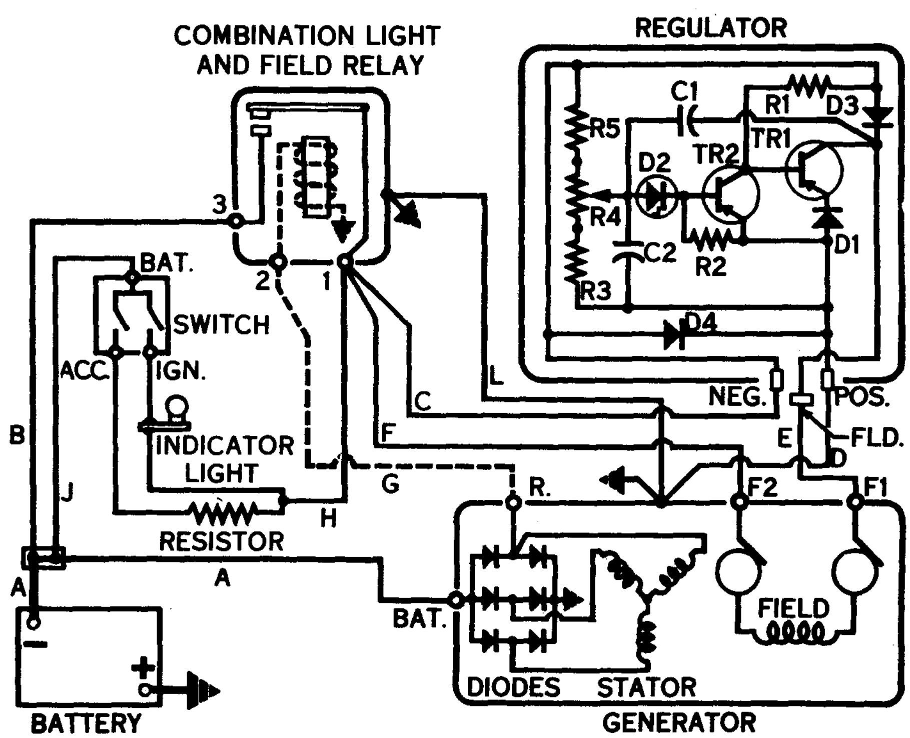


Figure 8—Positive ground circuit with combination light and field relay.

When the engine is started and the generator begins to operate, a.c. voltages are induced in the stator windings. These voltages are changed, or rectified, by the six diodes to a d.c. voltage which appears at the generator output, or "BAT," terminal.

As the generator operates, current flows from the "R" terminal to the winding on the combination light and field relay. The relay contacts close, connecting both sides of the indicator light to the battery. The light then goes out, indicating the generator is operating.

When the relay contacts are closed, generator field current flows from the generator or battery through the relay contacts to the "POS" terminal on the regulator, and then through the regulator and field winding as before. This by-passes the indicator light and resistor to provide full current through the field winding.

As generator speed increases, the output voltage reaches the pre-set value, and the components in the regulator cause transistor TR-1 to alternately "turn off" and "turn on" the generator field voltage. The regulator thus operates to limit the generator output voltage to the pre-set value.

In the positive ground circuit shown in Figure 8, with the switch on and the engine not running, field current can be traced from the battery positive ground to generator ground, and then to the regulator "POS" terminal. The current continues through diode D-1 and transistor TR-1 to the regulator "FLD" terminal, and then through the field winding, indicator lamp and resistor, and switch back to the battery, thus completing the circuit. Except for this primary difference, this circuit operates in the same manner as that described for the negative ground circuit in Figure 7.

ANALYZING CHARGING SYSTEM TROUBLES

In order to check these circuits, it is *necessary* to use an adapter at the regulator. This adapter is available from various automotive-type supply outlets, including United Motors Service under Packard Cable Test Adapter Catalog No. 1303. Note that the test leads on the adapter are of three different lengths, and the following illustrations show these lead lengths.

If the trouble is located in the generator during the test procedures, refer to the applicable Delco-Remy Service Bulletin 1G-251, 1G-252, 1G-253, 1G-271 or 1G-272 for corrective procedures. Refer to Delco-Remy Service Bulletin 1G-186 or 1G-187 to determine the correct service bulletin for a particular model generator if the bulletin number is unknown.

The following test procedures apply to all six circuits, including insulated circuits which are identical to those illustrated except wiring is substituted for ground returns. These circuits, as outlined in the "Operating Principles" sections, are identified as follows:

Figures 3 and 4 — These circuits use *separate* light and field relays. The light relay winding is connected to the battery when the switch is closed.

Figures 5 and 6 — These circuits are identical to Figures 3 and 4, except the light relay winding is connected to the "R" terminal on the generator.

Figures 7 and 8 — These circuits use a single *combination* light and field relay.

To analyze the system make sure all connections between the battery, junction block, and generator, (leads marked A in the wiring diagrams), are clean and tight. Then remove the wiring harness connector from the regulator, and connect the adapter between the wiring harness connector and the regulator.

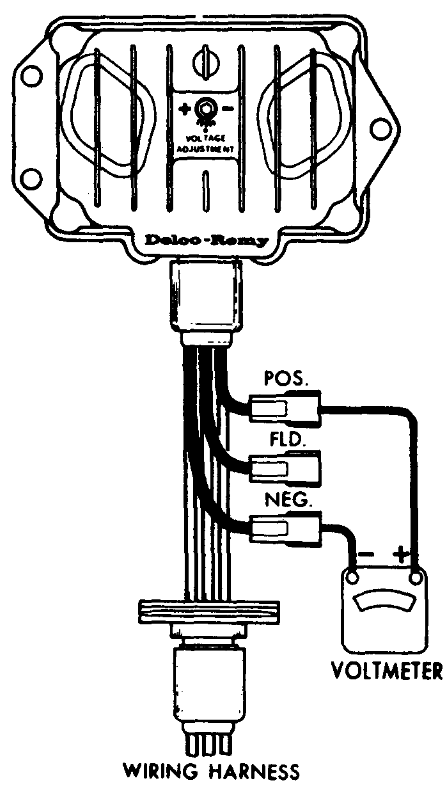


Figure 9—Voltmeter connections to test adapter.

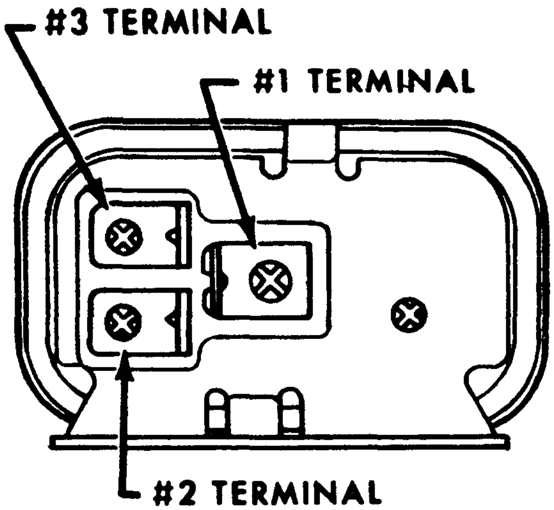


Figure 10—Underneath side of combination light and field relay (Used in Figures 7 and 8).

When the trouble is found, it is not necessary to make further checks; however, it is often advisable to complete all checks to insure that no other troubles exist.

TEST PROCEDURES

IMPORTANT: Observe the following test procedures exactly. Do not deviate. Improper connections and procedures may instantly damage the equipment.

If the regulator is found to be defective, it must be replaced or repaired as covered beginning on page 12.

If the battery condition is satisfactory, but the indicator light behavior is abnormal, begin with Step H, Page 10. If the battery is undercharged or overcharged, begin with Step A.

A. To check the field or combination relay, proceed as follows.
   1. Connect a voltmeter to the test adapter as shown in Figure 9.
   2. Make sure the switch is off.
   3. If the voltmeter reads battery voltage, the field relay contacts (Figs. 3, 4, 5 and 6), or combination light and field relay contacts (Figs. 7 and 8), are stuck closed, and the relay must be replaced. If the voltmeter reads zero, proceed to Step 4 if it applies and then to Step 5, otherwise go direct to Step 5.
   4. For the circuits in Figures 7 and 8 only, connect a jumper lead between the No. 1 and No. 3 terminals on the combination light and field relay. The terminals are identified in Figure 10. Slide prods into the connector body to make connections. *Leave this jumper lead connected for all test procedures through Part E, except where noted otherwise.*
   5. Turn the switch on.
   6. If the voltmeter reads battery voltage, proceed to Part B.
   7. If the voltmeter reads zero for circuits in Figures 3, 4, 5 and 6, check for excessive resistance or an open in leads A, B, C, D, J, and K and in the switch. If the leads and switch are satisfactory, replace the relay.
   8. If the voltmeter reads zero for circuits in Figures 7 and 8, there is excessive resistance or an open in leads A, B, C, and D.

B. To check the field circuit, proceed as follows.
   1. Connect a voltmeter to the test adapter as shown in Figure 11.
   2. Turn the switch on.
   3. If the voltmeter reads about 1 or 2 volts *less* than battery voltage, proceed to Part C, Page 9, entitled "Check the generator for specified output as follows."
   4. If the voltmeter reads zero volts the regulator is defective and must be replaced or repaired. IMPORTANT: The regulator defect may have been caused by a defective generator field. Check the field as follows *before* installing the new regulator.

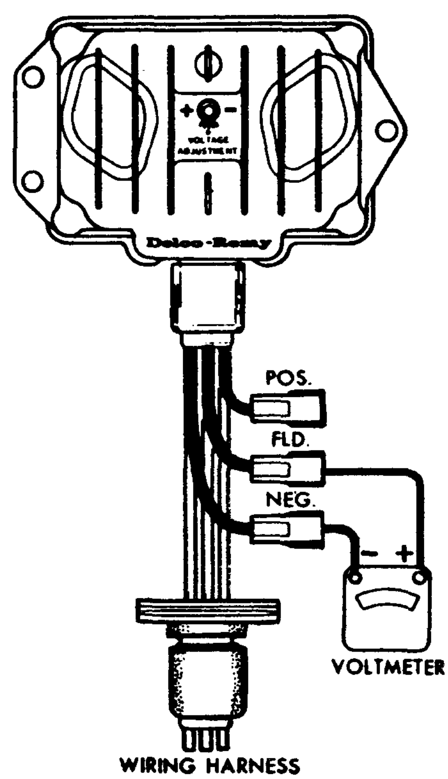


Figure 11—Voltmeter connections to test adapter.

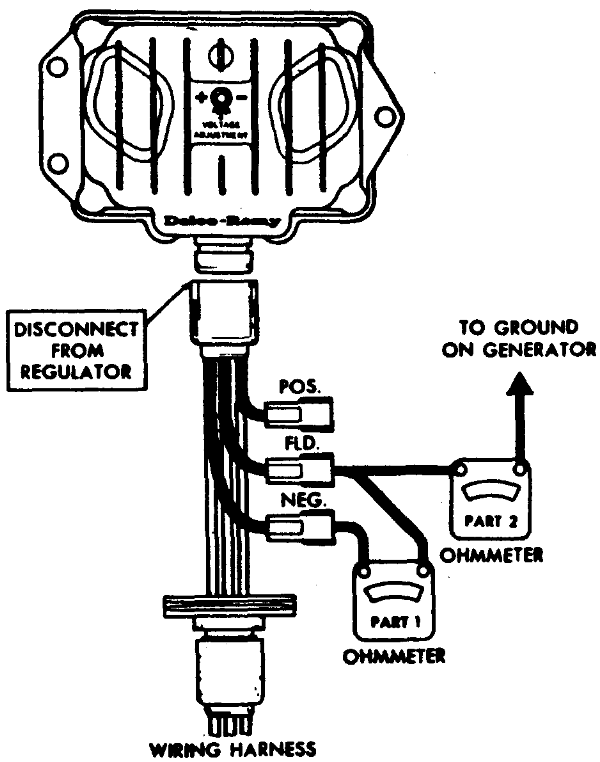


Figure 12—Ohmmeter connections to test adapter.

a. *Turn the switch off and disconnect the battery ground strap.*

b. *Disconnect the adapter from the regulator.*

c. Connect an ohmmeter to the adapter as shown in Part 1, Figure 12.

d. If the ohmmeter reads high, there is an open, or excessive resistance in the field winding, or in lead E (negative ground circuits) or leads E and F (positive ground circuits).

e. If the ohmmeter reads low for negative ground circuits, the winding is shorted or grounded.

f. If the ohmmeter reads low for positive ground circuits, the winding is shorted.

g. To check the winding in positive ground circuits for grounds, connect the ohmmeter as shown in Part 2, Figure 12. If the reading is less than the specified value, the winding is grounded.

NOTE: The specified resistance value can be determined by dividing the voltage by the current given in Delco-Remy Service Bulletin 1G-186 or 1G-187. Since the reading is taken through the adapter, leads, brushes and slip rings, the ohmmeter reading on a good field winding will be slightly higher than the specified value. This is true because the specified value is for an ohmmeter reading directly across the slip rings.

h. Disconnect ohmmeter and reconnect the battery ground strap.

5. If the voltmeter reads battery voltage, the regulator is shorted and must be replaced or repaired, or the generator field winding is open or grounded. Check as follows:

a. *To check the field, turn the switch off and disconnect the battery ground strap.*

b. *Disconnect the adapter from the regulator.*

c. Connect an ohmmeter to the adapter as shown in Part 1, Figure 12.

d. If the ohmmeter reads high, there is an open, or excessive resistance in the field winding, or in lead E (negative ground circuits) or leads E and F (positive ground circuits).

e. If the ohmmeter reads low for negative ground circuits, the winding is shorted or grounded.

f. If the ohmmeter reads low for positive ground circuits, the winding is shorted.

g. To check the winding in positive ground circuits for grounds, connect the ohmmeter as shown in Part 2, Figure 12. If the reading is less than the specified value, the winding is grounded.

NOTE: The specified resistance value can be determined by dividing the voltage by the current given in Delco-Remy Service Bulletin 1G-186 or 1G-187. Since the reading is taken through the adapter, leads, brushes and slip rings, the ohmmeter reading on a good field winding will be slightly higher than the specified value. This is true because the specified value is for an ohmmeter reading directly across the slip rings.

h. Disconnect ohmmeter and reconnect the battery ground strap.

i. To check the regulator, connect a voltmeter as shown in Figure 9 and operate the engine at moderate speed. If the voltage is uncontrolled and increases with speed to values above the specified setting range, replace the regulator.

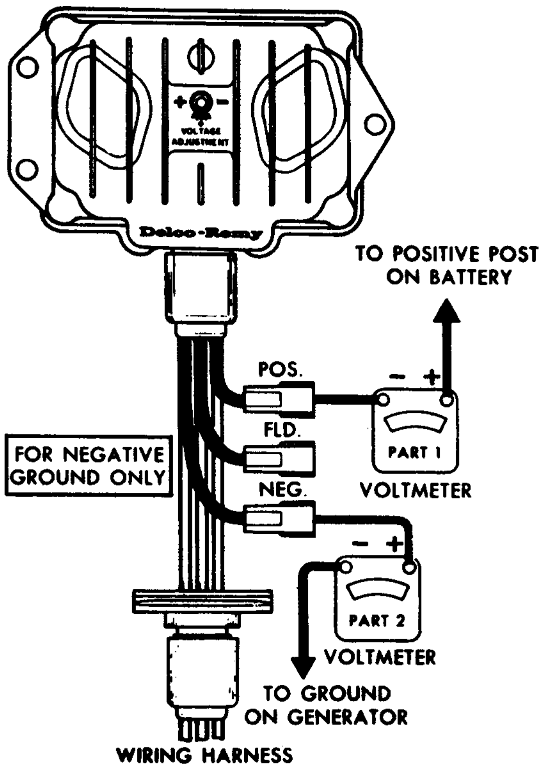


Figure 13—Voltmeter connections to test adapter for negative ground circuits only.

C. Check the generator for specified output as follows:

1. Connect an ammeter in the circuit at the output or "BAT" terminal on the generator.
2. Connect a voltmeter to the adapter as shown in Figure 9.
3. Turn on the switch.
4. Operate the generator at specified speed, and check for rated output as given in Delco-Remy Service Bulletin 1G-186 or 1G-187. Load the battery with a carbon pile or with accessories if needed to obtain rated output. If the generator does not provide rated output, repair per the appropriate Delco-Remy Service Bulletin. Reinstall on the vehicle, connect an ammeter in the circuit at the generator "BAT" terminal as before, and proceed to Step D.

D. Excessive resistance in the sensing circuit, consisting of leads B, C, and D and the regulator, can cause an overcharged battery or light flicker. If the trouble is not battery overcharge, or light flicker, proceed to Part E. Otherwise proceed as follows.

1a. For negative ground systems, connect a voltmeter as shown in Part 1 and Part 2 in Figure 13.

b. For positive ground systems, connect a voltmeter as shown in Part 1 and Part 2 in Figure 14.

c. For the circuits in Figures 7 and 8 only, remove the jumper lead from the combination light and field relay. Then connect a jumper lead from the insulated battery post to the No. 2 terminal on the light and field relay. (Fig. 10) Disconnect lead after 60 seconds to prevent overheating.

2. Turn on switch but do not start engine.
3. If the two voltmeter readings total more than .3 volt, check for excessive resistance in leads B, C, and D, which can cause an overcharged battery. If these leads are

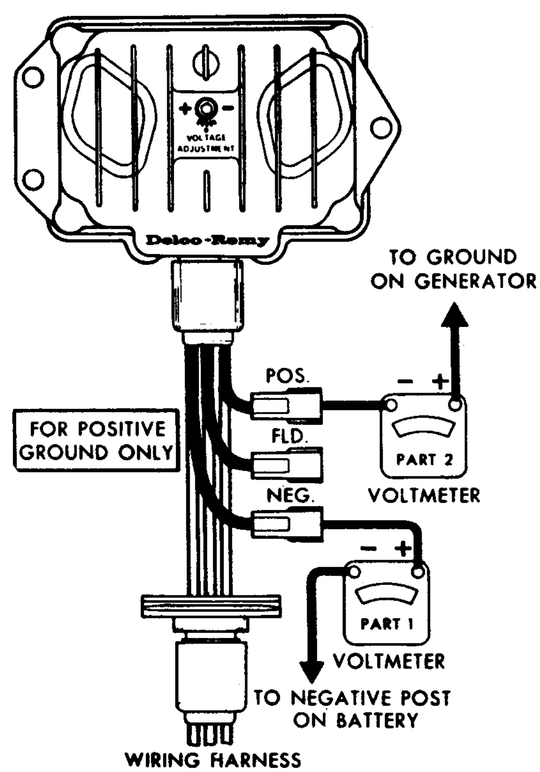


Figure 14—Voltmeter connections to test adapter for positive ground circuits only.

satisfactory, the field relay contacts (Figures 3, 4, 5 and 6), and the combination light and field relay contacts (Figures 7 and 8), may have excessive resistance. In this case replace the relay.

4. Remove the jumper lead connected from the battery post to the No. 2 terminal on the light and field relay (Figures 7 and 8), and then reconnect the jumper lead to the No. 1 and No. 3 terminals on the combination light and field relay. (Fig. 10)

E. A voltage setting not tailored to meet vehicle requirements can result in an undercharged or an overcharged battery. To adjust the voltage setting, proceed as follows:

1. Connect a voltmeter to the adapter as shown in Figure 9.
2. Connect an ammeter in the circuit at the output or "BAT" terminal on the generator.
3. Turn all accessories off.
4. Operate generator at approximately 3000 r.p.m.
5. The generator output should be at least 10 amperes below the rated generator output for this check. Example: If generator rated output per Bulletin 1G-186 or 1G-187 is 60 amperes, to adjust the voltage setting the output should be 50 amperes or less.
6. To adjust voltage setting, remove plug (Fig. 1) and turn slotted adjusting button inside regulator.

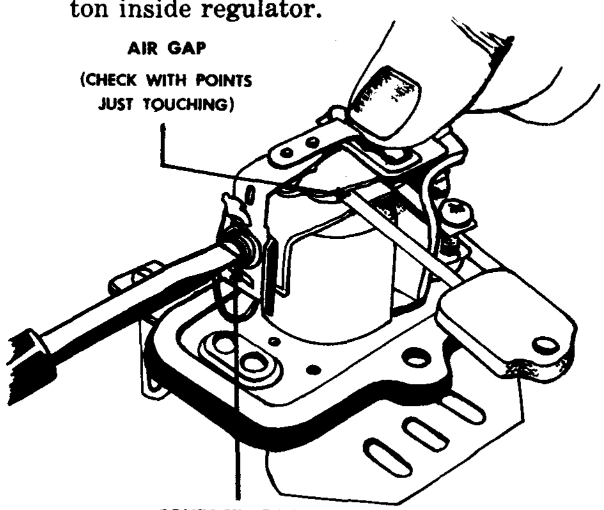


Figure 15—Checking and adjusting air gap.

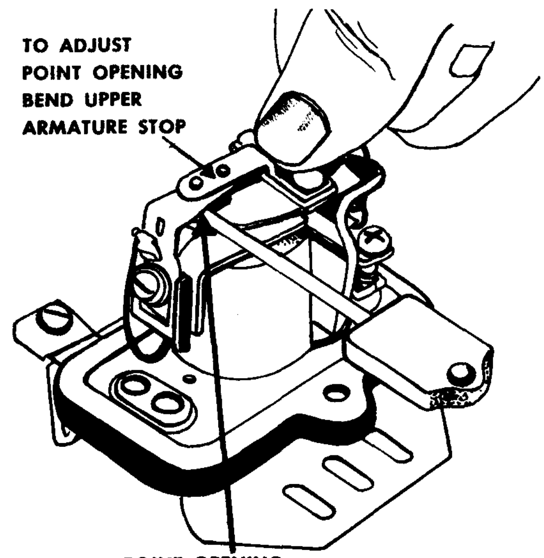


Figure 16—Checking and adjusting point opening.

7. For an undercharged battery, raise voltage setting by turning one notch and then check for an improved battery condition after a service period of reasonable length. (NOTE: After two notches in each direction, there is a positive stop).
8. For an overcharged battery, lower voltage setting by turning one notch and then check for an improved battery condition after a service period of reasonable length. (NOTE: After two notches in each direction, there is a positive stop.)
9. If the regulator cannot be adjusted to a value within the specified range as given in Bulletin 1R-186 or 1R-187, replace the regulator.
   NOTE: If repeated regulator failures are experienced on the vehicle, but no defects are found, a shorted, grounded, or open generator field winding, or grounded leads, of an *intermittent* nature should be suspected.

F. Disconnect the jumper lead from the combination light and field relay (Figures 7 and 8).

G. If the indicator light now operates normally, no further checks are needed. The following sections describe normal indicator light behavior.

H. With the switch on and the engine not running, normal indicator light behavior is as follows.

1. In Figures 3 and 4, the light may be on, or it may flash on at the instant the switch is closed and then go out. Either condition is normal. However, if the light fails to flash on, check for excessive resistance in the switch and leads J and H. If satisfactory, either the bulb is burned out, or the indicator light relay contacts have excessive resistance.
2. In Figures 5 and 6 the light should be on. If it is not, check for excessive resistance in the switch and in leads J and H. If satisfactory, either the bulb is burned out, or the indicator light relay contacts have excessive resistance.
3. In Figures 7 and 8, the light should be on. If it is not, check for excessive resistance in the switch and in leads J and H. If satisfactory, replace the bulb.

I. With the switch on and the engine running, normal indicator light behavior is as follows.

1. In Figures 3 and 4, the light may remain on at slow speeds with the battery discharged or loaded. This is normal. However, if the light fails to go out after a 10 minute engine run at moderate or high speed, replace the indicator light relay, or repair as covered in the following section.
2. In Figures 5, 6, 7, and 8, the light should be out. If it is not, replace the light relay.

J. If the switch is off but the light is on (Figs. 7 and 8 only), check for a shorted diode in the generator. This can cause a run-down battery with or without vehicle operation.

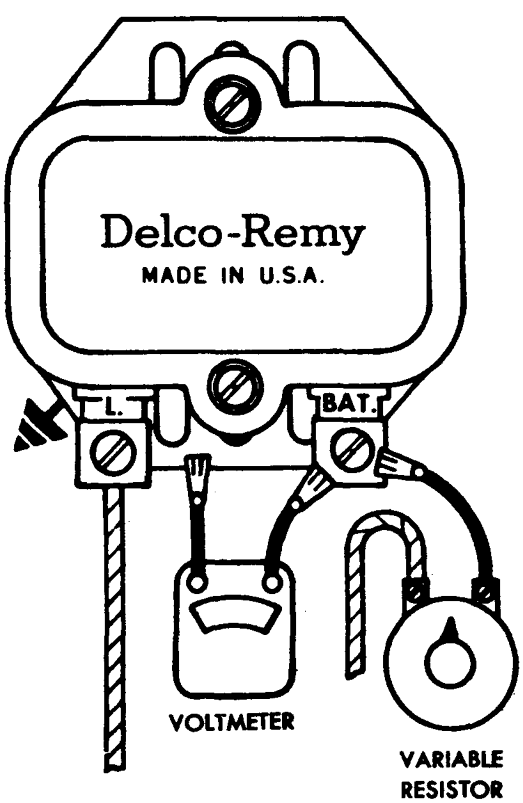


Figure 17—Connections for checking relay closing voltage.

INDICATOR LIGHT RELAY

(Type Used in Figures 3 and 4)

Specifications for relays of this type are covered in Delco-Remy Service Bulletin 1R-186 and 1R-187. Three checks and adjustments are required: air gap, point opening, and voltage setting. If the voltage setting can be properly adjusted, the air gap and point opening need not be checked.

Air Gap — Measure the air gap between the armature and core with the points just touching. (All relay leads must be disconnected.) If adjustment is necessary, hold the armature down against the gauge and adjust the upper contact support so the contacts are aligned squarely and just touch when the contact support screws are tightened. See Figure 15.

Point Opening — Check the point opening with the armature held down against the upper armature stop. (All relay leads must be disconnected.) To adjust the point opening, bend the upper armature stop. (Fig. 16)

Voltage Setting — To check the voltage setting, proceed as follows:

1. Connect a 25 ohm variable resistor in the circuit at the "BAT" terminal on the relay, and a voltmeter from the "BAT" terminal to ground. See Figure 17.
2. Turn variable resistor to full "off" or no-resistance position.
3. Operate the generator at moderate speed. The relay contacts should be open. If they are not, and the generator is supplying rated voltage, turn the adjusting screw (Fig. 18) until the contacts separate.
4. Slowly increase resistance, and note voltage at which the contacts close.

5. Then decrease resistance, and note voltage at which contacts open.
6. To adjust the closing voltage, turn the adjusting screw as shown in Figure 18.
7. To adjust the opening voltage, decrease the air gap adjustment (Fig. 15) to decrease the voltage spread between closing and opening voltage.

CAUTION: When turning the adjusting screw, always make final setting by turning the screw clockwise. This insures that the springholder will be up against the head of the screw. After turning screw counterclockwise, pry holder up against screw head, then turn clockwise to make setting.

After making settings, turn off switch, then turn switch on, repeat Steps 4 and 5 and read final settings.

REGULATOR REPAIR

To check the regulator for defective components, proceed as follows:

1. Remove the bottom plate from the regulator. (Fig. 2)
2. Remove the three panel board attaching screws identified by arrows (Fig. 2), and lift the assembly from the housing.
3. To aid in reassembly, note any identifying markings on the two transistors and their respective locations on the panel board and heat sink assembly. (Fig. 19)

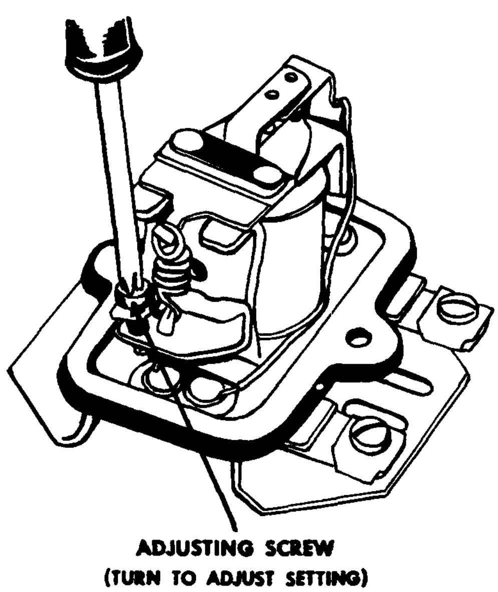


Figure 18—Adjusting relay closing voltage.

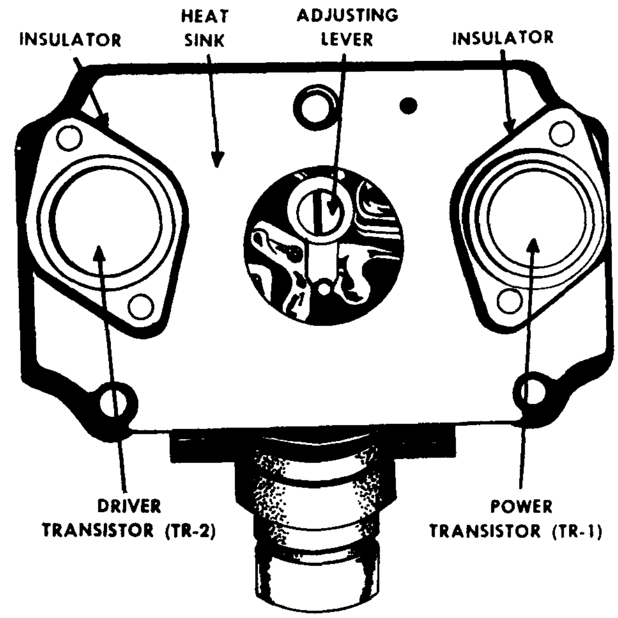


Figure 19—Panel board and heat sink assembly.

4. Note the insulators between the transistors and the heat sink, and the insulators separating the heat sink from the panel board. (Fig. 19)
5. Remove the transistor attaching screws, and separate the transistors and heat sink from the panel board.

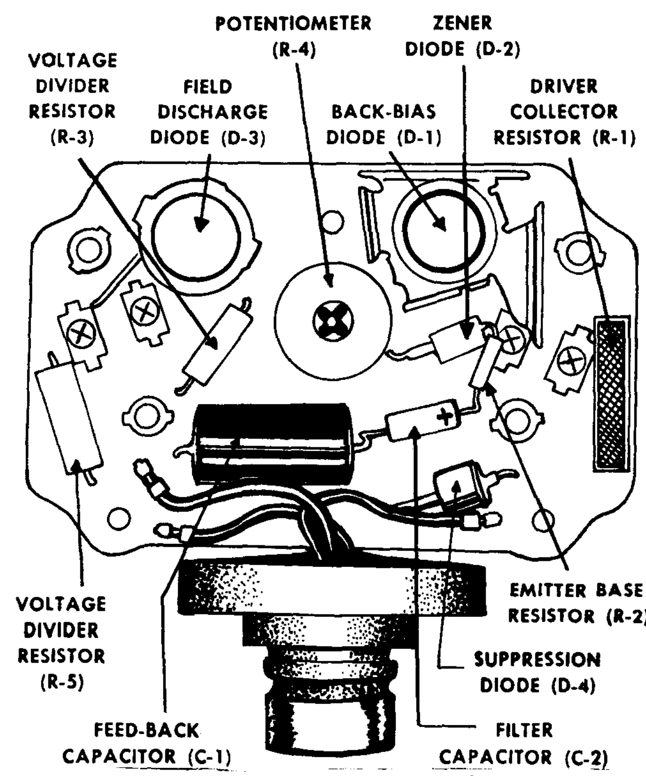


Figure 20—Identification of component parts (Parts keyed to Figs. 3-8).

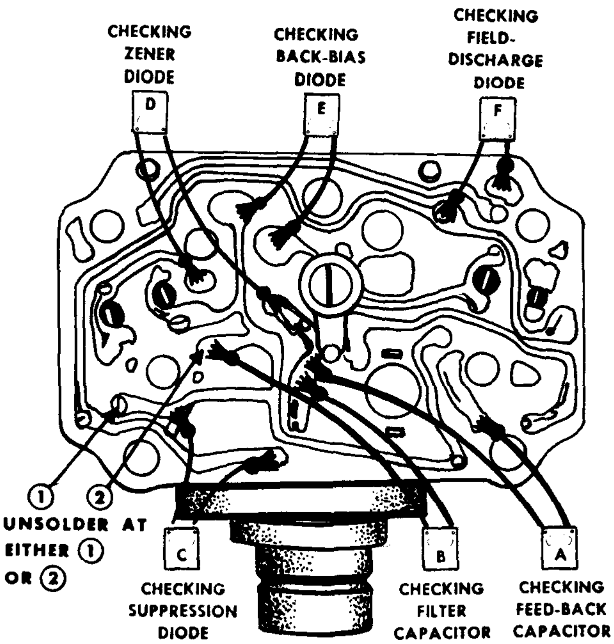


Figure 21—Checking components.

With the transistors separated from the assembly, an ohmmeter may be used to check the transistors and components on the panel board for defects. An ohmmeter having a 1½ volt cell, which is the type usually found in service stations, is recommended. The low range scale on the ohmmeter should be used.

If a component part on the panel board is found to be faulty, it should be replaced before proceeding with the remaining checks. A 25 watt soldering gun is recommended, and a 60% tin 40% lead solder should be used when re-soldering. Avoid excessive heat which may damage the panel board. Chip away any epoxy involved, and apply new epoxy which is commercially available.

The component parts are identified in Figures 19 and 20, with the symbols also shown in Figures 3 - 8.

In order to check the panel board assembly, it is necessary to unsolder the emitter-base resistor at location No. 1 or location No. 2 as shown in Figure 21. Earlier production regulators used a wire-wound emitter-base resistor soldered at location No. 1, and later regulators use a solid resistor soldered at location No. 2.

In all of the following checks, connect the ohmmeter as shown and then reverse the ohmmeter leads to obtain two readings.

Feed-Back Capacitor, Part A, Fig. 21: If both readings are zero, the capacitor is defective. Visually inspect for open soldered connections and broken leads.

Filter Capacitor, Part B, Fig. 21: If both readings are zero, the capacitor is defective. Visually inspect for open soldered connections and broken leads. To assemble a new capacitor properly, note the location of the "+" identifying mark in Figure 20.

Suppression Diode, Part C, Fig. 21: If the two readings are identical, the diode is faulty.

Zener Diode, Part D, Fig. 21: Replace the diode if both readings are zero, if both readings are infinite, or if both readings are identical.

Back-Bias Diode, Part E, Fig. 21: Replace the diode if both readings are zero, if both readings are infinite, or if both readings are identical.

Field-Discharge Diode, Part F, Fig. 21: Replace the diode if both readings are zero, if both readings are infinite, or if both readings are identical.

Driver-Collector Resistor, Part A, Fig. 22: If both readings are infinite, the resistor is open.

Voltage-Divider Resistor R-3, Part B, Fig. 22: If one reading is infinite or nearly infinite, or if both readings are infinite or nearly infinite, the resistor is open.

Voltage Divider Resistor R-5, Part C, Fig. 22: If one reading is infinite or nearly infinite, or if both readings are infinite or nearly infinite, the resistor is open.

Potentiometer, Parts D and E, Fig. 22: If one reading is infinite or nearly infinite in Part D, the potentiometer is open. If both readings are infinite in Part E, the potentiometer is open. NOTE: When installing a new potentiometer mount on the panel board, and turn the potentiometer adjustment to the middle position. Then, after all tests have been completed and the unit has been reassembled as shown in Figure 19, connect to a generator and adjust the potentiometer to 14 volts. Then, with the adjusting lever in the vertical position (Fig. 19) use a soldering iron to melt the adjusting lever into the potentiometer.

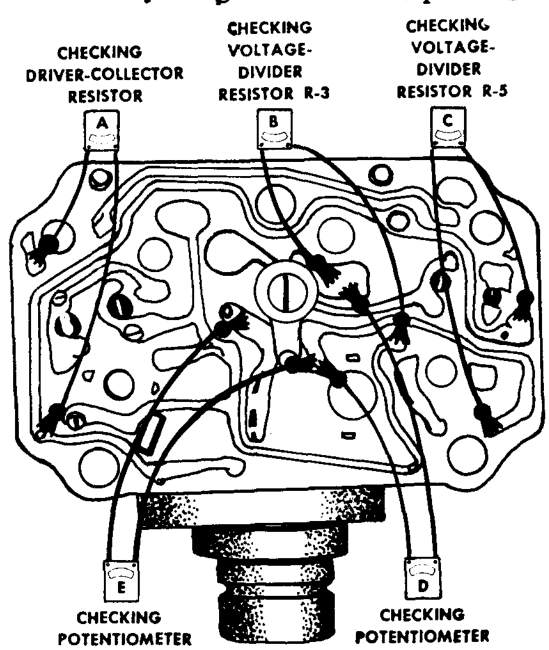


Figure 22—Checking components.

TRANSISTOR REGULATORS

Emitter-Base Resistor (Ohmmeter Check Not Illustrated): Since this resistor has been unsoldered from the panel board at one end, merely connect an ohmmeter across the resistor — an infinite reading indicates an open. Replace if defective. If not defective, *resolder to the panel board.*

Driver and Power Transistors, Fig. 23: If both readings in Step 1 are zero, or if both readings are very low and identical, the transistor is shorted. Similarly, if both readings in Step 2, or in Step 3, are zero or very low and identical, the transistor is shorted.

Driver and Power Transistors, Fig. 24: If both readings in Step 1 are infinite, or if both readings are very high and identical, the transistor is open. Similarly, if both readings in Step 2 are infinite or very high and identical, the transistor is open.

Reassembly and Final Check

During assembly, coat with silicone grease both sides of the flat insulators used between the transistors and heat sink, and also the heat sink on the side on which the transistors are mounted.

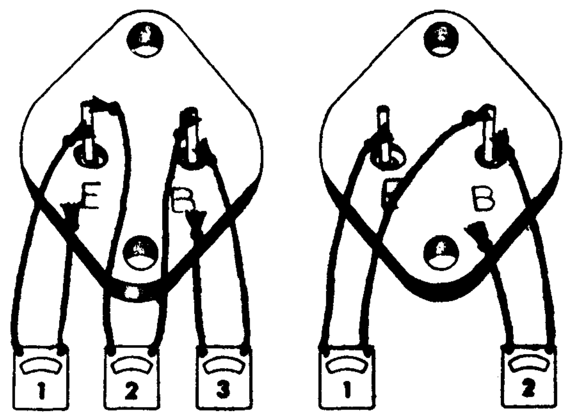


Figure 23—Checking transistor. **Figure 24—Checking transistor.**

The silicone grease which is available commercially, increases heat conduction and thereby provides better cooling.

After the regulator has been reassembled, the voltage setting should be checked and adjusted if necessary as covered in Section E, Page 10.

DELCOTRON INTEGRAL CHARGING SYSTEM

1G-285 Service Bulletin

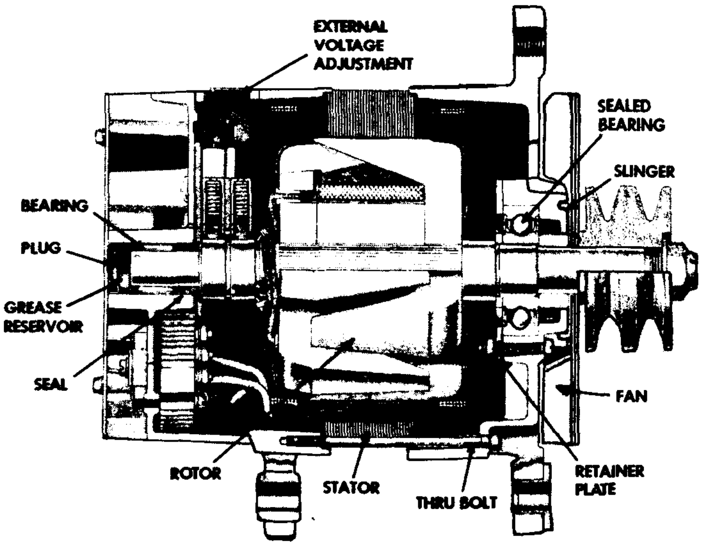


Figure 2—Cross-sectional view typical integral charging system.

OPERATING PRINCIPLES

(TWO-TERMINAL REGULATOR)

Typical wiring diagrams are illustrated in Figures 3 and 4. The basic operating principles are explained as follows.

With the Integral Charging System operating, a.c. voltages initially are generated in the stator windings by residual magnetism in the rotor. Current then flows through the diode trio, resistor R1, and resistor R4 to turn transistor TR1 on. The stator then supplies d.c. field current through the diode trio, the field, TR1, and then through the grounded diodes in the rectifier bridges back to the stator. Also, the diodes in the rectifier bridges change the stator a.c. voltages to a d.c. voltage which appears between ground and the "BAT" terminal. As speed increases, current is provided for charging the battery and operating electrical accessories.

As the speed and voltage increase, the voltage between R2 and R3 increases to the value where zener diode D1 conducts. Transistor TR2 then turns on and TR1 turns off. With TR1 off, the field current and system voltage decrease, and D1 then blocks current flow causing TR1 to turn back on. The field current and system voltage increase, and this cycle then repeats many times per second to limit the voltage to the adjusted value.

Capacitor C1 smooths out the voltage across R3, resistor R4 prevents excessive current through TR1 at high temperatures, and diode D2 prevents high-induced-voltages in the field windings when TR1 turns off.

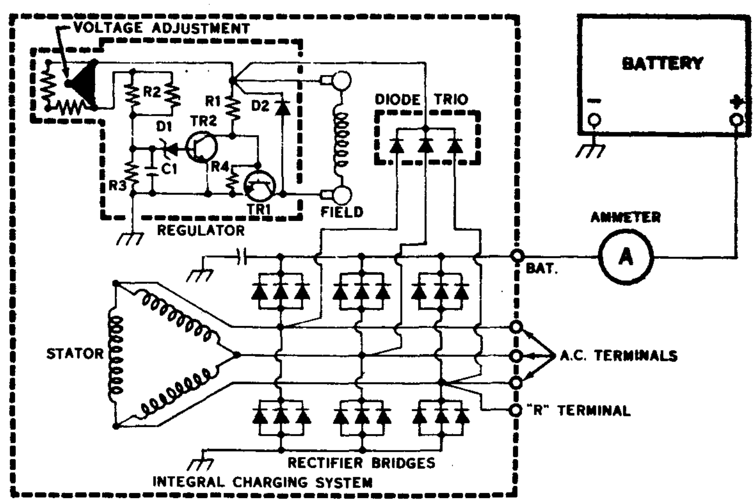


Figure 4—Typical wiring diagram showing internal circuits.
(Three-rectifier bridge type)

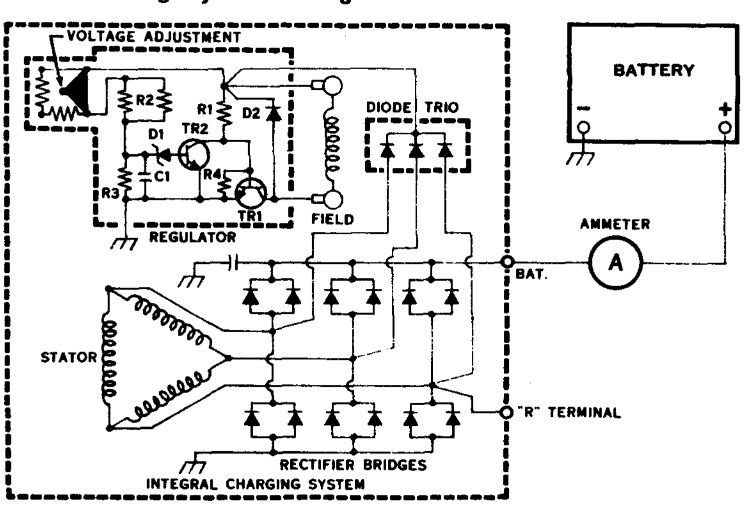


Figure 3—Typical wiring diagram showing internal circuits.
(Two-rectifier bridge type)

Delco-Remy

Tests of

DELCOTRON® INTEGRAL CHARGING SYSTEM

(40-SI Series, 150 Type)

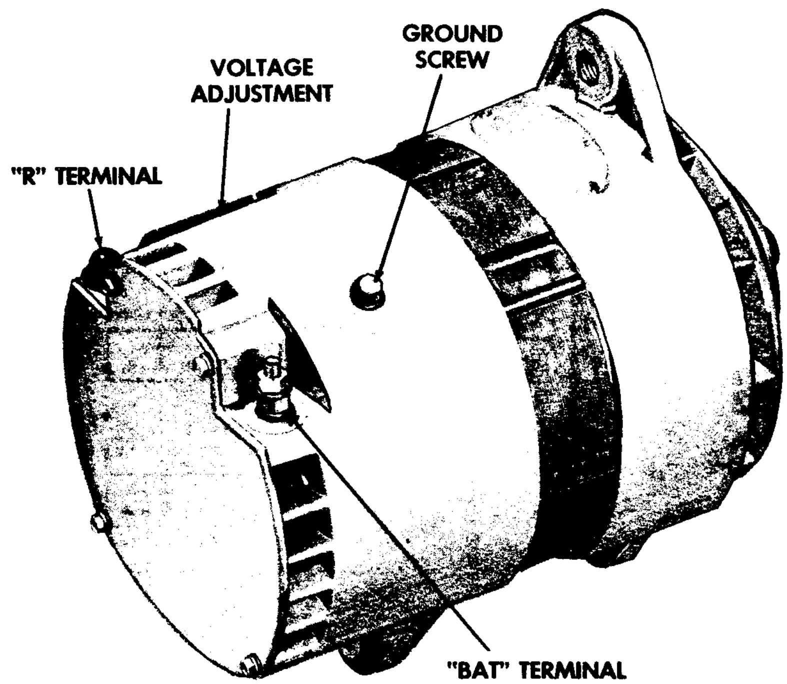


Figure 1—Typical integral charging system.

INTRODUCTION

The Integral Charging System or generator, illustrated in Figures 1 and 2 features a solid state regulator that is mounted inside the slip ring end frame. The regulator voltage setting can be adjusted externally by repositioning a voltage adjustment cap in the slip ring end frame. This feature is covered in detail in Figure 8. Only one wire is needed to connect the Integral Charging System to the battery, along with an adequate ground return. An "R" terminal is provided to operate auxiliary equipment in some circuits. Also, some models have three a.c. terminals to which a transformer-rectifier combination may be connected for conversion to 110 volts d.c.

The rotor bearing in the slip ring end frame contains a supply of lubricant sufficiently adequate to eliminate the need for periodic lubrication. The drive end frame bearing is sealed on both sides and is serviced by complete replacement. Two brushes carry current through the two slip rings to the field coil mounted on the rotor, and under normal conditions will provide long periods of attention-free service.

IMPORTANT: This bulletin covers generators with a two-terminal regulator having two male blade terminals and also generators with a three-terminal regulator having two male blade terminals plus a threaded stud terminal. The procedures in this bulletin cover both types of generators; namely, the two-terminal type and the three-terminal type.

OPERATING PRINCIPLES

(THREE-TERMINAL REGULATOR)

Typical wiring diagrams are shown in Figures 5 and 6. The basic operating principles are explained as follows.

With the Integral Charging System operating, a.c. voltages initially are generated in the stator windings by residual magnetism in the rotor. The diodes in the rectifier bridge change the stator a.c. voltages to a d.c. voltage which appears between ground and the "BAT" terminal. As speed increases, current is provided for charging the battery and operating electrical accessories.

Current also flows from the stator and rectifier bridge through resistor R1 and resistor R4 to turn transistor TR1 on.

The stator then supplies d.c. field current through the diode trio, the field, TR1, and then through the diodes in the rectifier bridge back to the stator.

As the speed and voltage increase the voltage between R2 and R3 increases to the value where zener diode D1 conducts. Transistor TR2 then turns on and TR1 turns off. With TR1 off, the field current and system voltage decrease and D1 then blocks current flow causing TR1 to turn back on. The field current and system voltage increase and this cycle then repeats many times per second to limit the voltage to the adjusted value.

Capacitor C1 smooths out the voltage across R3, resistor R4 prevents excessive current through TR1 at high temperatures, and diode D2 prevents high-induced-voltages in the field windings when TR1 turns off.

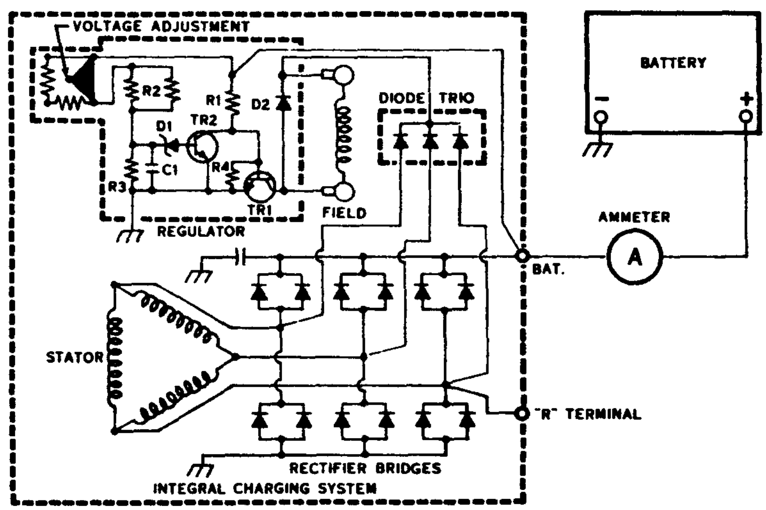


Figure 5—Typical wiring diagram showing internal circuits. (Two-rectifier bridge type)

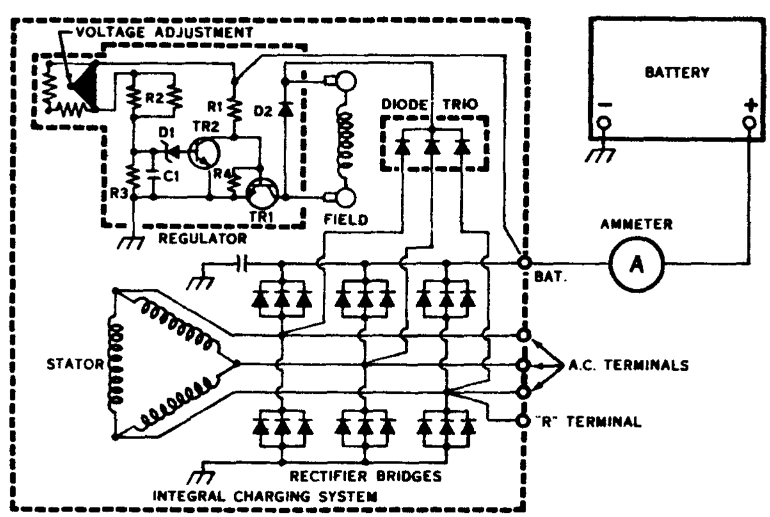


Figure 6—Typical wiring diagram showing internal circuits. (Three-rectifier bridge type)

TROUBLESHOOTING PROCEDURES

(Close adherence to the following procedures in the order presented will lead to the location and correction of charging system defects in the shortest possible time. Only a portion of these procedures need be performed. It will never be necessary to perform all the procedures in order to locate the trouble.)

A basic wiring diagram showing lead connections is shown in Figure 7. To avoid damage to the electrical equipment, always observe the following precautions:

- Do not polarize the Integral Charging System.
- Do not short across or ground any of the terminals in the charging circuit except as specifically instructed herein.
- Make sure the Integral Charging System and battery have the same ground polarity.
- When connecting a charger or a booster battery to the vehicle battery, connect negative to negative and positive to positive.

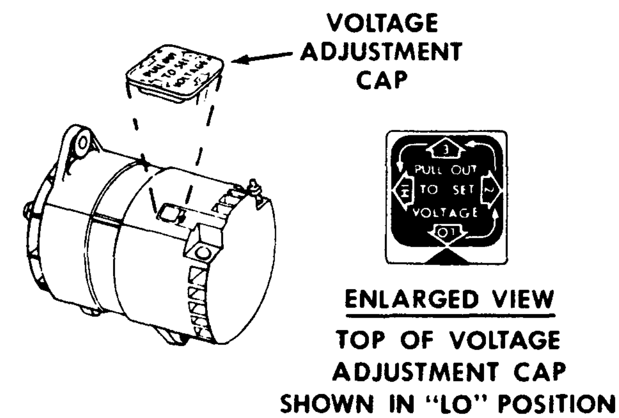


Figure 8—Voltage adjustment cap.

Trouble in the charging system will show up as one or more of the following conditions:

A. An undercharged battery, as evidenced by slow cranking and low specific gravity readings.
B. An overcharged battery, as evidenced by excessive water usage.

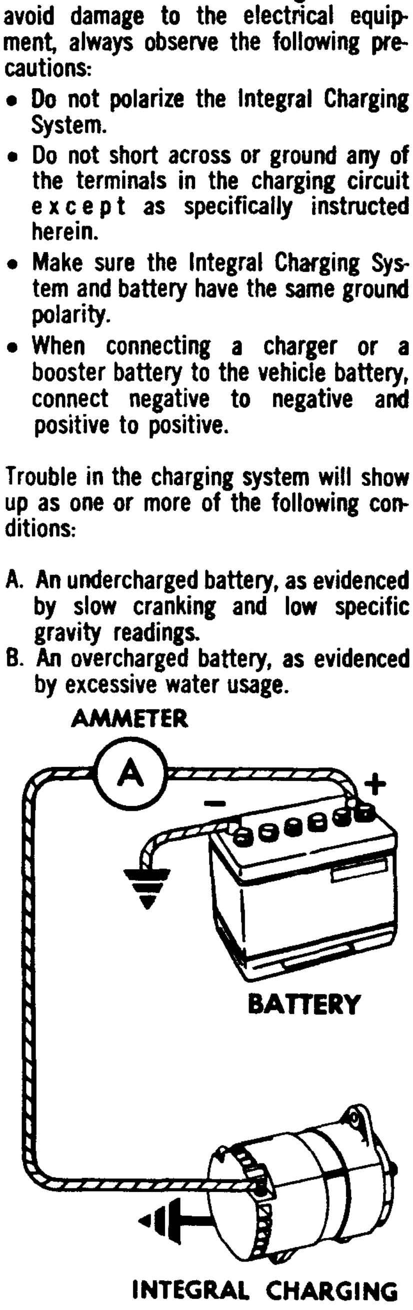


Figure 7—Typical wiring diagram showing basic lead connections.

A. UNDERCHARGED BATTERY

This condition, as evidenced by slow cranking and low specific gravity readings, can be caused by one or more of the following conditions:

1. Insure that the undercharged condition has not been caused by accessories having been left on for extended periods.
2. Check the drive belt for proper tension.
3. If a battery defect is suspected, check per Delco-Remy Service Bulletin 1B-115 or 1B-116.
4. Inspect the wiring for defects. Check all connections for tightness and cleanliness, including the cable clamps and battery posts.
5. Connect a voltmeter from "BAT" terminal on Integral Charging System to ground. A zero reading indicates an open between voltmeter connection and battery.
6. If previous Steps 1 through 5 check satisfactorily, check Integral Charging System as follows:
   a. Disconnect battery ground cable.
   b. Connect an ammeter in the circuit at the "BAT" terminal of the Integral Charging System.
   c. Reconnect battery ground cable.
   d. Turn on accessories. Connect a carbon pile across the battery.
   e. Operate engine at moderate speed as required, usually 4000 generator r.p.m. or more, and adjust carbon pile as required, to obtain maximum current output.

   IMPORTANT: Initial voltage build-up is by residual magnetism in the rotor. Increase the speed as required to obtain maximum current output.

   f. If ampere output is within 10 percent of rated output as stamped on generator frame, Integral Charging System is not defective. In this case, an adjustment of the voltage setting may correct the undercharged condition. Raise the setting by removing the voltage adjusting cap, rotating in increments of 90°, and then re-inserting the cap in the connector body. As illustrated in Figure 8, the cap is set for low voltage. With position 2 aligned with the arrow, the setting is increased to medium low, position 3 is medium high, and position "HI" is the highest regulator setting. After adjusting the setting, check for an improved battery condition after a service period of reasonable length, such as one week. **IMPORTANT: The volt-**

age adjustment in Figure 8 is for purposes of illustration only. The actual adjustment as shipped from the factory may be in some other position such as position 3, depending on the application requirement. If readjusting the setting does not correct the undercharged condition, proceed to "Integral Charging System Repair."

g. If ampere output is not within 10 percent of rated output as stamped on Integral Charging System frame, remove the Integral Charging System for repair as covered in section entitled "INTEGRAL CHARGING SYSTEM REPAIR."

B. OVERCHARGED BATTERY

1. Check the battery per Delco-Remy Service Bulletin 1B-115 or 1B-116. IMPORTANT—Remember that an overheated battery will be overcharged even though no charging circuit defects are present.
2. If battery is not defective or overheated, connect a voltmeter between Integral Charging System "BAT" terminal and ground.
3. With all accessories turned off, increase engine speed as required to obtain maximum voltage reading.
4. If voltage exceeds 15 volts on a 12-volt system, or 30 volts on a 24-volt system, remove Integral Charging System for repair as covered under heading of "INTEGRAL CHARGING SYSTEM REPAIR."
5. If voltage does not exceed the values listed in Step 4 preceding, adjust voltage to a lower value by removing voltage adjusting cap and re-inserting into connector body. Then check battery condition after a service period of reasonable length, such as one week. Figure 8 is for purposes of illustration only, and shows the cap adjusted for the lowest setting. The actual adjustment as shipped from the factory may be in some other position, such as position 3, depending on the application requirement. The lowest setting is with "LO" aligned with the arrow, position 2 is medium low, position 3 is medium high, and "HI" is the highest setting.

INTEGRAL CHARGING SYSTEM REPAIR

To repair the Integral Charging System, observe the following procedure.

DISASSEMBLY

1. Remove end plate from slip ring end frame.
2. Hold shaft with hex wrench inserted into hex hole in end of shaft while removing shaft nut. Remove washer, pulley, fan and slinger.
3. Remove four thru-bolts from drive end frame.
4. Separate slip ring end frame and stator assembly from drive end frame and rotor assembly.
5. Separate stator from end frame by removing three stator lead attaching nuts. Figures 9 and 10, and 11 and

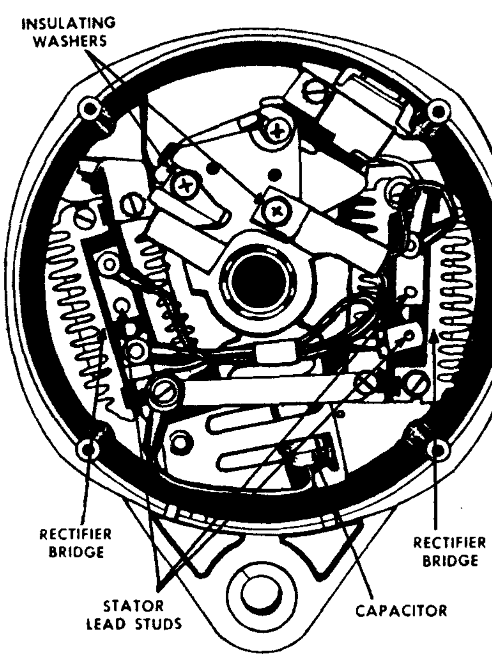


Figure 9—End frame view with stator removed. (Two-rectifier bridge type with two-terminal regulator)

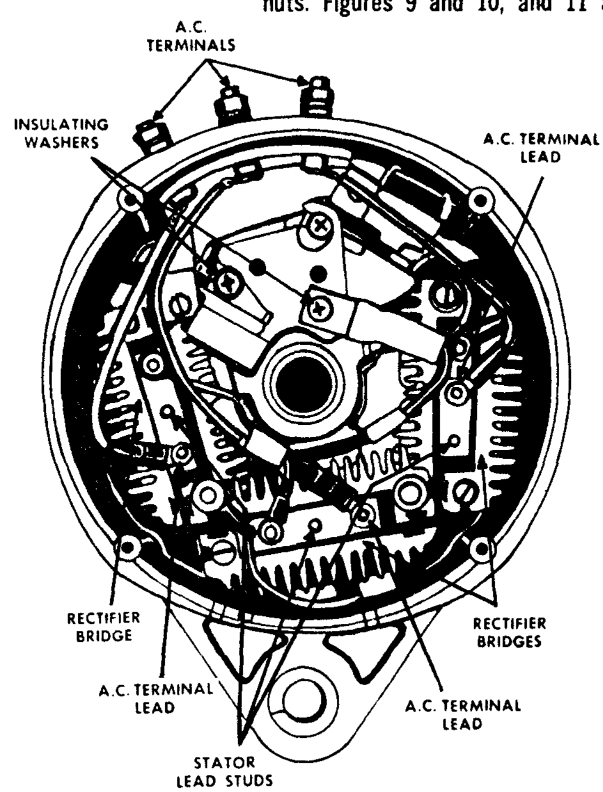


Figure 10—End frame view with stator removed. (Three-rectifier bridge type with two-terminal regulator)

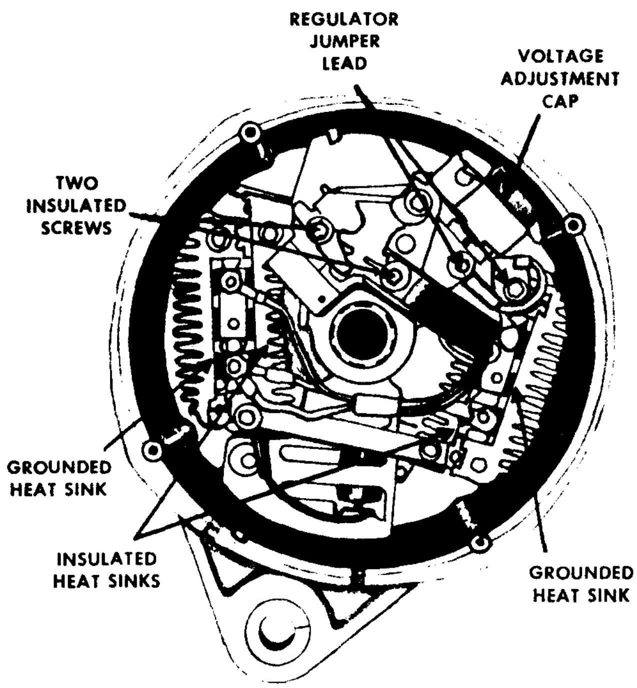


Figure 11—End frame view with stator removed. (Two-rectifier bridge type with three-terminal regulator)

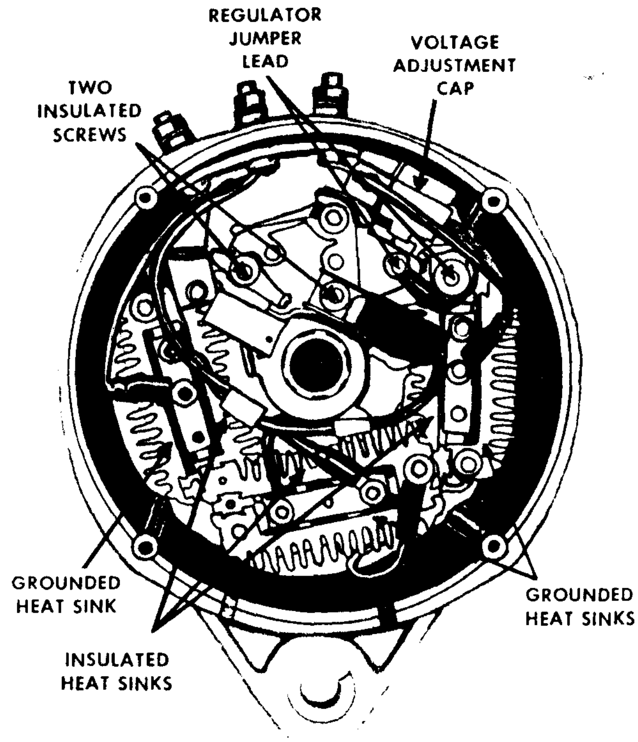


Figure 12—End frame view with stator removed. (Three-rectifier bridge type with three-terminal regulator)

12 show end frame with stator removed.

6. Place tape over bearing and shaft to protect from dirt. Use pressure sensitive tape and not friction tape that would leave a gummy deposit.
7. Inspect all leads for burned connections or opens, and brushes for excessive wear. Inspect springs for distortion or discoloration. Replace as required. Clean brushes with a soft dry cloth if they are to be reused. During servicing and reassembly hold brushes and springs in holder with a pin or toothpick inserted through end frame hole.

REGULATOR CHECK

If the battery is overcharged, check first the voltage adjustment connector body for opens. Remove the connector body from the regulator and check with an ohmmeter using the middle range scale as shown in Figure 13. Connect the ohmmeter to each adjacent pair of terminals, making four checks in all. If any one check is infinite, replace the connector body. The connector body need not be checked for an undercharged condition.

To check the regulator, remove from the end frame and use an approved regulator tester, available from commercial test equipment manufacturers. Follow the manufacturer's recommended test procedure.

DIODE TRIO CHECK

The diode trio is identified in Figures 14 and 15. To check the diode trio, remove it from the end frame assembly

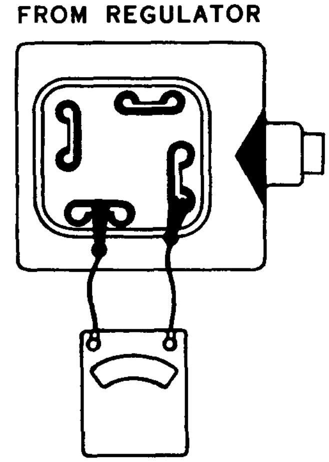


Figure 13—Checking connector body.

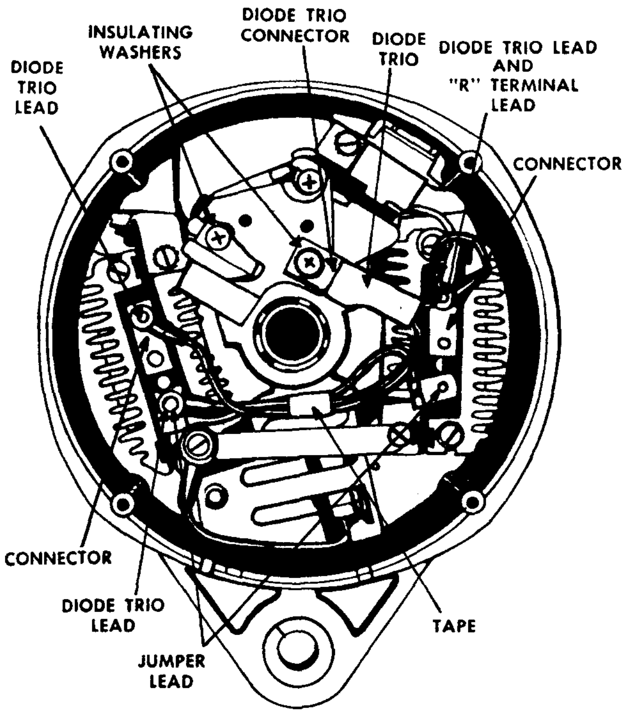


Figure 14—End frame view with stator removed. (Two-rectifier bridge type)

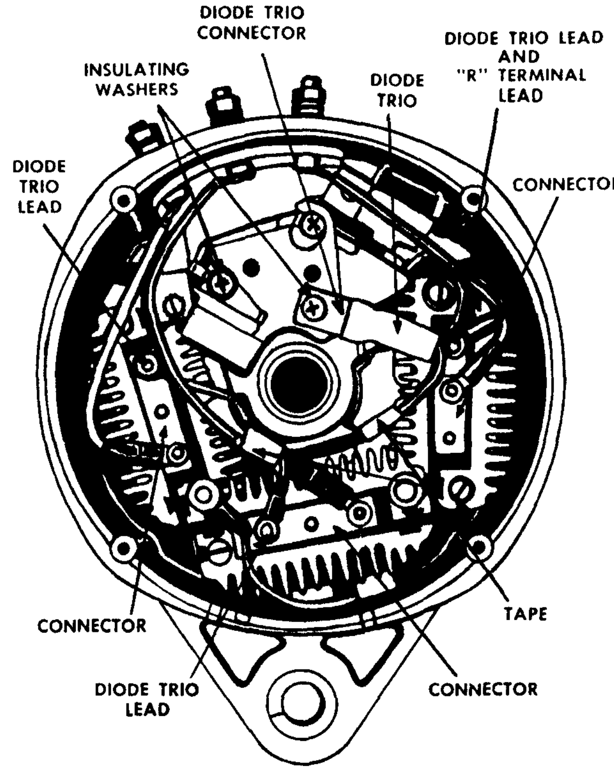


Figure 15—End frame view with stator removed. (Three-rectifier bridge type)

by detaching the nuts and attaching screw. **Note that the insulating washer on the screw is assembled over the top of the diode trio connector.** Connect an ohmmeter having a 1½ volt cell, and using the lowest range scale, to the single connector and to one of the three connectors (Fig. 16). Observe the reading. Then reverse the ohmmeter leads to the **same two** connectors. If both readings are the same, replace the diode trio. A good diode trio will give one high and one low reading. Repeat this same test between the single connector and each of the other two connectors. NOTE: Diode trios differing in appearance may be specified for use in the same Integral Charging System, and the two are completely interchangeable.

RECTIFIER BRIDGE CHECK

(Omit for overcharged battery)

Note that each rectifier bridge has a grounded heat sink and an insulated heat sink. The insulated heat sinks are connected together, and electrically are connected to the output or "BAT" terminal.

To check the rectifier bridge, disconnect the regulator jumper lead on three-terminal regulator end frame, then connect the ohmmeter to a heat sink and one of the three terminals (Figs. 17 and 18). Then reverse the lead connections to the same heat sink and same terminal.

If both readings are the same, replace the rectifier bridge by detaching the necessary screws and nuts. A good rectifier bridge will give one high and one low reading. Repeat this same test between the same heat sink and the other two terminals, and between the other heat sink and each of the three terminals. This makes a total of six checks, with two readings taken for each check on each rectifier bridge. Check the other two rectifier bridges in the same manner. IMPORTANT: If rectifier bridge is constructed with flat metal clips at the three studs, press down very firmly onto flat metal clips, and not onto threaded stud (Fig. 18). Rectifier bridges differing in appearance and with or without metal clips at the three studs may be specified for use in the same Integral Charging System, and the different types are interchangeable.

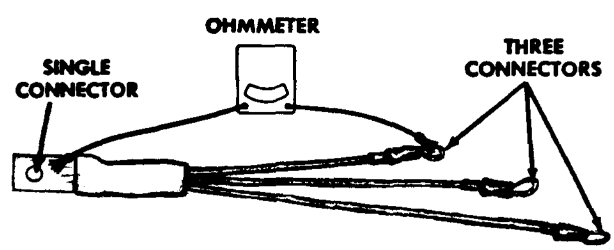


Figure 16—Checking diode trio.

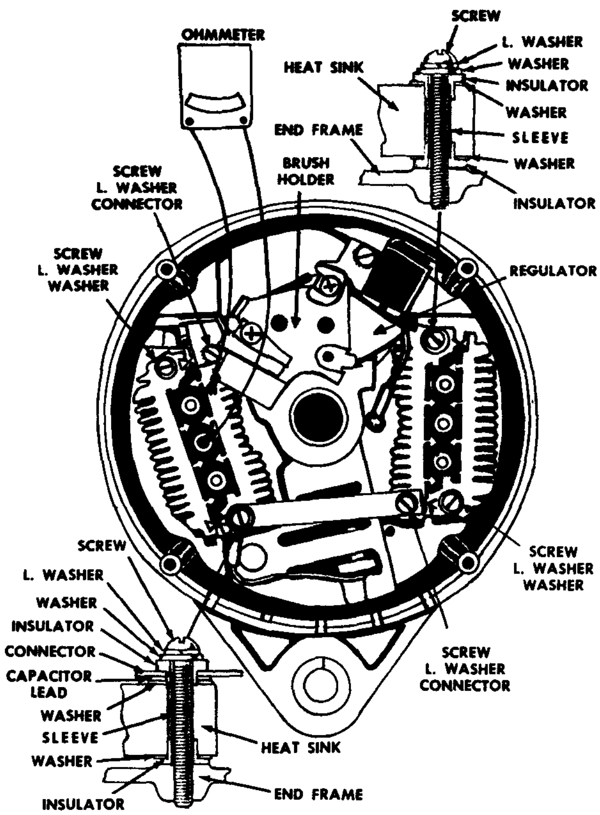


Figure 17—Parts stack-up and ohmmeter check. (Stator and diode trio removed)

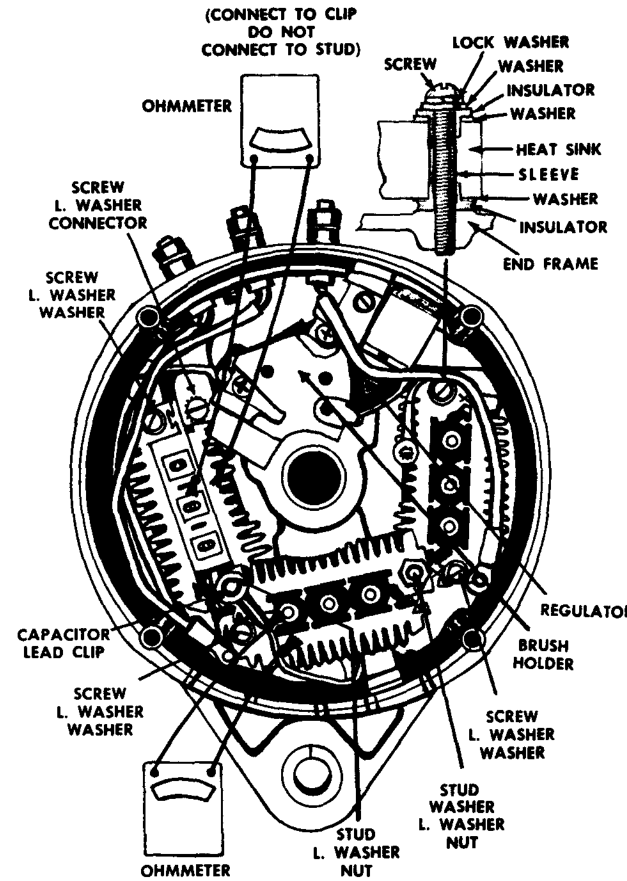


Figure 18—Parts stack-up and ohmmeter checks. (Stator and diode trio removed)

The ohmmeter check of the rectifier bridge, and of the diode trio as previously covered, is a valid and accurate check. **Do not** replace either unit unless at least one pair of readings is the same. CAUTION: Do not use high voltage to check these units such as a 110-volt test lamp.

ROTOR FIELD WINDING CHECKS

To check for opens, connect the test lamp or ohmmeter to each slip ring. If the lamp fails to light, or if the ohmmeter reading is high (infinite), the winding is open (Fig. 19).

The winding is checked for short circuits or excessive resistance by connecting a battery and ammeter in series with the edges of the two slip rings. Note the ammeter reading and refer to Delco-Remy Service Bulletin 1G-187 for specifications. An ammeter reading above the specified value indicates shorted windings; a reading below the specified value indicates excessive resistance. If the winding is shorted, **replace the rotor.**

An alternate method is to check the resistance of the field by connecting an ohmmeter to the two slip rings (Fig. 19). If the resistance reading is below the specified value, the winding is shorted; if above the specified value the winding has excessive resistance. The specified resistance value can be determined by dividing the voltage by the current given in Bulletin 1G-187. Remember that the winding resistance and ammeter reading will vary slightly with winding temperature changes.

STATOR CHECKS

(Omit for overcharged battery)

The stator windings may be checked for grounds with a 110-volt test lamp or an ohmmeter. If the lamp lights, or if the meter reading is low when connected from any stator lead to a clean metal part of the frame, the windings are grounded (Fig. 20). The delta windings cannot be checked for opens or for short circuits without laboratory test equipment. However, if all other electrical checks are normal and the generator fails to supply rated output, but will supply at least 10 amperes output, shorted stator windings are indicated.

BRUSH HOLDER AND REGULATOR REPLACEMENT

After removing the stator and diode trio, the brush holder and regulator may be replaced by removing the two remaining screws. Note the two insulators located over the top of the brush clips and that these two screws have special insulating sleeves over the screw body above the threads. The third mounting screw may or may not have an insulating sleeve. If not, this screw must not be interchanged with either one of the other two screws, as a ground may result, causing no output or uncontrolled output.

SLIP RING SERVICING

If the slip rings are dirty, they may be cleaned and finished with 400 grain or finer polishing cloth. Spin the rotor, and hold the polishing cloth against the slip rings until they are clean. CAUTION: The rotor must be rotated in order that the slip rings will be cleaned evenly. Cleaning the slip rings by hand without spinning the rotor may result in flat spots on the slip rings, causing brush noise.

Slip rings which are rough or out of round should be trued in a lathe to .002 inch maximum indicator reading. Remove only enough material to make the rings smooth and round. Finish with 400 grain or finer polishing cloth and blow away all dust.

BEARING REPLACEMENT AND LUBRICATION

The drive end frame bearing is sealed on both sides, and cannot be lubricated. To replace the bearing, press the rotor from the end frame, remove the retainer plate, and press the bearing from the end frame. Use a tube or collar that just fits over the outer race to press the new bearing into the end frame.

Figure 21 Only

The bearing in the slip ring end frame should be replaced if its grease supply is exhausted. No attempt should be made to relubricate and reuse the bearing. To remove the bearing from the slip ring end frame, press out with a tube or collar that just fits inside the end frame housing. Press from the outside of the housing towards the inside.

To install a new bearing, use the tube or collar to press the bearing in from the outside of the housing towards the inside to the dimension shown in Figure 21. Fill the plug with Delco-Remy No. 1948791 lubricant so that when pressed in flush with the end frame the grease reservoir will be half filled. Insure that some of the lubricant will be contacting the bearing when the plug is assembled. Use a new seal, and press in to the dimension shown in Figure 21. Coat the seal lip with the lubricant to facilitate assembly of the rotor shaft into the bearing. Note that the lip of the seal is toward the bearing.

Figure 22 Only

The type bearing shown in Figure 22 is a complete assembly, and the bearing, seal and grease reservoir cannot be separated.

To replace the bearing assembly, push out from either end. Push the new bearing in as directed in Figure 22. The bearing need not be relubricated.

REASSEMBLY

Reassembly is the reverse of disassembly.

To install the slip ring frame assembly to the rotor and drive end frame assembly, remove the tape over the bearing and shaft, and make sure the shaft is perfectly clean after removing the tape. Insert a pin through the holes to hold up the brushes. Carefully install the shaft into the slip ring end frame assembly to avoid damage to the seal. After tightening the thru-bolts remove

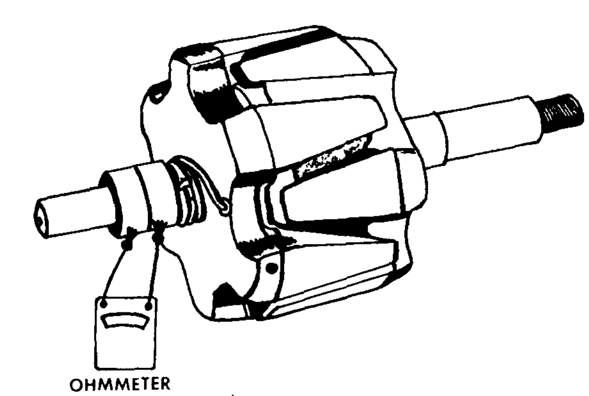


Figure 19—Checking rotor.

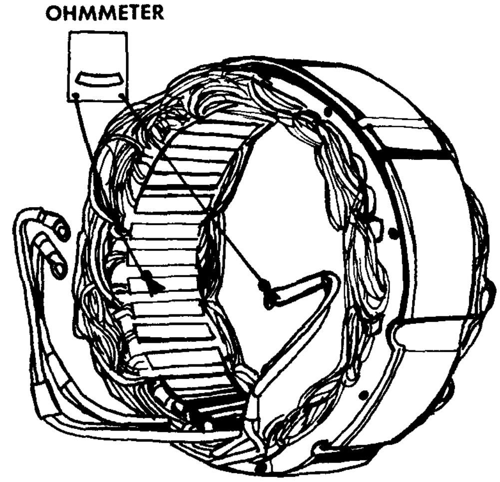


Figure 20—Checking stator.

the brush retaining pin to allow the brushes to fall down onto the slip rings.

Assemble the slinger, fan, pulley, washer and nut. Hold the shaft with a hex wrench inserted into the hex hole in the shaft end, then tighten the nut to 70-80 lb. ft.

MAGNETIZING THE ROTOR

IMPORTANT: The rotor normally retains magnetism to provide voltage build-up when the engine is started. After disassembly or servicing, however, it may be necessary to reestablish the magnetism. To magnetize the rotor connect the Integral Charging System to the battery in a normal manner, then momentarily connect a jumper lead from the **battery positive post to the Integral Charging System relay terminal,** identified in Figure 1. This procedure will restore the normal residual magnetism in the rotor.

INTEGRAL CHARGING SYSTEM BENCH CHECK

The Integral Charging System may be checked on the bench for output by connecting an ammeter in the circuit (Fig. 7) and a voltmeter from the "BAT" terminal to ground, then following the procedure in the "TROUBLESHOOTING PROCEDURES" section.

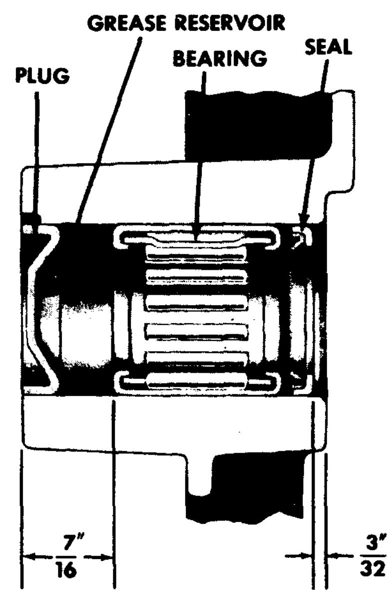


Figure 21—Slip ring end bearings and seal locations.

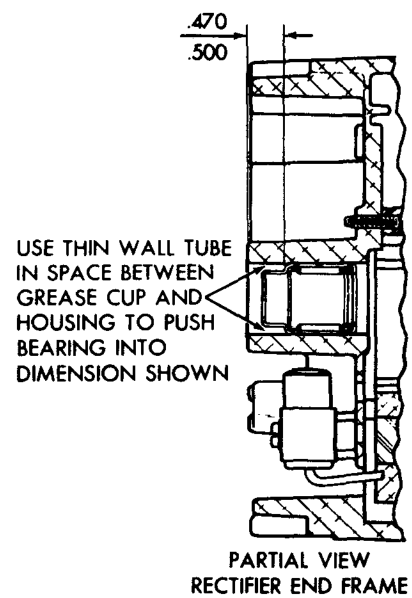


Figure 22—Slip ring end bearing location.

IMPORTANT: Read the introductory paragraphs on page 4 before proceeding with either one of these sections.

UNDERCHARGED BATTERY

This condition, as evidenced by slow cranking and low specific gravity readings, can be caused by one or more of the following conditions:

1. Insure that the undercharged condition has not been caused by accessories having been left on for extended periods.
2. Check the drive belt for proper tension.
3. If a battery defect is suspected, check per Delco-Remy Service Bulletin 1B-115 or 1B-116, respectively.
4. Inspect the wiring for defects. Check all connections for tightness and cleanliness, including the cable clamps and battery posts.
5. Connect a voltmeter from "BAT" terminal to ground. A zero reading indicates an open between voltmeter connection and battery.
6. If previous Steps 1 through 5 check satisfactorily, check Integral Charging System as follows:
   a. Disconnect battery ground cable.
   b. Connect an ammeter in the circuit at the "BAT" terminal of the Integral Charging System.
   c. Reconnect battery ground cable.
   d. Turn on accessories. Connect a carbon pile across the battery.
   e. Operate engine at moderate speed as required, usually 4000 generator r.p.m. or more, and adjust carbon pile as required, to obtain maximum current output.
   IMPORTANT: Initial voltage build-up is by residual magnetism in the rotor. Increase the speed as required to obtain maximum current output.

If ampere output is within 10 percent of rated output as stamped on frame, Integral Charging System is not defective. In this case, an adjustment of the voltage setting may correct the undercharged condition. Raise the setting by removing the voltage adjusting cap, rotating in increments of 90°, and then re-inserting the cap in the connector body as illustrated in Figure 8.

If ampere output is not within 10 percent of rated output as stamped on Integral Charging System frame, remove the Integral Charging System for repair as covered in section entitled "INTEGRAL CHARGING SYSTEM REPAIR."

OVERCHARGED BATTERY

1. Check the battery per Delco-Remy Service Bulletin 1B-115 or 1B-116. IMPORTANT—Remember that an overheated battery will be overcharged even though no charging circuit defects are present.
2. If an obvious overcharge condition exists as evidenced by excessive water usage, and if the battery is not overheated and not defective, remove the Integral Charging System for repair as covered under heading of "INTEGRAL CHARGING SYSTEM REPAIR."

Delco Remy
DELCOTRON® INTEGRAL CHARGING SYSTEM
(27-SI Series, 200 Type)
(with Three-Terminal Regulator)

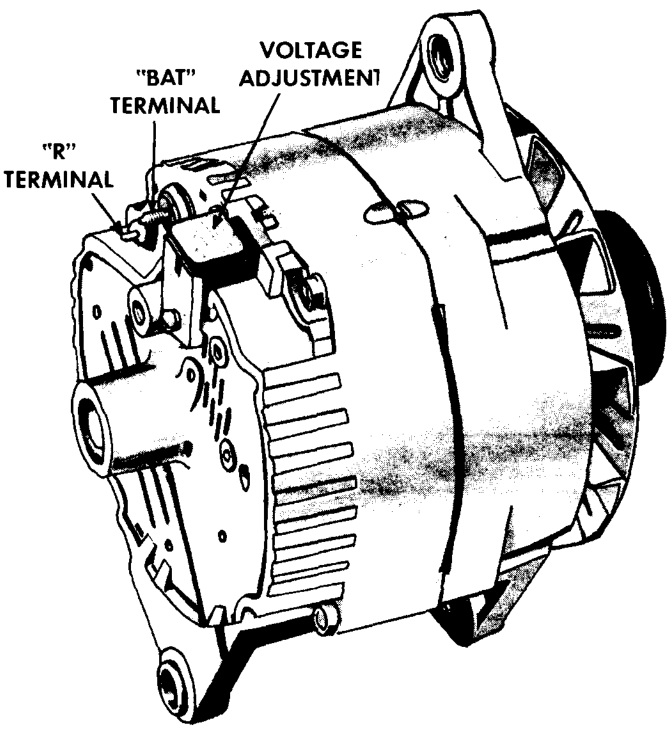


Figure 1—Typical 27-SI Series Integral Charging System.

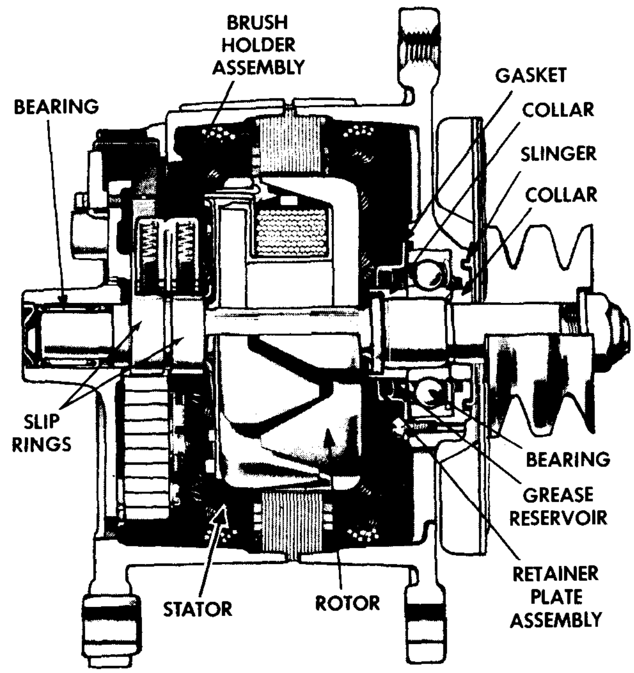


Figure 2—Cross-sectional view of typical Integral Charging System.

THIS BULLETIN IS DIVIDED INTO FOUR SECTIONS:

INTRODUCTION

The Integral Charging System illustrated in Figure 1 features a solid state regulator that is mounted inside the slip ring end frame. The regulator voltage setting can be adjusted externally by repositioning a voltage adjustment cap in the slip ring end frame. This feature is covered in detail in Figure 5. Only one wire is needed to connect the Integral Charging System to the battery, along with an adequate ground return. An "R" terminal is provided to operate auxiliary equipment in some circuits.

The bearings contain a supply of lubricant sufficiently adequate to eliminate the need for periodic lubrication. Two brushes carry current through the two slip rings to the field coil mounted on the rotor, and under normal conditions will provide long periods of attention-free service.

The stator windings are assembled on the inside of a laminated core that forms part of the frame. A rectifier bridge connected to the stator windings contains six diodes, and electrically changes the stator a.c. voltages to a d.c. voltage which appears at the output terminal. Field current is supplied through a diode trio which also is connected to the stator windings. A capacitor, or condenser, mounted in the end frame protects the rectifier bridge and diode trio from high voltages, and suppresses radio noise.

OPERATING PRINCIPLES

A typical wiring diagram is shown in Figure 3. The basic operating principles are explained as follows:

The base-emitter of transistors TR3 and TR1 is connected to the battery through resistor R5, thus turning these transistors on. Also, resistors R2 and R3 are connected to the battery through the voltage adjustment, but the discharge current of the battery is very low because of the resistance values of R2, R3, R5, TR1 and TR3.

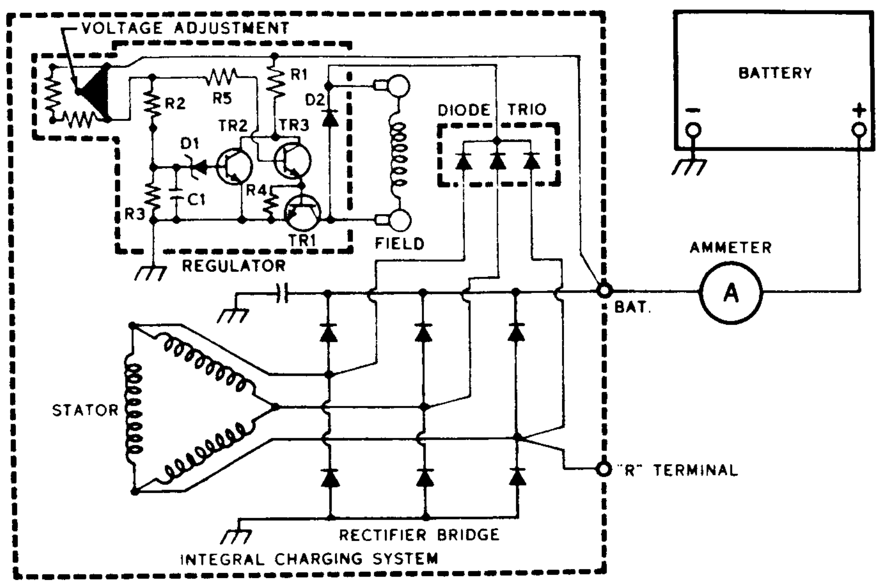
With the generator operating, a.c. voltages initially are generated in the stator windings by residual magnetism in the rotor. The diodes in the rectifier bridge change the stator a.c. voltages to a d.c. voltage which appears between ground and the "BAT" terminal. As speed increases, current is provided for charging the battery and operating electrical accessories.

The stator also supplies d.c. field current through the diode trio, the field, TR1, and then through the diodes in the rectifier bridge back to the stator.

As the speed and voltage increase the voltage between R2 and R3 increases to the value where zener diode D1 conducts. Transistor TR2 then turns on and TR1 and TR3 turn off. With TR1 off, the field current and system voltage decrease and D1 then blocks current flow causing TR1 and TR3 to turn back on. The field current and system voltage increase and this cycle then repeats many times per second to limit the voltage to the adjusted value.

If the voltage adjustment cube should become open-circuit TR3 and TR1 will turn off, thus preventing high system voltage.

Capacitor C1 smooths out the voltage across R3, resistor R4 prevents excessive current through TR1 at high temperatures, and diode D2 prevents high-induced-voltages in the field windings when TR1 turns off.



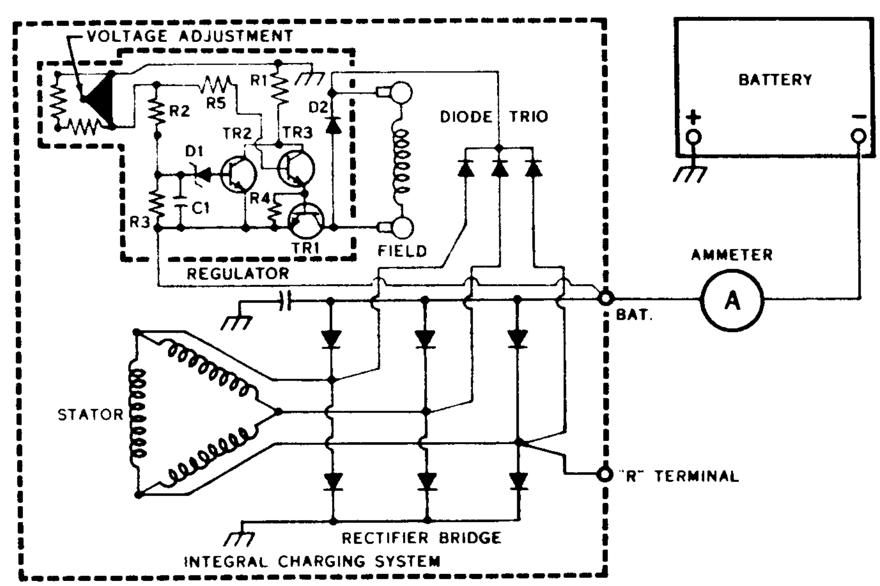


Figure 3—Typical 27-S1 wiring diagrams showing internal circuits. (Negative ground shown above, positive ground shown below.)

TROUBLESHOOTING PROCEDURES

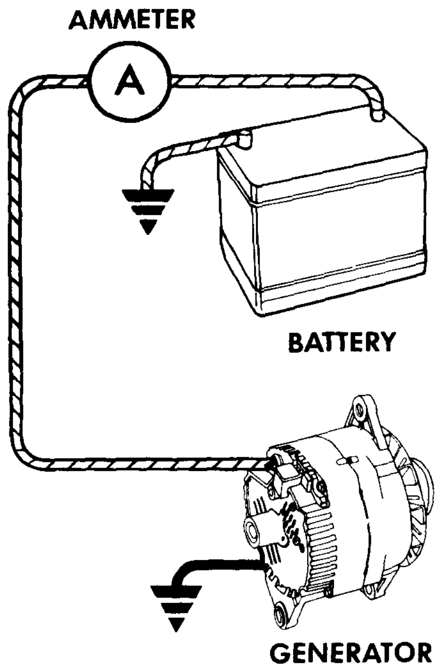


Figure 4—Typical wiring diagram showing basic lead connections.

A basic wiring diagram is shown in Figure 4. The charging system may be checked as follows:

1. Insure that an undercharged condition has not been caused by accessories having been left on for extended periods.
2. Check the drive belt for proper tension.
3. If battery defect is suspected, check per the applicable Delco Remy Service Bulletin.
4. Inspect the wiring for defects. Check all connections for tightness and cleanliness.
5. Connect a voltmeter from "BAT" terminal on generator to ground. A zero reading indicates an open between voltmeter connection and battery.
6. With all accessories turned off connect a voltmeter across the battery. Operate engine at moderate speed. If voltage is 15.5 or more on a 12 volt system, or 31 volts or more on a 24 volt system, remove generator for repair.
7. If previous Steps 1 thru 6 check satisfactorily, check generator as follows:
   a. Disconnect battery ground cable.
   b. Connect an ammeter in the circuit at the "BAT" terminal of the generator.
   c. Reconnect battery ground cable.
   d. Turn on accessories. Connect a carbon pile across the battery.
   e. Operate engine at moderate speed as required, usually 4000 generator r.p.m. or more, and adjust carbon pile as required to obtain maximum current output. **IMPORTANT: Initial voltage build-up is by residual magnetism in the rotor. Increase the speed as required to obtain maximum current output.**
   f. If ampere output is within 10 amperes of rated output as stamped on generator frame, generator is not defective. In this case, an adjustment of the voltage setting may correct the condition. Raise or lower the setting by removing the voltage adjusting cap, rotating in increments of 90°, and then reinserting the cap in the connector body.
   g. As illustrated in Figure 5, the cap is set for medium high voltage. With position 2 aligned with the arrow, the setting is medium low, position "LO" is low and position "HI" is the highest regulator setting.
   h. If ampere output is not within 10 amperes of rated output as stamped on generator frame:

      Negative ground only—Insert screwdriver into end frame hole to ground tab to end frame (Fig. 6). CAUTION: Tab is within ¾ inch of casting surface. Do not force screwdriver deeper than one inch into end frame. Proceed to Step i.

      Positive ground only—Insert small screwdriver into end frame hole to touch tab. Connect voltmeter to metal screwdriver and Integral Charging System "BAT" terminal. If reading is battery voltage, replace rotor and regulator, as both are defective. If reading is not battery voltage, disconnect voltmeter and connect a jumper lead from metal screwdriver to Integral Charging System "BAT" terminal. Proceed to Step i.
   i. Operate engine at moderate speed as required, and adjust carbon pile as required to obtain maximum current output.
   j. If output is within 10 amperes of rated output, replace regulator as covered in "Integral Charging System Repair" section, and check field winding.
   k. If output is not within 10 amperes of rated output, check the field winding, diode trio, rectifier bridge, and stator as covered in "Integral Charging System Repair" section.
   l. Remove ammeter from generator and turn accessories off.

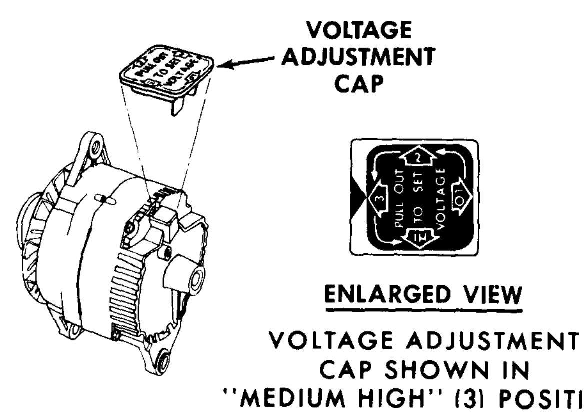


Figure 5—Voltage adjustment cap.

INTEGRAL CHARGING SYSTEM REPAIR

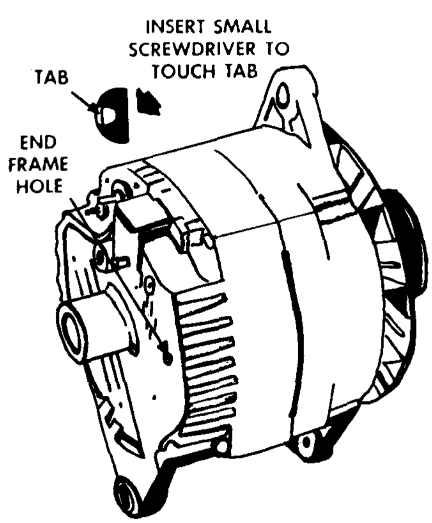


Figure 6—Testing generator. **(Wiring connections not shown.)**

To repair the Integral Charging System, observe the following procedure.

DISASSEMBLY

1. Remove four thru-bolts from drive end frame.
2. Separate slip ring end frame and stator assembly from drive end frame and rotor assembly.
3. Separate stator from end frame by removing three stator lead attaching nuts.
4. Place tape over bearing and shaft to protect from dirt. Use pressure sensitive tape and not friction tape that would leave a gummy deposit.
5. Inspect all leads for burned connections or opens, and brushes for excessive wear. Inspect springs for distortion or discoloration. Replace as required. Clean brushes with a soft dry cloth if they are to be reused. During servicing and reassembly hold brushes and springs in holder with a pin or toothpick inserted through end frame hole.

INSULATED SCREW CHECKS

Carefully inspect the regulator and brush holder mounting screws as shown in Figures 7 and 8. Note that on negative ground Integral Charging Systems two insulated and one grounded screw are used. On positive ground Integral Charging Systems, all three mounting screws are insulated. Damaged or missing insulators can cause damage to electrical components and improper charge to the battery.

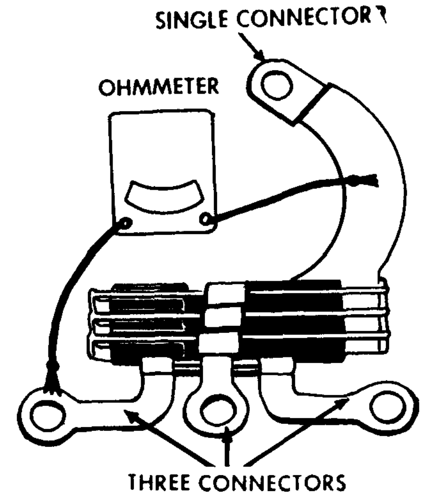


Figure 9—Diode trio check.

DIODE TRIO CHECK

The diode trio is identified in Figures 7 and 8. To check the diode trio, remove it from the end frame assembly by detaching the nuts and attaching screw. Connect an ohmmeter having a 1½-volt cell, and using the low range scale to the single connector and to one of the three connectors (Fig. 9). Observe the reading. Then reverse the

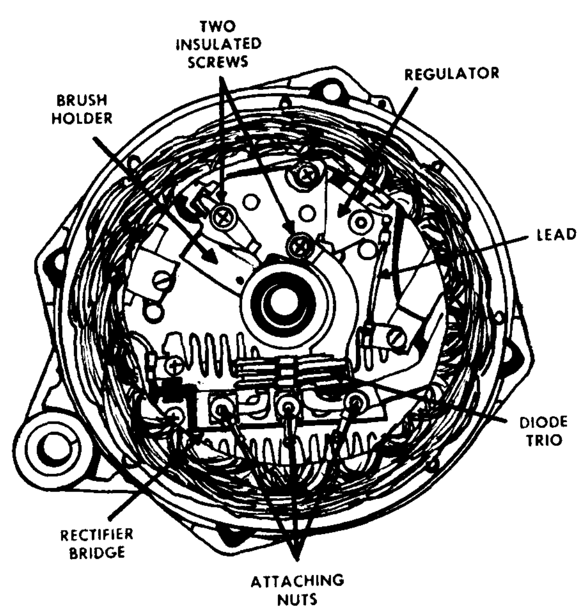


Figure 7—Inside view end frame assembly. Negative ground.

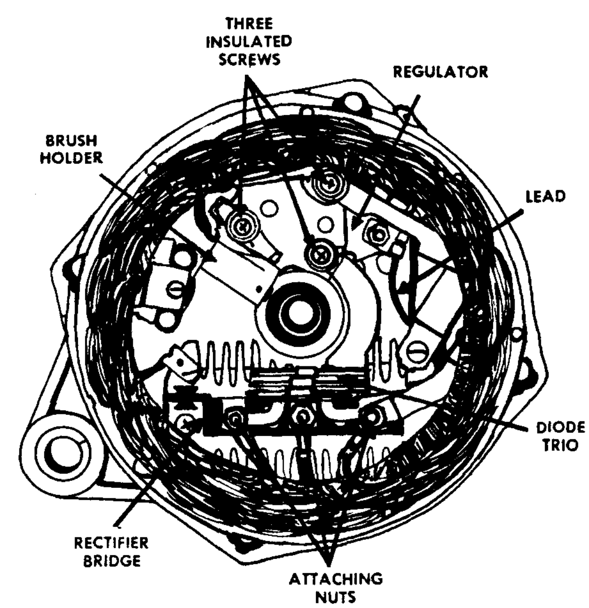


Figure 8—Inside view end frame assembly. Positive ground.

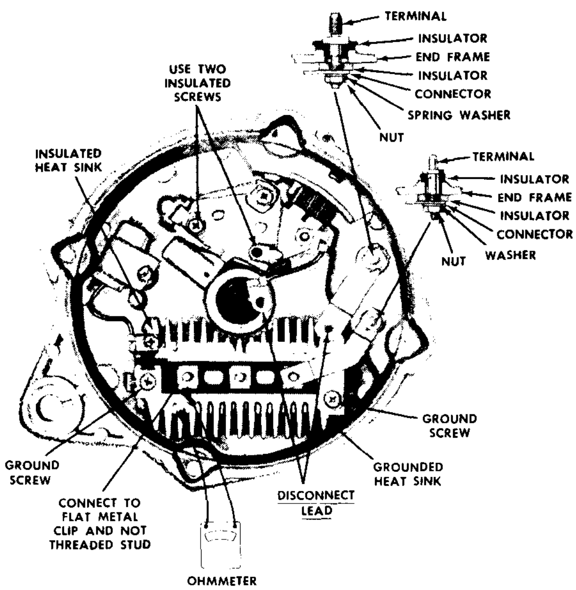


Figure 10—Rectifier bridge check. Negative ground.

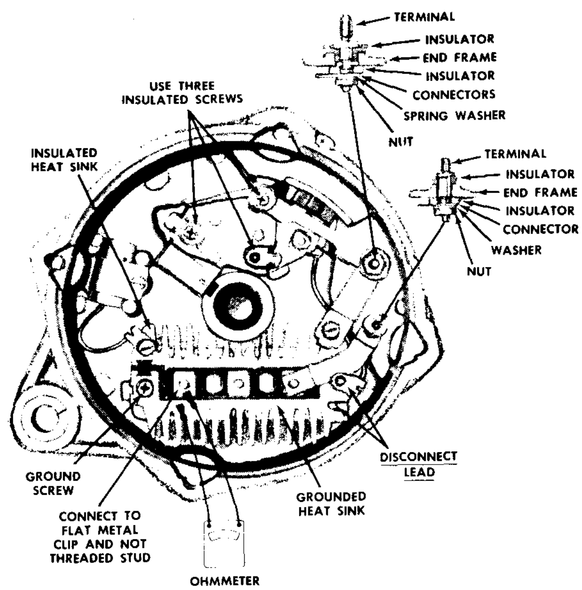


Figure 11—Rectifier bridge check. Positive ground.

ohmmeter leads to the same two connectors. If both readings are the same, replace the diode trio. A good diode trio will give one high and one low reading. Repeat this same test between the single connector and each of the other two connectors. NOTE: Diode trios differing in appearance may be specified for use in the same Integral Charging System, and the two are completely interchangeable.

RECTIFIER BRIDGE CHECK

Note that the rectifier bridge has a grounded heat sink and an insulated heat sink (Figs. 10 and 11).

To check the rectifier bridge, connect the ohmmeter to a heat sink and one of the flat metal clips and not to threaded stud. Press down firmly onto flat metal clip. Then reverse lead connections. If both readings are the same, replace the rectifier bridge.

Repeat this same test between the same heat sink and other two metal clips and between the other heat sink and the three metal clips.

CAUTION: Do not use high voltage such as a 110 volt test lamp to check the rectifier bridge.

ROTOR FIELD WINDING CHECKS

To check for opens, connect the test lamp or ohmmeter to each slip ring. If the lamp fails to light, or if the ohmmeter reading is high (infinite), the winding is open (Fig. 12).

The winding is checked for short circuits or excessive resistance by connecting a battery and ammeter in series with the edges of the two slip rings. Note the ammeter reading and refer to Delco Remy Service Bulletin 1G-187 or 1G-188 for specifications. An ammeter reading above the specified value indicates shorted windings; a reading below the specified value indicates excessive resistance.

An alternate method is to check the resistance of the field by connecting an ohmmeter using low scale to the two slip rings (Fig. 12). If the resistance reading is below the specified value, the winding is shorted; if above the specified value the winding has excessive resistance. The specified resistance value can be determined by dividing the voltage by the current given in Bulletin 1G-187, or 1G-188. Remember that the winding resistance and ammeter reading will vary slightly with winding temperature changes.

To check for grounds, connect ohmmeter as shown. Replace rotor if reading is less than infinite. Use low scale on ohmmeter.

STATOR CHECKS

The stator windings may be checked for grounds with a 110-volt test lamp or an ohmmeter. If the lamp lights, or if the meter reading is low when connected from any stator lead to a clean metal part of the frame, the windings are grounded (Fig. 13). The delta windings cannot be checked for opens or for short circuits without laboratory test equipment. However, if all other electrical checks are normal and the generator fails to supply rated output, shorted stator windings are indicated. Check the regulator in next section before replacing stator.

CONNECTOR BODY CHECK

If none of the previous checks show any defects, remove the connector

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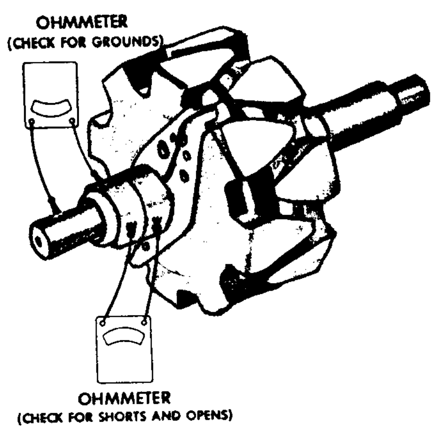

Figure 12—Checking rotor winding.

body from the regulator and check with an ohmmeter using the middle range scale as shown in Figure 14. Connect the ohmmeter to each adjacent pair of terminals, making four checks in all. If any one check is infinite, replace the connector body.

BRUSH HOLDER AND REGULATOR REPLACEMENT

To determine if the regulator is defective, an approved regulator tester must be used.

After removing the stator and diode trio, the brush holder and regulator may be replaced by removing the two remaining screws. Note the insulated screws in Figures 7 and 8.

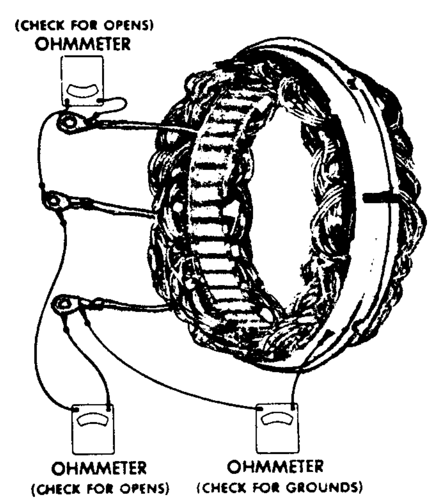

Figure 13—Checking stator windings.

SLIP RING SERVICING

If the slip rings are dirty, they may be cleaned and finished with 400 grain or finer polishing cloth. Spin the rotor, and hold the polishing cloth against the slip rings until they are clean. CAUTION: The rotor must be rotated in order that the slip rings will be cleaned evenly.

Cleaning the slip rings by hand without spinning the rotor may result in flat spots on the slip rings, causing brush noise.

Slip rings which are rough or out of round should be trued in a lathe to .002 inch maximum indicator reading. Remove only enough material to make the rings smooth and round. Finish with 400 grain or finer polishing cloth and blow away all dust.

BEARING REPLACEMENT AND LUBRICATION (FIG. 2)

To replace the drive end bearing:

1. Remove shaft nut, pulley, fan and slinger.
2. Press rotor from end frame.
3. Remove retainer plate screws, retainer plate assembly, gasket and collar.
4. Press bearing from end frame.
5. Remove retainer plate and felt washer.
6. Install retainer plate and new felt washer.
7. Press bearing in with sealed side away from grease reservoir.
8. Fill grease cavity one-half full with Delco Remy lubricant Part No. 1948791 and arrange the lubricant so a portion will touch the bearings after retainer plate attachment.
9. Attach gasket and retainer plate assembly to end frame, using new retainer plate assembly.
10. With collar on shaft, press rotor into end frame.
11. Assemble collar, slinger, fan, pulley and nut. Torque nut to 70-80 lb. ft.

The bearing in the slip ring end frame should be replaced if its grease supply is exhausted. No attempt should be made to relubricate and reuse the bearing. To remove the bearing from the slip ring end frame, press out with a tube or collar that just fits inside the end frame housing. Press from the outside of the housing towards the inside.

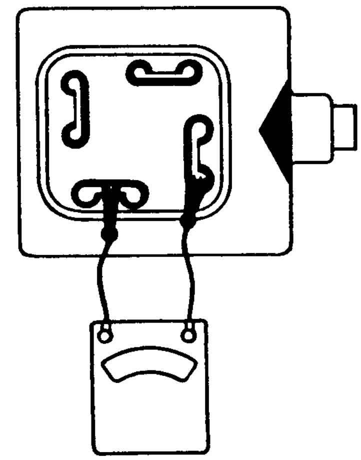

Figure 14—Checking connector body.

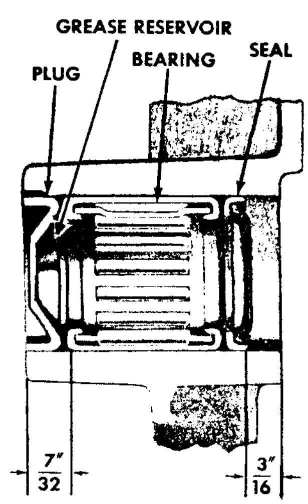

Figure 15—Slip ring end bearing and seal locations.

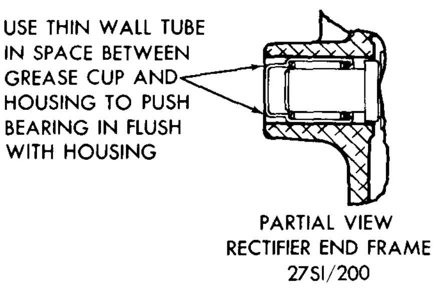

Figure 16—Slip ring end frame bearing assembly, pre-lubricated.

To install a new bearing, use the tube or collar to press the bearing in from the outside of the housing towards the inside to the dimension shown in Figure 15.

Fill the plug with No. 1948791 lubricant so that when pressed in flush with the end frame the grease reservoir will be half filled. Insure that some of the lubricant will be contacting the bearing when the plug is assembled. Use a new seal, and press in to the dimension shown in Figure 15. Coat the seal lip with the lubricant to facilitate assembly of the rotor shaft into the bearing.

FIGURE 16 ONLY: The bearing is prelubricated and should be installed as shown in Figure 16.

REASSEMBLY

Reassembly is the reverse of disassembly.

To install the slip ring end frame assembly to the rotor and drive end frame assembly, remove the tape over the bearing and shaft, and make sure the shaft is perfectly clean after removing the tape. Insert a pin through the holes to hold up the brushes. Carefully install the shaft into the slip ring end frame assembly to avoid damage to the seal. After tightening the thru-bolts remove the brush retaining pin to allow the brushes to fall down onto the slip rings.

MAGNETIZING THE ROTOR

IMPORTANT: The rotor normally retains magnetism to provide voltage build-up when the engine is started. After disassembly or servicing, however, it may be necessary to reestablish the magnetism. To magnetize the rotor connect the Integral Charging System to the battery or Energizer in a normal manner, then momentarily connect a jumper lead from the **battery or Energizer positive post to the Integral Charging System relay terminal**, identified in Figure 1. This procedure will restore the normal residual magnetism in the rotor.

GENERATOR BENCH CHECK

To check the generator in a test stand, proceed as follows:

1. Make connections as shown in Figure 17 except leave the carbon pile disconnected. IMPORTANT —Ground polarity of battery and generator must be the same. The battery must be fully charged.
2. Slowly increase the generator speed and observe the voltage.
3. If the voltage is uncontrolled with speed and increases above 15.5 volts on a 12-volt system, or 31 volts on a 24-volt system, test regulator with an approved regulator tester, and check field winding NOTE: The battery **must** be fully charged when making this check.
4. If voltage is below 15.5 volts on a 12-volt system, or 31 volts on a 24-volt system, connect the carbon pile as shown.
5. Operate the generator at moderate speed as required and adjust the carbon pile as required to obtain maximum current output.
6. If output is within 10 amperes of rated output as stamped on generator frame, generator is good.
7. If output is not within 10 amperes of rated output, keep battery loaded with carbon pile, and:

   Negative ground only—Insert screwdriver into end frame hole to ground tab to end frame (Fig. 6). CAUTION: Tab is within ¾ inch of casting surface. Do not force screwdriver deeper than one inch into end frame. Proceed to Step 8.

   Positive ground only—Insert small screwdriver into end frame hole to touch tab. Connect voltmeter to metal screwdriver and Integral Charging System "BAT" terminal. If reading is battery voltage, replace rotor and regulator, as both are defective. If reading is not battery voltage, disconnect voltmeter and connect a jumper lead from metal screwdriver to Integral Charging System "BAT" terminal. Proceed to Step 8.

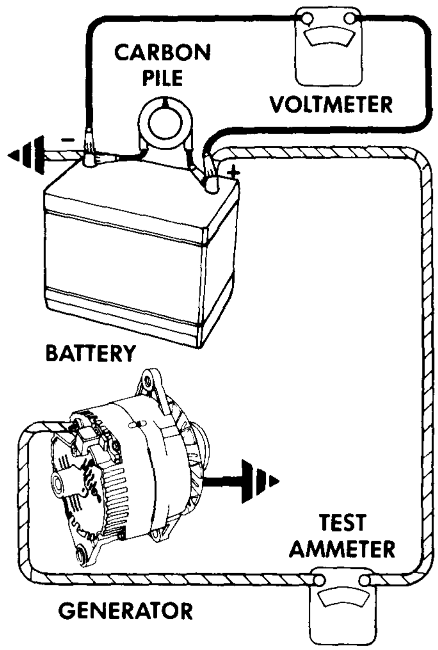

Figure 17—Connections for bench check of generator.

8. Operate engine at moderate speed as required, and adjust carbon pile as required to obtain maximum current output.
9. If output is within 10 amperes of rated output, replace regulator as covered in "Integral Charging System Repair" section, and check field winding.
10. If output is not within 10 amperes of rated output, check the field winding diode trio, rectifier bridge, and stator as covered in "Integral Charging System Repair" section.
11. Remove ammeter from generator and turn accessories off.

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Pages: 12

Delco-Remy

Tests of

DELCOTRON® INTEGRAL CHARGING SYSTEM

(25-SI Series, 400 and 450 Types)

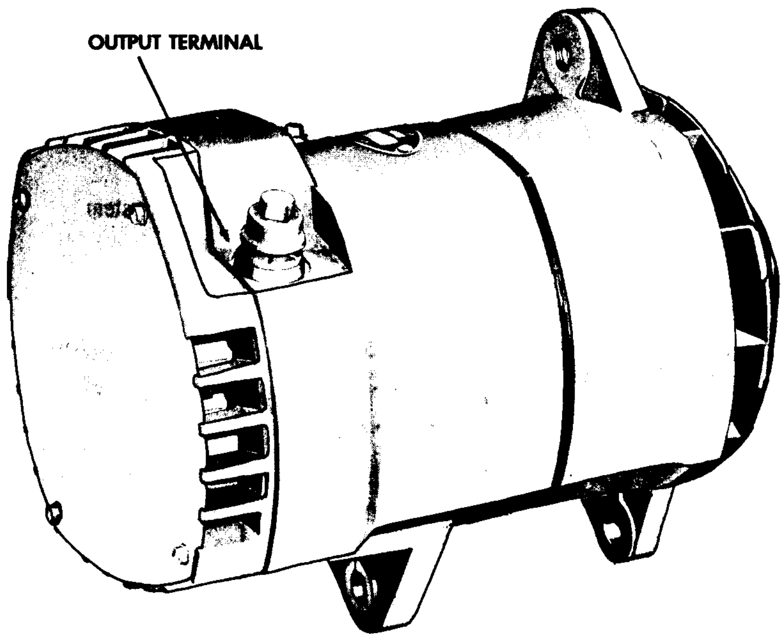

Figure 1—Typical integral charging system

INTRODUCTION

The Integral Charging System shown in Figure 1 and Figure 2 is a self-rectifying, brushless unit featuring a built-in voltage regulator. The only movable part in the assembly is the rotor, which is mounted on a ball bearing at the drive end, and a roller bearing at the rectifier end. All current-carrying conductors are stationary. These conductors are the field winding, the stator windings, the six rectifying diodes, and the regulator circuit components. The regulator and diodes are enclosed in a sealed compartment.

A fan located on the drive end provides airflow for cooling. Extra large grease reservoirs contain an adequate supply of lubricant so that no periodic maintenance of any kind is required.

Only one wire is needed to connect the Integral Charging System to the battery, along with an adequate ground return. The specially designed output terminal is connected directly to the battery. A red output terminal is used on negative ground models, and is to be connected only to battery positive. A black output terminal is used on positive ground models and is to be connected only to battery negative. An "R" terminal is provided for use in some circuits to operate auxiliary equipment.

The hex head bolt on the output terminal is electrically insulated; no voltage reading can be obtained by connecting to the hex head.

OPERATING PRINCIPLES

(Type shown in Figures 3 and 4.)

Typical wiring diagrams are shown in Figures 3 and 4. The basic operating principles are explained as follows.

As the rotor begins to turn, the permanent magnetism therein induces voltages in the stator windings. Current then flows through diodes D1, D2, and D3, resistors R1 and R3, and the generator diodes back to the stator winding. Transistors TR1 and TR2 then turn on, and the battery supplies current through resistor R5, the field coil, and TR1. Current also flows from the battery through R5, R2 and R4.

DELCOTRON INTEGRAL CHARGING SYSTEM

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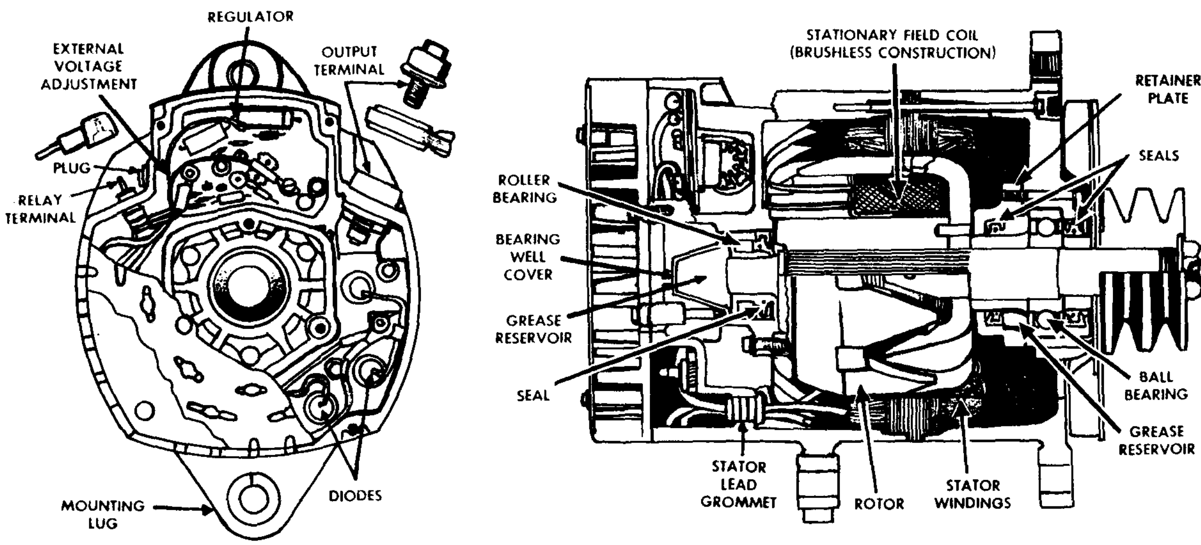

Figure 2—Cross sectional view typical integral charging system

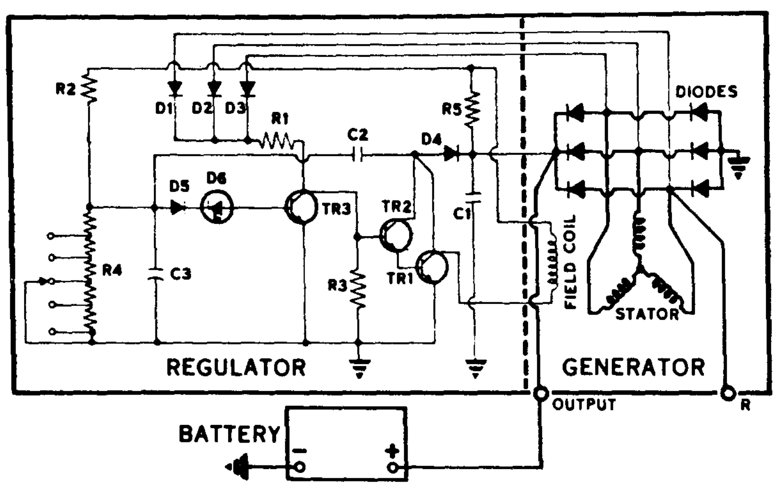

Figure 3—Negative ground circuit. Regulator shown in Figures 12 and 13.

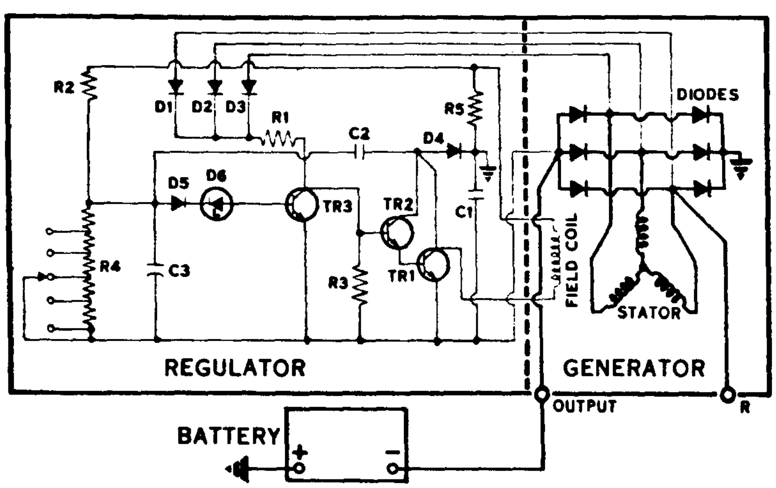

Figure 4—Positive ground circuit. Regulator shown in Figures 12 and 13

As system voltage increases, a voltage across R4 is impressed across diodes D5 and D6, caused by current flow through R5, R2 and R4. When the pre-set voltage is reached, diodes D5 and D6 conduct, TR3 turns on, TR1 and TR2 turn off, and the generator voltage decreases. Diodes D5, D6 and TR3 then turn off, TR1 and TR2 turn back on, and the cycle repeats many times per second to limit the generator voltage to the adjusted value.

Capacitor C1 protects the generator diodes from high transient voltages, and suppresses radio interference.

Capacitor C2 used on 24 volt systems only causes TR1 and TR2 to turn on and off quickly. Diode D4 prevents high field-coil-induced voltages when TR1 and TR2 turn off.

Capacitor C3 smooths out the voltage across R4. Resistor R5 raises the generator voltage slightly as generator output increases to maintain a more nearly constant voltage across the battery by compensating for line drop.

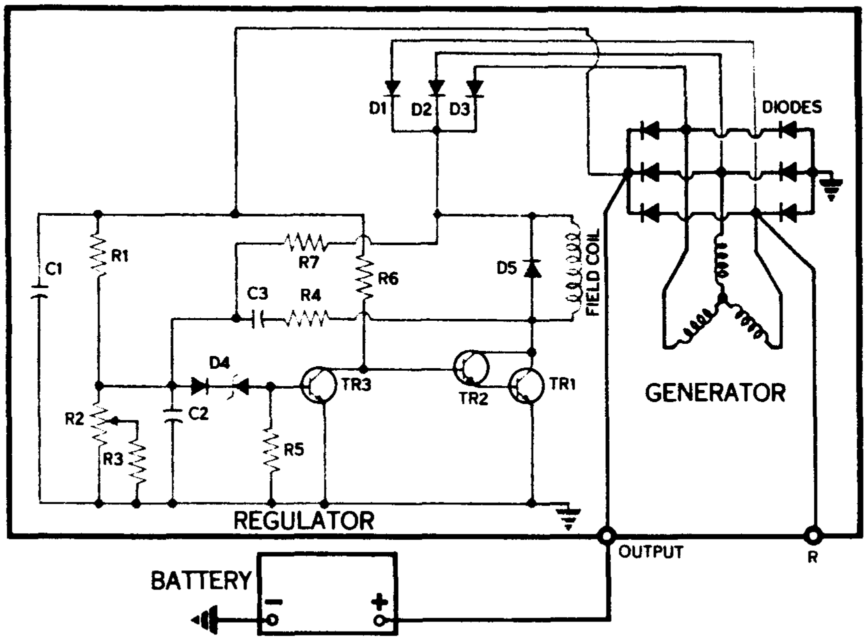

Figure 5—Negative ground circuit. Regulator shown in Figures 16 and 17

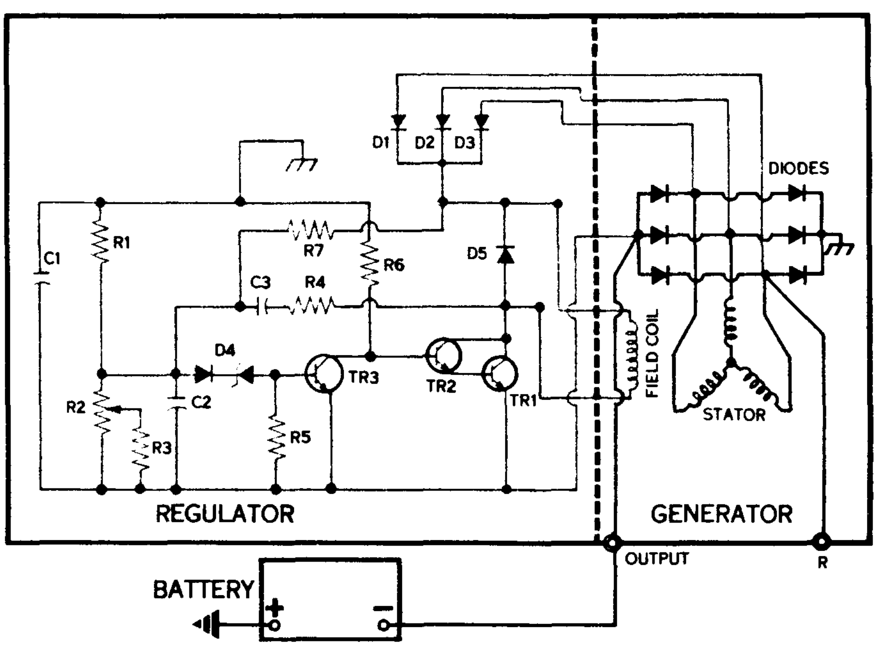

Figure 6—Positive ground circuit. Regulator shown in Figures 16 and 17.

OPERATING PRINCIPLES

(Type shown in Figures 5 and 6.)

The basic operating principles are explained as follows:

As the rotor begins to turn, the permanent magnetism therein induces voltages in the stator windings. The voltages across the six diodes cause current to flow to charge the battery.

Current from the stator flows through the three diodes to resistor R6 and the base-emitter of TR2 and TR1 to turn these transistors on. Current also flows from the stator through the diode trio D1, D2, and D3, the field coil and transistor TR1, returning to the stator through the other three diodes. All stator current, except through the diode trio D1, D2, and D3, flows through the six diodes connected to the stator.

Current flow through R1, R2, and R3 causes a voltage to appear at zener diode D4. When the voltage becomes high enough due to increasing generator speed, D4 and the base-emitter of TR3 conduct current and TR3 turns on. TR2 and TR1 then turn off, decreasing the field current and the system voltage decreases. The voltage at D4 decreases, D4 and TR3 turn off, TR2 and TR1 turn back on and the system voltage increases. This cycle then repeats many times per second to limit the system voltage as determined by the setting of the potentiometer R2, R3.

Capacitor C1 protects the generator diodes from high transient voltages and suppresses radio interference.

Resistor R5 prevents current leakage through TR3 at high temperatures.

Diode D5 prevents high transient voltages in the field coil when the field current is decreasing.

Resistor R7, capacitor C3 and resistor R4 all act to cause transistors TR2 and TR1 to turn on and off more quickly.

TROUBLESHOOTING PROCEDURES

ENERGIZING SPEED

The energizing speed is the rpm at which the regulator turns on to energize the field coil. This speed is higher than some speeds at which output can be obtained. Therefore, when checking output at low speeds, increase the speed until the regulator turns on, then reduce the speed to check the output. No output can be obtained until the regulator turns on. Once the regulator turns on, it will remain turned on until the engine is stopped.

RATED VOLTAGE

On 12, 24 and 32-volt systems, the Integral Charging System output preferably should be checked at the "RATED VOLTAGE" given in the table. However, it is permissible to check the output in amperes at any voltage within the "OPERATING RANGE" listed in the table, since the current output will be quite close to the value that would be obtained at "RATED VOLTAGE." The voltage should never be allowed to rise above the "OPERATING RANGE" for any length of time.

SYSTEM VOLTAGE	RATED VOLTAGE	OPERATING RANGE
12	14.0	13.0-15.0
24	28.0	26.0-30.0
32	37.5	33.0-39.0

It should be noted that the voltage may be below the "OPERATING RANGE" if the battery is in a low state of charge. However, as the battery receives a charge, the voltage will rise to some value within the "OPERATING RANGE."

MAGNETIZING THE ROTOR

The rotor normally retains magnetism to provide voltage build-up when the engine is started. After disassembly or servicing, however, it may be necessary to reestablish the magnetism. To magnetize the rotor connect the Integral Charging System to the battery in a normal manner, then momentarily connect a jumper lead from the **battery positive post to the Integral Charging System relay terminal,** identified in Figure 2. This procedure applies to both negative and positive ground systems, and will restore the normal residual magnetism in the rotor.

Trouble in the vehicle charging system will be indicated by one of two conditions:

- An undercharged battery as evidenced by low specific gravity readings and slow cranking.
- An overcharged battery as evidenced by excessive battery water usage.

These conditions can be caused by:

I. A defective battery
II. Poor circuit connections
III. Defective Integral Charging System

I. BATTERY

Since the battery may have an internal defect, it must be checked to determine its condition. Use the applicable Delco-Remy Service Bulletin.

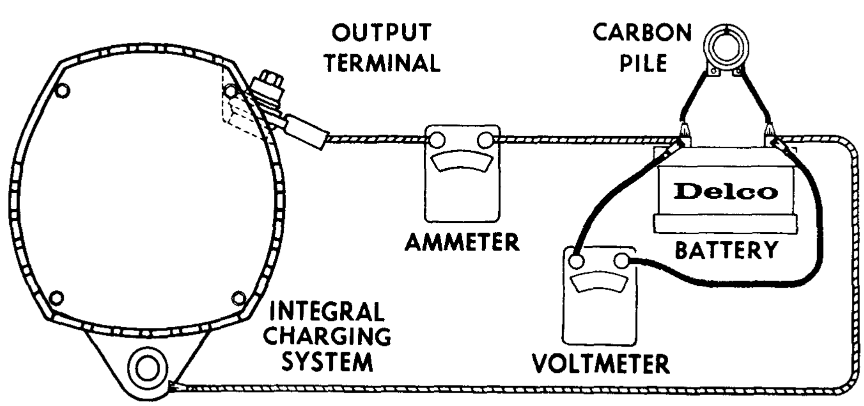

Figure 7—Output check **(Remember—the hex bolt on the output terminal is electrically insulated).**

II. CIRCUIT CONNECTIONS

Poor circuit connections in the 25 SI Integral Charging System can cause an undercharged condition only. Carefully inspect all connections including grounds between the Integral Charging System and battery for cleanliness and tightness. Insure that the battery cable clamps are clean and tight, and that the battery is dry and clean.

III. INTEGRAL CHARGING SYSTEM

If the battery and circuit connection checks are satisfactory, the Integral Charging System may be checked either on or off the vehicle by making connections as shown in Figure 7. Assemble a closed end terminal clip with ½ inch hole to output terminal, then connect ammeter lead clip to this terminal clip.

1. With all accessories and carbon pile turned off, increase engine speed as required to obtain maximum voltage reading.
2. If voltage exceeds 15 volts on a 12-volt system, 30 volts on a 24-volt system or 39 volts on a 32-volt system, remove Integral Charging System for repair as covered under heading of "INTEGRAL CHARGING SYSTEM REPAIR."
3. If voltage does not exceed these values, proceed as follows:
4. Insure that accessories have not been left on for extended periods.
5. Check the drive belt for proper tension.
6. Inspect the wiring for defects. Check all connections for tightness and cleanliness, including the cable clamps and battery posts.

   Connect a voltmeter from "OUTPUT" terminal on Integral Charging System to ground. A zero reading indicates an open between voltmeter connection and battery.

   If previous Steps check satisfactorily, check Integral Charging System as follows:

   a. Disconnect battery ground cable.
   b. Connect an ammeter in the circuit at the "OUTPUT" terminal of the Integral Charging System.
   c. Reconnect battery ground cable.
   d. Turn on accessories. Connect carbon pile across the battery.
   e. Operate engine at moderate speed as required, usually 4000 generator rpm or more, and adjust carbon pile as required, to obtain maximum current output.

      IMPORTANT: Initial voltage buildup is by residual magnetism in the rotor. Increase the speed as required to obtain maximum current output.
   f. If ampere output is not within 10 amperes of rated output as stamped on generator frame, remove generator for repair. If ampere output is within 10 amperes of rated output as stamped on generator frame, Integral Charging System is not defective. In this case, an adjustment of the voltage setting may correct the condition.

7. **Type Regulator Shown in Figures 3, 4 and 12.**

   a. Remove pipe plug from Integral Charging System (Figure 2).
   b. Turn adjusting screw one or two notches clockwise to raise the voltage setting and one or two notches counterclockwise to lower the voltage setting.
   c. Replace pipe plug.

   After adjusting setting, check for an improved battery condition over a service period of reasonable length. **If adjusting the setting does not correct the battery condition, remove the generator for repair.**

   Remember that if the battery state of charge is low, the regulator may not be limiting the voltage, and turning the adjusting screw will show no change on the voltmeter. However, turning the adjusting screw will change the voltage setting to a new value, which will be indicated by the voltmeter when the battery state of charge increases.

8. **Type Regulator Shown in Figures 5, 6 and 16.**

   Follow same procedure previously outlined, except adjust voltage by removing end cover to expose potentiometer as shown in Figure 8. Turn potentiometer clockwise to raise setting and counterclockwise to lower setting. Use voltmeter across battery to read setting.

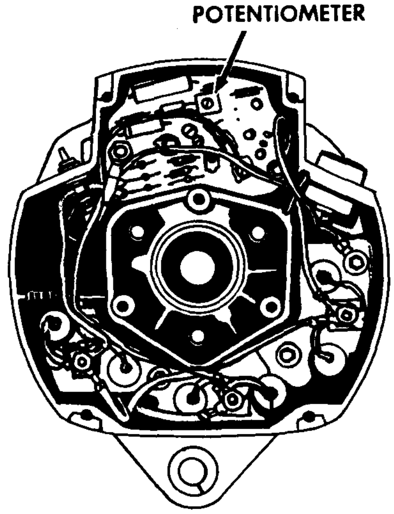

Figure 8—Adjusting voltage setting

INTEGRAL CHARGING SYSTEM DISASSEMBLY

After removing the cover plate, cover and gasket, typical rectifier end frame components are exposed to view as shown in Figure 9, Figure 10 and Figure 11. Note carefully the proper connections, then proceed as follows:

1. To check the stator and diodes, remove the three nuts, the three regulator leads, the three stator leads, the six diode leads, and the "R" terminal lead from the three studs. During reassembly place over each stud **in this order** the two diode leads, the stator lead, the "R" terminal lead on one stud only, the regulator lead, and the nut.
2. To check the field coil, disconnect the two field coil leads from the regulator.
3. Later on, it may be necessary to separate the drive end frame assembly from the rectifier end frame assembly by removing the shaft nut, washer, pulley, fan, slinger and the thru bolts from the drive end.

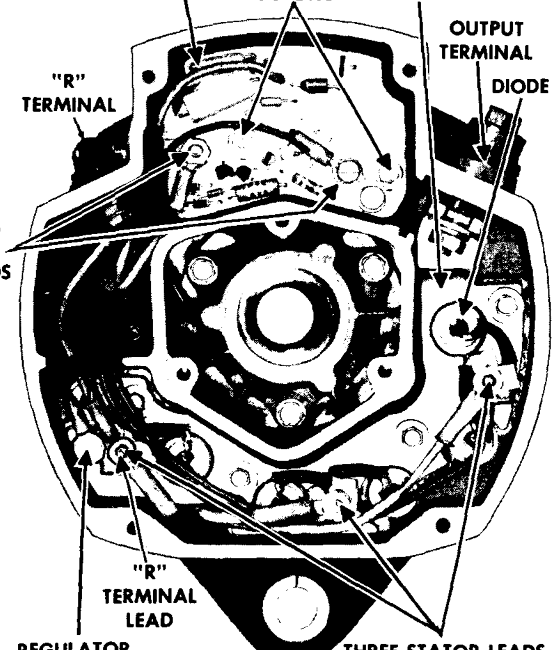

Figure 9—End view, cover removed, early type discrete-component 12-volt regulator

FIELD COIL CHECKS (Figure 11)

To check for grounds, connect a test lamp, or an ohmmeter to one field coil lead and to the end frame as illustrated. If the lamp lights, or if ohmmeter reading is low, the field coil is grounded.

To check for opens, connect a test lamp, or an ohmmeter to the two field coil leads as shown. If the lamp fails to light, or if ohmmeter reading is high (infinite), the field coil is open.

The winding is checked for short-circuits by connecting a battery and ammeter in series with the field coil. Note the ammeter reading and refer to Delco-Remy Service Bulletin 1G-187 or 1G-188 for specifications. An ammeter reading above the specified value indicates shorted windings. An alternate method is to check the resistance of the field by connecting an ohmmeter to the field coil. If the resistance reading is below the specified value, the winding is shorted. The specified resistance value can be determined by dividing the voltage by the current given in Bulletin 1G-187 or 1G-188.

To replace the field coil, separate drive end frame from rectifier end frame, remove field coil attaching screws and pull leads and grommet through end frame hole. Place grease on grommet and pull grommet into hole during assembly.

DIODE CHECKS (Figure 11)

Check each of the six diodes by removing each diode lead from the stud and connecting an ohmmeter using the lowest range scale to the diode lead and case. Then reverse the ohmmeter lead connections to the diode lead and case. If both readings are the same, replace the diode. A good diode will give one high and one low reading.

CAUTION: Do not use high voltage such as 110 volt test lamps, to check diodes.

Before replacing a diode in the rectifier end frame, the end frame must be separated from the drive end frame. Also, before replacing a diode in the heat sink or end frame, it is necessary to remove the heat sink from the end frame by detaching from the heat sink the regulator lead, the heat sink mounting screws, and the generator output terminal. Note the round insulators under the heat sink mounting screws, and the flat insulator located behind the heat sink. The silicone grease on both sides of the flat insulator provides the necessary heat transfer between heat sink and end frame. **Reapply silicone grease during assembly, tighten the heat sink mounting screws loosely, securely tighten the output terminal, then securely tighten the heat sink screws.**

To replace a diode in the heat sink, support the heat sink, and use an arbor press or vise to push the diode out. Use a suitable tool to pull the diode out of the end frame. Also use a suitable tool which fits over the outer diode edge to push the diode in, and support the heat sink or end frame with a suitable tool. NOTE: Diode replacement tools are available from various manufacturers normally supplying tools and test equipment to the automotive industry. CAUTION: Do not strike the diode, as the shock may damage it and the other diodes. Use only those diodes listed in the parts list for these units. Never use substitutes.

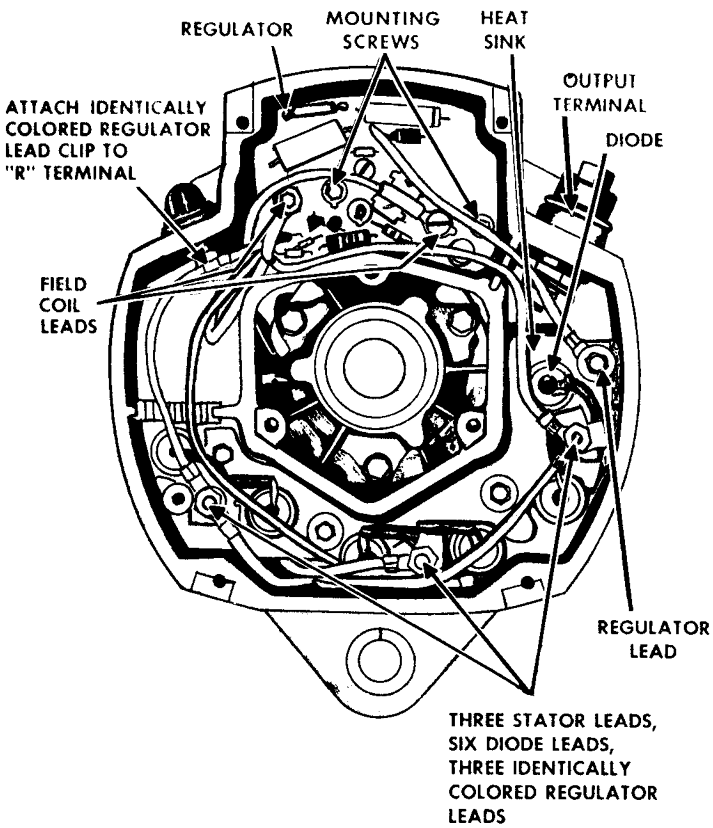

Figure 10—End view, cover removed, discrete-component 12-volt regulator

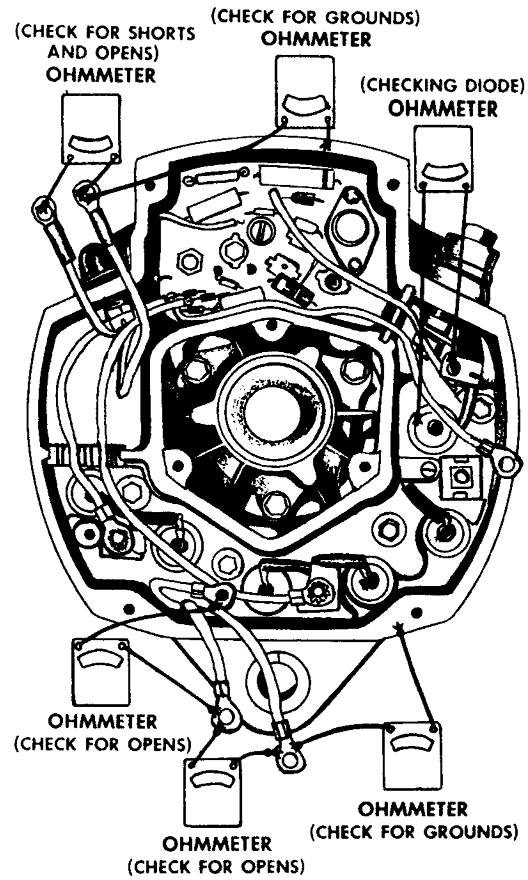

Figure 11—Electrical checks for all types (24-volt regulator shown)

STATOR CHECKS (Figure 11)
(Omit for overcharged battery)

The stator windings may be checked with a 110-volt test lamp or an ohmmeter. If the lamp lights, or if the meter reading is low when connected from any stator lead to the frame, the windings are grounded.

If the lamp fails to light, or if the meter reading is high when successively connected between each pair of stator leads, the windings are open.

A short circuit in the stator windings is difficult to locate without laboratory test equipment due to the low resistance of the windings. However, if all other electrical checks are normal and the generator fails to supply rated output, shorted stator windings are indicted.

To replace the stator, separate drive end frame from rectifier end frame, and pull leads and grommet through hole. Place grease on grommet and pull into hole during assembly.

REGULATOR REPLACEMENT OR REPAIR (Figure 12 only)

After disconnecting the three identically colored regulator leads, the regulator may be replaced by removing the attaching screws and disconnecting the regulator lead from the heat sink. NOTE: Some 24- and 32-volt regulator models have a permanently-connected separate transistor mounted onto the rectifier end frame (not illustrated). Regulators may differ in appearance, but the various types are completely interchangeable.

If previous checks indicate the regulator should be repaired, proceed as follows.

A. The panel board is shown without the sealing compound so the seven (7) serviceable parts can be easily identified (Figure 12).
B. Remove screw, transistor TR1, and pry apart heat sink and panel board with screwdriver.
C. Carefully inspect printed circuit for poor solder joints.
D. Carefully inspect for broken parts.
E. Check components as follows (Figure 13). Use 1½-volt ohmmeter on low scale. Reverse leads to get two (2) readings. SCRATCH HARD WITH SHARP INSTRUMENT TO BREAK THROUGH TRANSPARENT COATING OVER SOLDER TO MAKE OHMMETER CONTACT. Use 50 watt soldering gun.
   1. TAP SWITCH AND HEAT SINK ASSEMBLY—Turn slotted screw with screwdriver to 5 positions. If screw is loose, replace assembly. Also, replace **old** type assemblies having brass slotted screw and attaching nut even if screw is not loose. New assemblies have aluminum slotted screw and no attaching nut. Make sure switch is epoxied to heat sink.
   2. RESISTOR R5—If any reading is over one (1) ohm, replace resistor. Cut away sealing compound with sharp blade.
   3. TRANSISTOR TR2—
      a. Step 1: Should get one low and one high reading. If not, replace transistor.

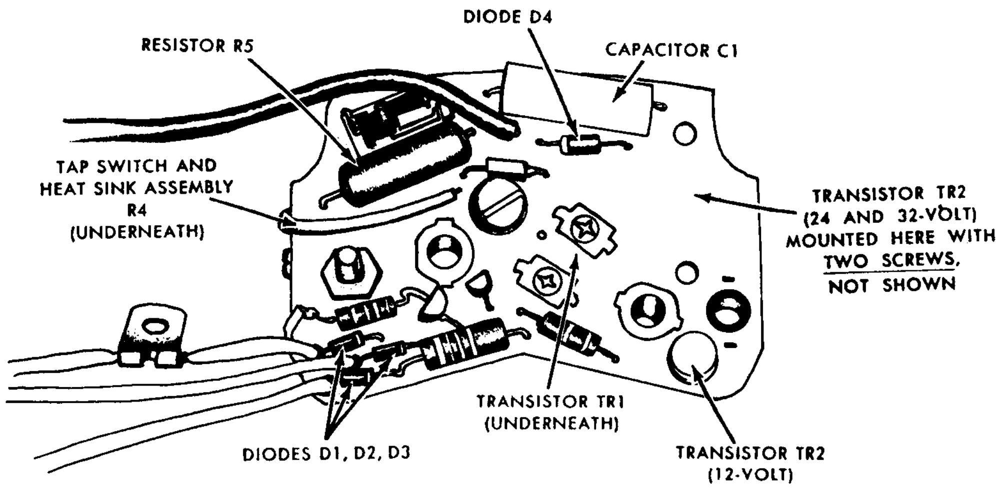

Figure 12—Panel Board Assembly

b. Step 2: Same as Step 1.

c. Step 3: Both readings should be very high. If not, replace transistor.

IMPORTANT: The replacement transistor for TR2 may be a small black unit with a red dot and a flat side. When assembled, the flat side should face towards diodes D1, D2 and D3 (Figure 12)

4. DIODE D4—Should get one low and one high reading. If not, replace diode.
5. DIODES D1, D2 and D3—Check each diode separately. Should get one low and one high reading. If not, replace diode being checked.
6. TRANSISTOR TR1 (Figure 15)—
   a. Step 1: Both readings should be very high. If not, replace transistor.
   b. Step 2: Should get one low and one high reading. If not, replace transistor.
   c. Step 3: Same as Step 2.

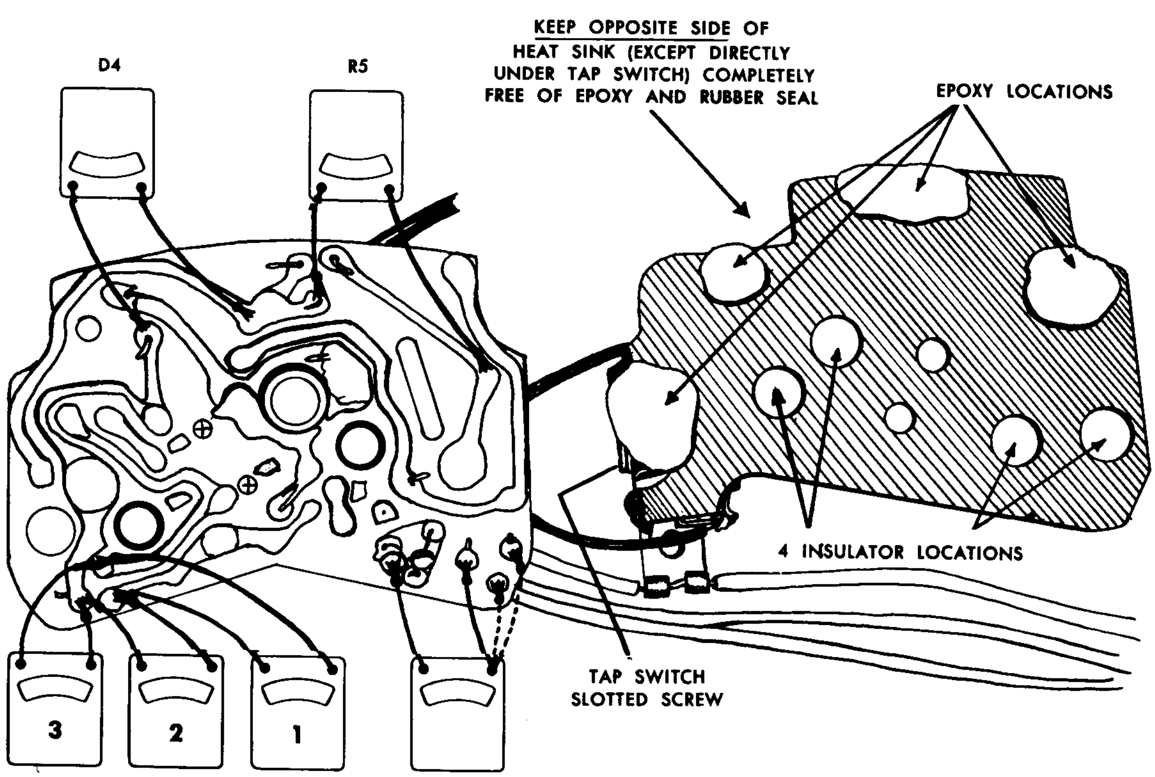

Figure 13—Checking Components

7. CAPACITOR C1—Visually inspect for broken leads.

F. If no defects have been found, replace complete regulator assembly.

G. If regulator was repaired, reassemble as follows:

1. If heat sink is reused, burn away with soldering iron old epoxy separating heat sink from panel board. Apply new epoxy Part No. 1966807 at **all four (4)** locations on old or new heat sink (Figure 13).

   IMPORTANT: Keep opposite side of heat sink (except under tap switch) perfectly clean and free of epoxy and rubber seal (Figure 13).

2. Using 4 insulators, assemble heat sink, panel board and transistor TR1. Use silicone grease available commercially on both sides of mica insulator located between transistor and heat sink.

3. Apply sealing compound as shown in Figure 14 around components using Dow Chemical RTV Silastic 732 silicone rubber seal or equivalent, available at hardware, drug and paint stores. Keep metal clips perfectly clean and free of rubber seal.

H. Test regulator to see if it works. If O.K., return to service. If defective, replace complete regulator assembly.

Figure 15—Checking Transistor TR1

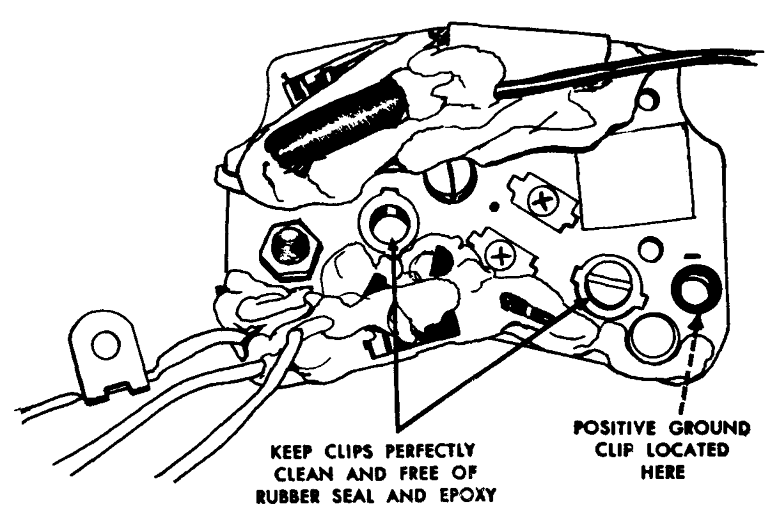

Figure 14—Rubber Seal Applied. Typical Regulator Shown

REGULATOR REPLACEMENT OR REPAIR (Figure 16 only)

After disconnecting the three identically colored regulator leads, the regulator may be replaced by removing the attaching screws and disconnecting the regulator lead from the heat sink.

If previous checks indicate the regulator should be repaired, proceed as follows:

A. The panel board is shown without the sealing compound so the seven (7) serviceable parts can be easily identified (Figure 16).

B. Remove screw, transistor TR1 and pry apart heat sink and panel board with screwdriver.

C. Carefully inspect printed circuit for poor solder joints.

D. Carefully inspect for broken parts.

E. Check components as follows (Figure 17). Use 1½-volt ohmmeter on low scale. SCRATCH HARD WITH SHARP INSTRUMENT TO BREAK THROUGH TRANSPARENT COATING OVER SOLDER TO MAKE OHMMETER CONTACT. Use 50-watt soldering gun.

   IMPORTANT: The ohmmeter polarity must be determined by connecting its leads to voltmeter leads. The voltmeter will read up scale when the negative leads are connected together and the positive leads are connected together. The polarity of the voltmeter leads can be determined by connecting the leads to the identified terminals of a battery.

1. Transistor TR2—
   a. Step 1: Should read about 5-50 ohms. If zero or well above 50, replace transistor.
   b. Step 2: Should read very high. If not, replace transistor.
   c. Step 3: Same as Step 1.
2. Transistor TR3—
   a. Step 1: Should read very high. If not, replace transistor.
   b. Step 2: Should read about 5-50 ohms. If zero or well above 50, replace transistor.
   c. Step 3: Same as Step 2.
3. Diode D5—Should read 5-50 ohms. If zero, or well above 50, replace diode.
4. Diode trio D1, D2 and D3—Each diode should read 5-50 ohms. If zero, or well above 50, replace diode being tested.
5. Capacitor C2—Should read high. If zero, replace capacitor.

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6. Potentiometer R2—
   IMPORTANT: Change ohmmeter to X10 or middle scale. With ohmmeter connected, turn potentiometer slotted screw, Figure 16. Ohmmeter needle should deflect slightly. If no deflection at all, replace R2.
7. Transistor TR1—
   IMPORTANT: Turn ohmmeter back to low or X1 scale. See Fig 15. Connect ohmmeter both ways in each step.
   a. Step 1: Both readings should be very high. If not, replace transistor.
   b. Step 2. Should read high and low. If not, replace transistor.
   c. Step 3: Same as Step 2.

F. If no defects have been found, replace complete regulator assembly.

G. If regulator was repaired, reassemble, using silicone grease on both sides of mica under transistor TR1.

H. Apply sealing compound as shown in Figure 14 around components using Dow Chemical RTV Silastic 732 silicone rubber seal or equivalent, available at hardware, drug and paint stores. Keep metal clips perfectly clean and free of rubber seal.

I. Test regulator to see if it works. If okay, return to service. If defective, replace complete regulator assembly.

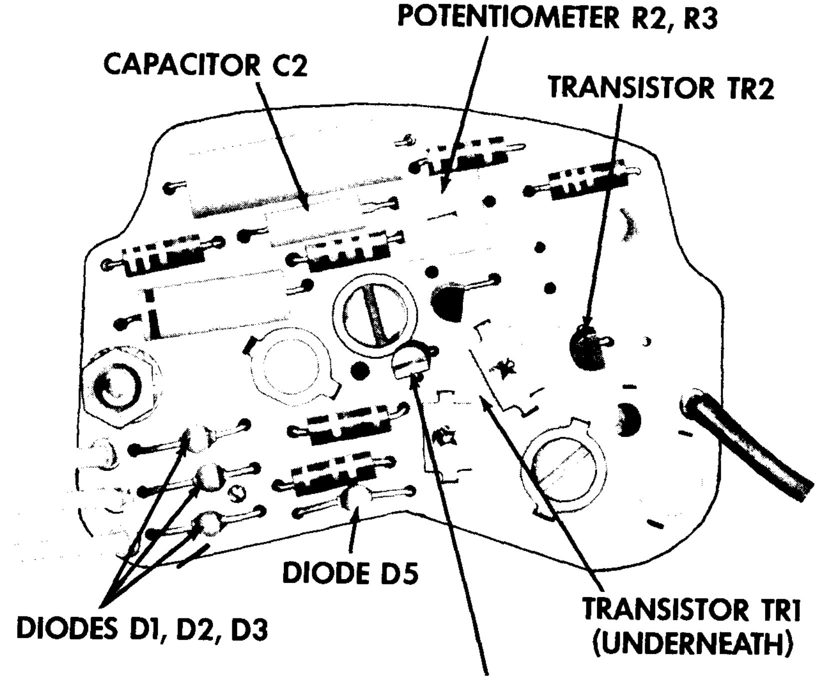


Figure 16—Panel Board Assembly.
Note parallel arrangement of components.

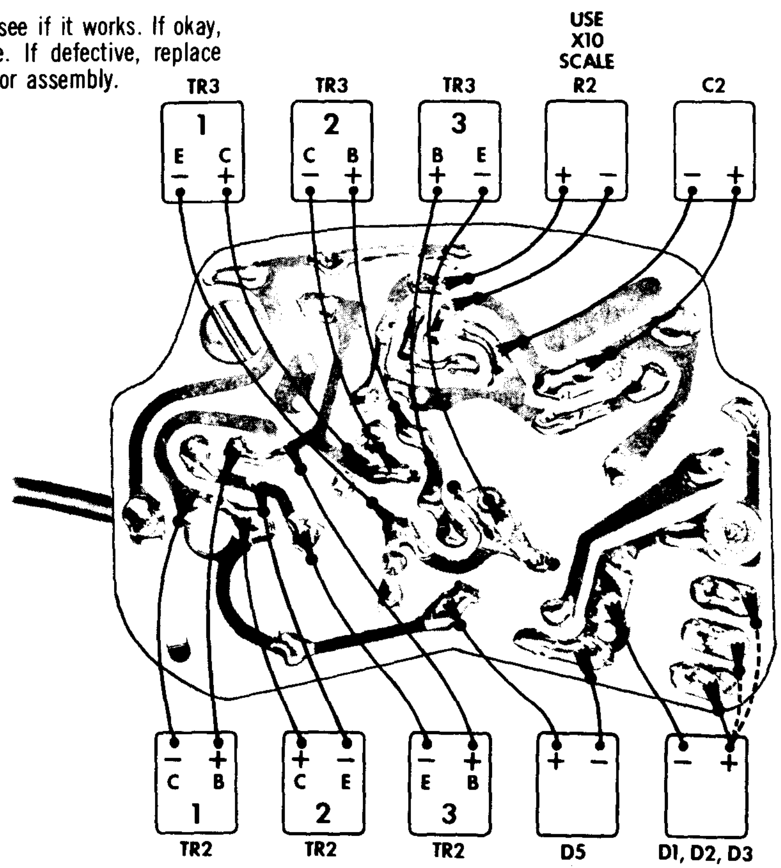


Figure 17—Checking components.
Regulator Shown in Figure 16.

BEARING REPLACEMENT AND LUBRICATION

The bearings normally will operate between engine overhaul periods without attention. At time of engine overhaul, the bearings and seals should be replaced, and a fresh supply of lubricant added to the reservoirs.

To replace the drive end bearing:

1. Remove shaft nut, washer, pulley, fan, slinger and the four retainer plate bolts, then remove the rotor and bearing assembly from the end frame.
2. Pull the bearing from the rotor shaft, separate retainer plate and collar from shaft, and discard seals in retainer plate and end frame.
3. Add Delco-Remy lubricant No. 1948791 so each reservoir between the bearing and seal after assembly will be only three-quarters full. Arrange the lubricant so at least a portion will contact the bearing after reassembly. Otherwise the oil in the lubricant will not bleed to the bearing. Also add lubricant to each seal lip and fill the cavity with lubricant between the rubber lip and steel case of each seal. The seals must be assembled so the seal lip is toward or next to the bearing.
4. Lubricate collar, then install collar and retainer plate, then press against the inner race only to install the new bearing onto the shaft against the collar.
5. The remaining assembly procedure is the reverse of disassembly.

To replace the rectifier end frame bearing: (Figures 18, 19, and 20 only.)

1. Pull the old inner race from the shaft, and press the new inner race onto the dimension shown in Figure 18.

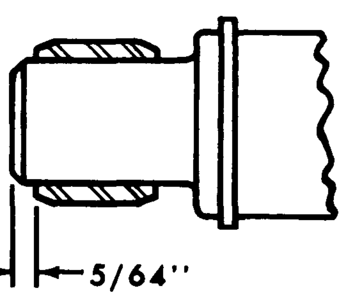


Figure 18—Inner race location

2. Discard the old seal, and push the old bearing out of the housing from inside toward the outside.
3. Push against the race only to install the new bearing to the dimension shown in Figure 19. To facilitate the installation, heat the end frame in an oven to 200 to 300° F. This will not damage the regulator.

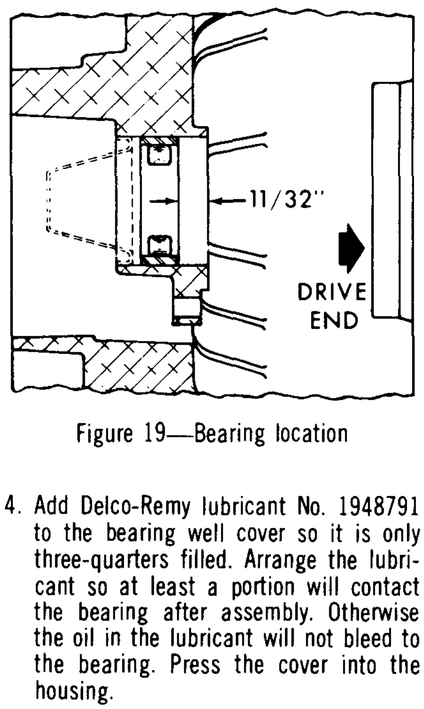


Figure 19—Bearing location

4. Add Delco-Remy lubricant No. 1948791 to the bearing well cover so it is only three-quarters filled. Arrange the lubricant so at least a portion will contact the bearing after assembly. Otherwise the oil in the lubricant will not bleed to the bearing. Press the cover into the housing.
5. Add lubricant to the seal lip and fill the cavity with lubricant between the rubber lip and steel case of the seal. Install the seal with the lip towards the bearing to the dimension shown in Figure 20.

To replace the rectifier end frame bearing: Figure 21 only.

a. Pull inner race from shaft and bearing from end frame.

b. Assemble new inner race and bearing as shown in Figure 21. Assemble bearing seal toward drive end. Press against **seal end** of bearing to assemble into housing.

c. Use Delco-Remy lubricant Part No. 1948791 and fill reservoir half full. Arrange lubricant so a portion will touch bearing when assembled.

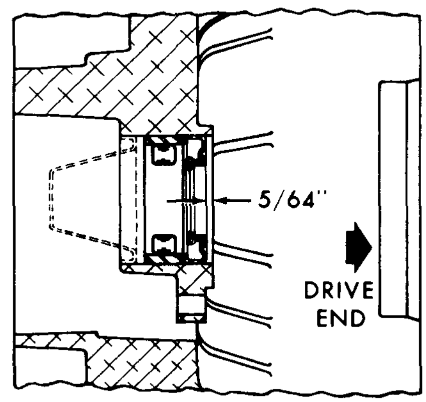


Figure 20—Seal location

REASSEMBLY

Reassembly procedures are the reverse of disassembly. Torque the shaft nut to 70-80 lb. ft. Torque the output terminal bolt to 100-110 inch-pounds when attaching cable. Be sure to magnetize the rotor as covered on page 4.

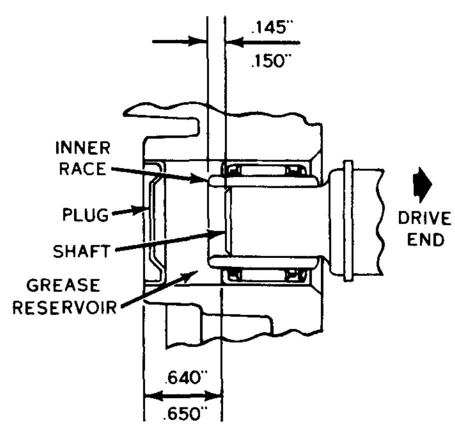


Figure 21—Bearing assembled between shaft and housing.

Delco Remy

Tests of

DELCOTRON INTEGRAL CHARGING SYSTEM

(30-SI And 30-SI/TR Series)

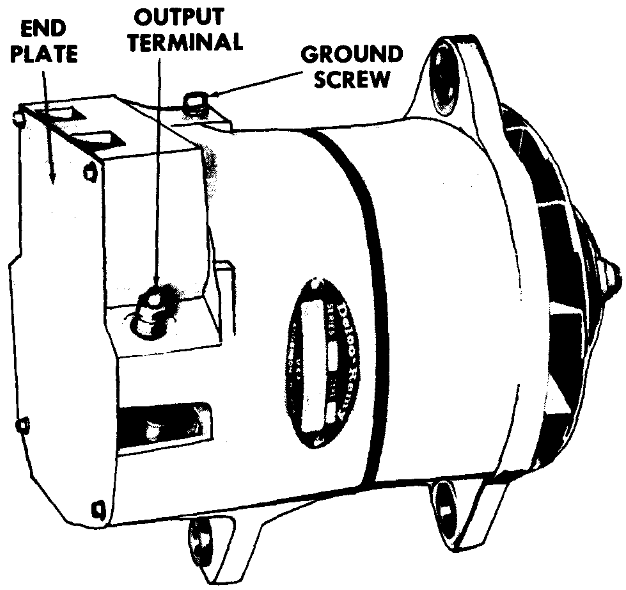


Figure 1—Typical 30-SI Series

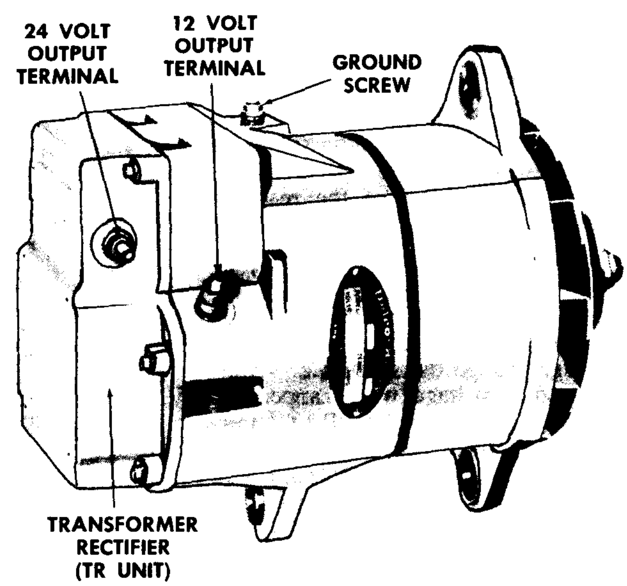


Figure 2—Typical 30-SI/TR Series

INTRODUCTION

The Integral Charging Systems, or generators, shown in Figures 1 and 2 feature a solid state regulator that is mounted inside the end frame. The regulator voltage setting can be adjusted externally by repositioning a voltage adjustment cap in the rectifier end frame. On some models a relay terminal provides about half system voltage to which accessories can be connected.

The 30-SI Series shown in Figure 1 uses one wire with an adequate ground return to charge the vehicle battery in the usual manner. The 30-SI/TR is a standard 30-SI with a transformer-rectifier, or TR unit, mounted on the end frame. The TR unit provides a separate voltage to charge a cranking battery. The cranking battery is connected in series with the system battery to provide 24-volt cranking. When the engine is running, the cranking battery is charged at a low rate to maintain its full state of charge. The vehicle electrical system, except for the cranking motor is 12 volts. The 30-SI/TR eliminates the need for a series-parallel switch and associated wiring.

OPERATING PRINCIPLES

(30-SI SERIES)

A typical wiring diagram is shown in Figures 3 and 4. The basic operating principles are explained as follows:

The base-emitter of transistors TR3 and TR1 is connected to the battery through resistor R5, thus turning these transistors on. Also, resistors R2 and R3 are connected to the battery through the voltage adjustment, but the discharge current of the battery is very low because of the resistance values of R2, R3, R5, TR1 and TR3.

With the generator operating, a.c. voltages initially are generated in the stator windings by residual magnetism in the rotor. The diodes in the rectifier bridge change the stator a.c. voltages to a d.c. voltage which appears between ground and the "BAT" terminal. As speed increases, current is provided for charging the battery and operating electrical accessories.

The stator also supplies d.c. field current through the diode trio, the field, TR1, and then through the diodes in the rectifier bridge back to the stator.

As the speed and voltage increase the voltage between R2 and R3 increases to the value where zener diode D1 conducts. Transistor TR2 then turns on and TR1 and TR3 turn off. With TR1 off, the field current and system voltage decrease and D1 then blocks current flow causing TR1 and TR3 to turn back on. The field current and system voltage increase and this cycle then repeats many times per second to limit the voltage to the adjusted value.

If the voltage adjustment cube should become open-circuit TR3 and TR1 will turn off, thus preventing high system voltage.

Capacitor C1 smooths out the voltage across R3, resistor R4 prevents excessive current through TR1 at high temperatures, and diode D2 prevents high-induced voltages in the field windings when TR1 turns off.

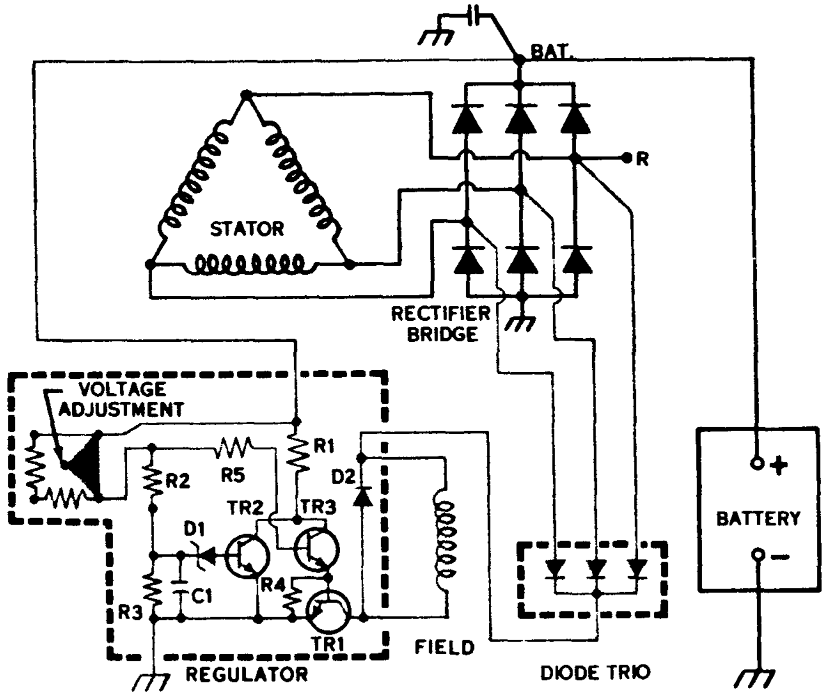


Figure 3—Typical circuit, negative ground, 30-SI Series

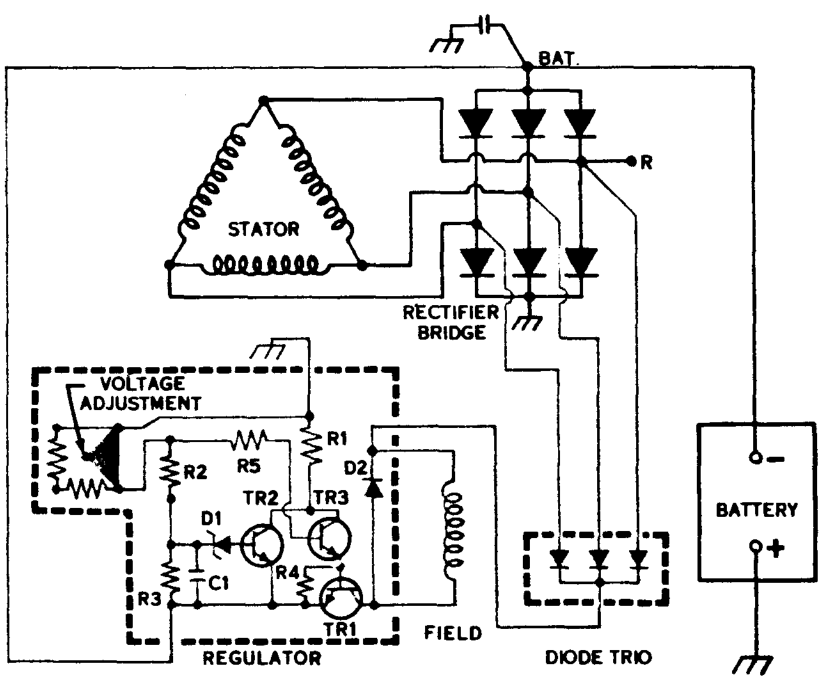


Figure 4—Typical circuit, positive ground, 30-SI Series

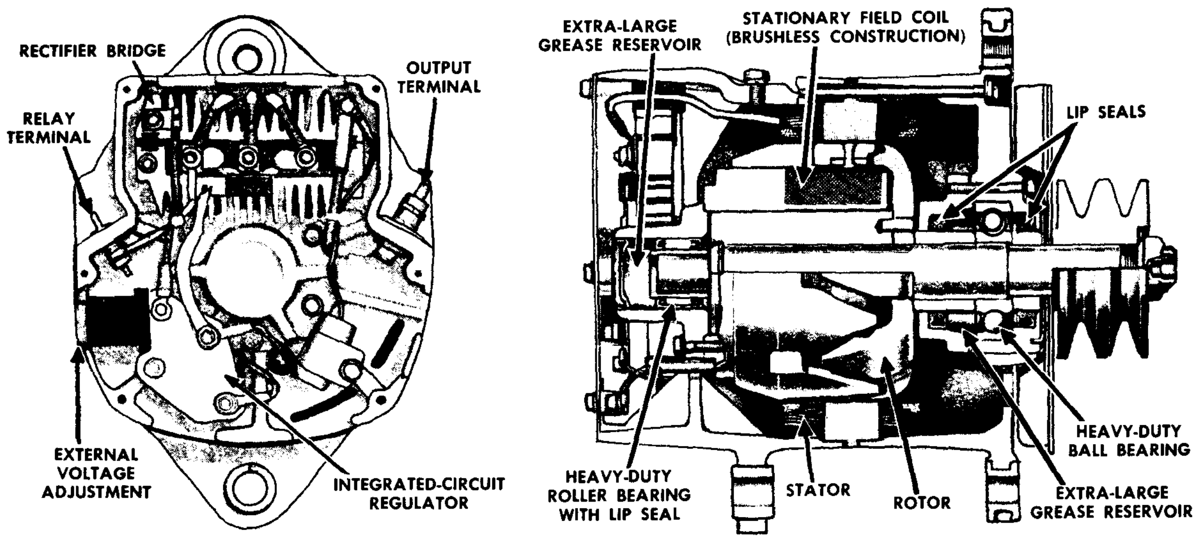


Figure 5—Cross-sectional view typical 30-SI

TROUBLESHOOTING PROCEDURES

(30-SI SERIES)

ENERGIZING SPEED

The energizing speed is the rpm at which the regulator turns on to energize the field coil. This speed is higher than some speeds at which output can be obtained. Therefore, when checking output at low speeds, increase the speed until the regulator turns on, then reduce the speed to check the output. No output can be obtained until the regulator turns on. Once the regulator turns on, it will remain turned on until the engine is stopped.

RATED VOLTAGE

On 12-, 24-, and 32-volt systems, the Integral Charging System output preferably should be checked at the "RATED VOLTAGE" given in the table.

However, it is permissible to check the output in amperes at any voltage within the "OPERATING RANGE" listed in the table, since the current output will be quite close to the value that would be obtained at "RATED VOLTAGE." The voltage should never be allowed to rise above the "OPERATING RANGE" for any length of time

SYSTEM VOLTAGE	RATED VOLTAGE	OPERATING RANGE
12	14.0	13.0-15.0
24	28.0	26.0-30.0
32	37.5	33.0-39.0

It should be noted that the voltage may be below the "OPERATING RANGE" if the battery is in a low state of charge. However, as the battery receives a charge, the voltage will rise to some value within the "OPERATING RANGE."

MAGNETIZING THE ROTOR

The rotor normally retains magnetism to provide voltage build-up when the engine is started. After disassembly or servicing, however, it may be necessary to re-establish the magnetism. To magnetize the rotor connect the Integral Charging System to the battery in a normal manner, then momentarily connect a jumper lead from the **battery positive post to the Integral Charging System relay terminal,** identified in Figure 5. This procedure applies to both negative and positive ground systems, and will restore the normal residual magnetism in the rotor.

On the 30-SI/TR series, be sure to jumper from the positive post of the system battery so that 12 volts will be applied to the relay terminal. On generators without a relay terminal, remove the end plate and jumper from the battery positive post to one of the stator lead terminals on the rectifier bridge.

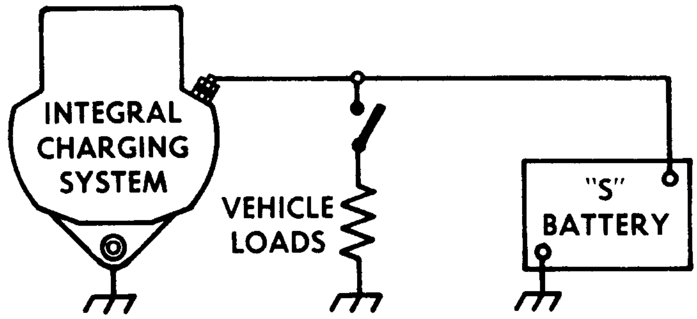
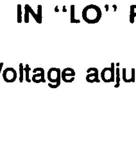


Figure 6—Typical 30-SI wiring diagram

A cross-sectional view of a typical 30-SI is shown in Figure 5. A basic wiring diagram is shown in Figure 6.

1. Insure that an undercharged condition has not been caused by accessories having been left on for extended periods.
2. Check the drive belt for proper tension.
3. If a battery defect is suspected, check per the applicable Delco Remy Service Bulletin.
4. Inspect the wiring for defects. Check all connections for tightness and cleanliness, including the battery connectors.
5. Connect a voltmeter from output or "BAT" terminal on Integral Charging System to ground. A zero reading indicates an open between voltmeter connection and battery.
6. With all accessories turned off, increase engine speed as required to obtain maximum voltage reading.
7. If voltage exceeds 15 volts on a 12-volt system, 30 volts on a 24-volt system or 39 volts on a 32-volt system, remove Integral Charging System for repair as covered under heading of "INTEGRAL CHARGING SYSTEM REPAIR."
8. If previous Steps 1 thru 6 check satisfactorily, check generator as follows:
   a. Disconnect battery ground cable.
   b. Connect an ammeter in the circuit at the output terminal of the generator.
   c. Reconnect battery ground cable.
   d. Turn on accessories. Connect a carbon pile across the battery.
   e. Operate engine at moderate speed as required, usually 4000 generator r.p.m. or more, and adjust carbon pile as required to obtain maximum current output. **IMPORTANT: Initial voltage build-up is by residual magnetism in the rotor. Increase the speed as required to obtain maximum current output.**
   f. If ampere output is within 10 amperes of rated output as stamped on generator frame, generator is not defective. In this case, an adjustment of the voltage setting may correct the condition. Raise or lower the setting by removing the voltage adjusting cap, rotating in increments of 90°, and then reinserting the cap in the connector body.
   g. As illustrated in Figure 7, the cap is set for low voltage. With position 2 aligned with the arrow, the setting is medium low, position 3 is medium high, and position "HI" is the highest regulator setting.
   h. If ampere output is not within 10 amperes of rated output as stamped on Integral Charging System frame, remove the Integral Charging System for repair as covered in section entitled "INTEGRAL CHARGING SYSTEM REPAIR."



ENLARGED VIEW
TOP OF VOLTAGE ADJUSTMENT CAP SHOWN IN "LO" POSITION

Figure 7—Voltage adjustment caps

INTEGRAL CHARGING SYSTEM REPAIR

Component parts and connections are shown in Figures 8, 9, 10, and 11. Note that the diode trio has been removed in Figure 12, along with the end plate.

CONNECTOR BODY CHECK

Remove the connector body from the regulator and check with an ohmmeter using the middle range scale as shown in Figure 8. Connect the ohmmeter to each adjacent pair of terminals, making four checks in all. If any one check is infinite, replace the connector body.

REGULATOR CHECK

The regulator cannot be checked with an ohmmeter. Use an approved regulator tester available from various test equipment manufacturers.

RECTIFIER BRIDGE CHECK

(Omit for overcharged battery) To check the rectifier bridge, connect the ohmmeter to a heat sink and one of the three terminals (Step 1, Fig. 12). Then reverse the lead connections to the same heat sink and same terminal.

If both readings are the same, replace the rectifier bridge by detaching the necessary screws and nuts. A good

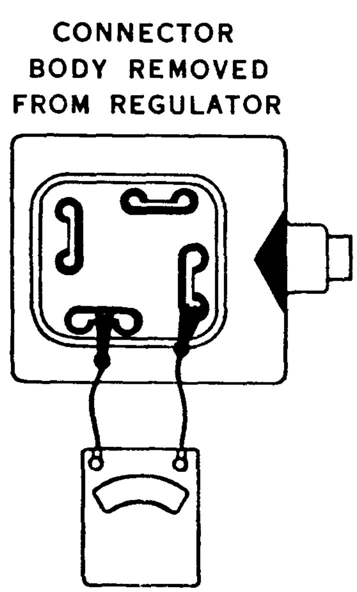


Figure 8—Checking connector body

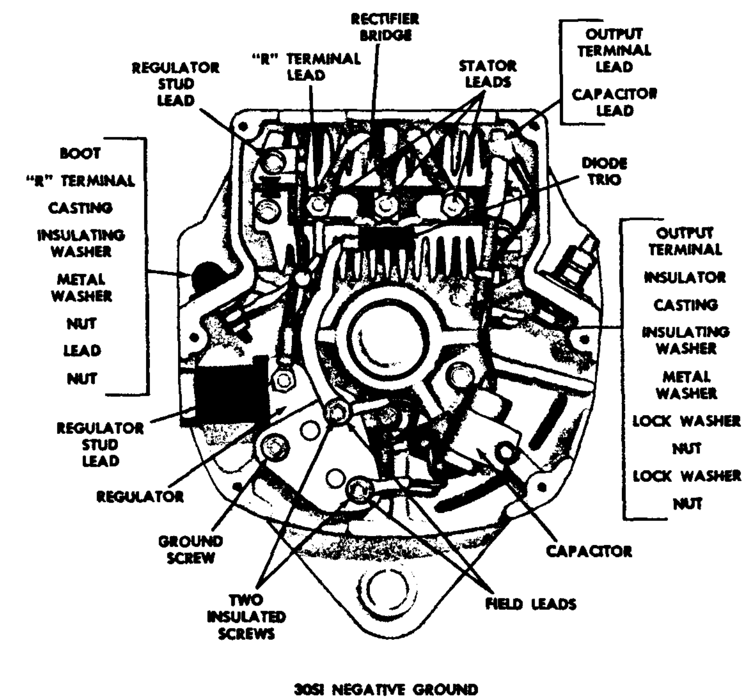


Figure 9—Typical 30-SI negative ground

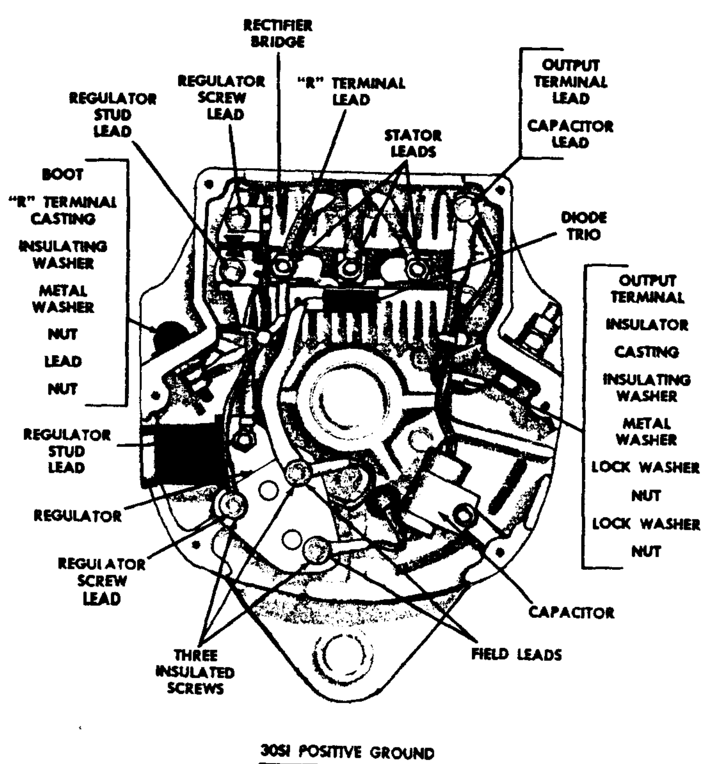


Figure 10—Typical 30-SI positive ground

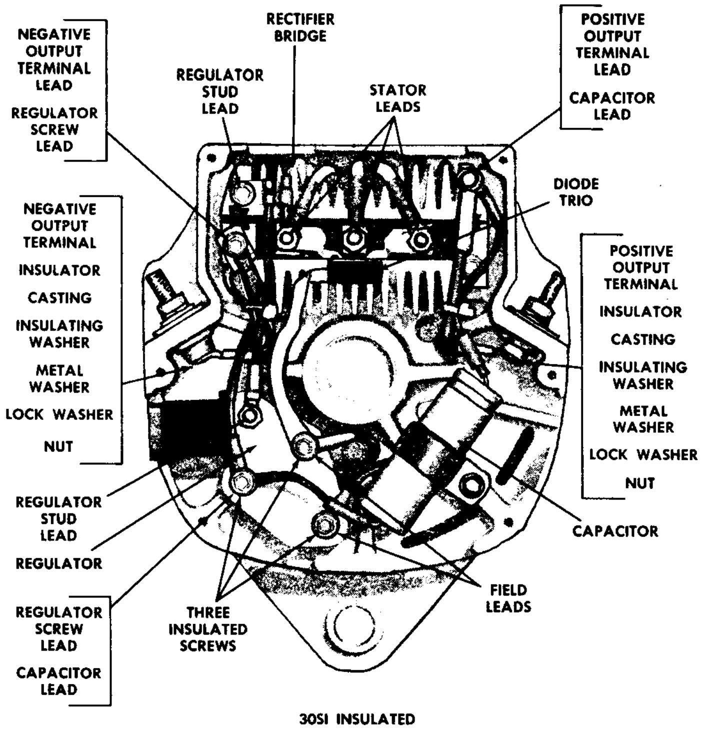


Figure 11—Typical 30-SI insulated

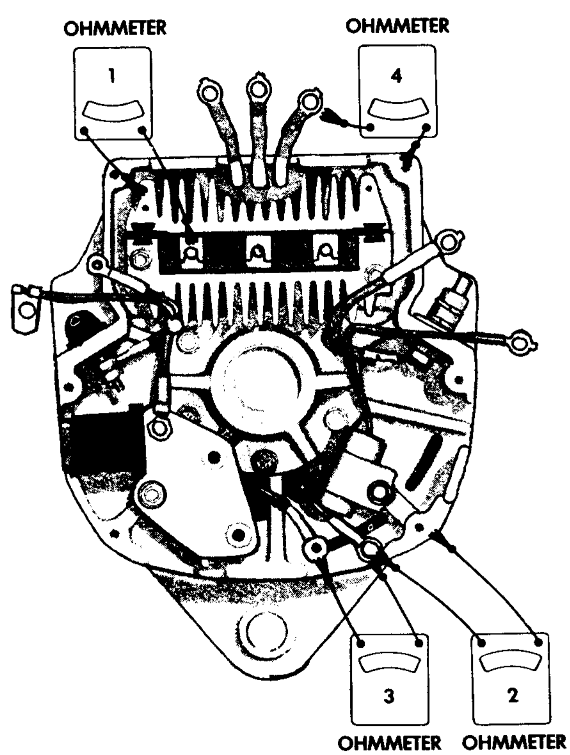


Figure 12—Ohmmeter checks

rectifier bridge will give one high and one low reading. Repeat this same test between the same heat sink and the other two terminals, and between the other heat sink and each of the three terminals. This makes a total of six checks, with two readings taken for each check on each rectifier bridge. IMPORTANT: If rectifier bridge is constructed with flat metal clips at the three studs, press down firmly onto flat metal clips and not onto threaded stud.

FIELD COIL CHECKS

To check for grounds, connect an ohmmeter to one field coil lead and to the end frame as illustrated in Step 2, Figure 12. If ohmmeter reading is low, the field coil is grounded.

To check for opens, connect an ohmmeter to the two field coil leads as shown in Step 3, Figure 12. If ohmmeter reading is high (infinite), the field coil is open.

The winding is checked for short-circuits by connecting a battery and ammeter in series with the field coil. Note the ammeter reading and refer to Delco Remy Service Bulletin 1G-187 or 1G-188 for specifications. An ammeter reading above the specified value indicates shorted windings. An alternate method is to check the resistance of the field by connecting an ohmmeter to the field coil. If the resistance reading is below the specified value, the winding is shorted. The specified resistance value can be determined by dividing the voltage by the current given in Bulletin 1G-187 or 1G-188. To replace the field coil, see the section entitled "Disassembly."

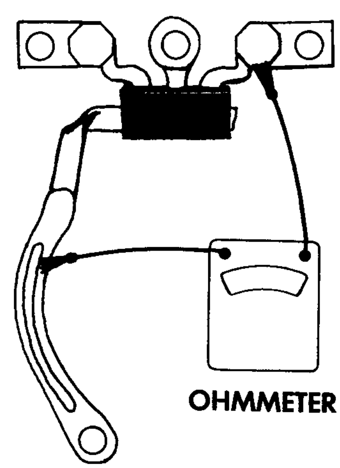


Figure 13—Diode trio check

DIODE TRIO CHECK

To check the diode trio, remove it from the end frame assembly by detaching the nuts and attaching screw. **NOTE that the insulating washer on the screw is assembled over the top of the diode trio connector.** Connect an ohmmeter having a 1½-volt cell, and using the lowest range scale, to the single connector and to one of the three connectors, (Fig. 13). Observe the reading. Then reverse the ohmmeter leads to the **same two** connectors. If both readings are the same, replace the diode trio. A good diode trio will give one high and one low reading. Repeat this same test between the single connector and each of the other two connectors.

STATOR CHECK

(Omit for overcharged battery)
Most stators are delta wound and only a check for grounds can be made with an ohmmeter. Connect from either lead to the frame, (Step 4, Fig. 12). The reading should be infinite. If not, replace the stator. See section entitled "Disassembly."

If the regulator checks good and if the generator fails to supply rated output, replace the stator if it is badly discolored.

DISASSEMBLY (Fig. 5)

1. Remove screws and end plate.
2. Remove fan and pulley.
3. Remove 4 thru-bolts.
4. Separate Drive End frame and rotor from Rectifier End frame and stator.
5. Press rotor from end frame.
6. Remove collar from end frame.
7. Remove collar from shaft.
8. To replace Drive End frame bearing:
   a. Remove 4 retaining plate attaching screws.
   b. Remove retainer plate and gasket.
   c. Push on inner race to remove bearing.
   d. Pull out seals from end frame and from retainer.
   e. Press in new seals with lip toward bearing.
   f. Press in new bearing against outer race.
   g. Fill retainer cavity half full with Delco Remy Lubricant Part No. 1948791 so part of lubricant will touch bearing when assembled.
   h. Assemble retainer with thru-bolts.
   i. Assemble inside collar over shaft.
   j. Assemble outer collar under seal next to bearing while supporting outer collar.
   k. Press rotor into drive end frame.
9. To replace Rectifier End Frame bearing:
   a. Pull inner race from shaft and bearing from end frame.
   b. Assemble new inner race and bearing as shown in Figure 5, with bearing seal away from grease resevoir.
   c. Use Delco Remy lubricant Part No. 1948791 and fill reservoir half full. Arrange lubricant so a portion will touch bearing when assembled.
10. To replace field coil:
    a. Remove attaching bolts.
    b. Install new field coil and torque bolts to 55 inch-lbs.

TROUBLESHOOTING PROCEDURES

(30-SI/TR Series)

Read the section on Page 3 before proceeding.

A basic wiring diagram is shown in Figure 14. A cross-sectional view of a typical 30-SI/TR is shown in Figure 15. The 30-SI and system battery, or "S" battery, operate together in the normal manner in the 12-volt vehicle electrical system. The transformer rectifier, or TR unit, is an "add on" unit on the 30-SI generator. It charges the cranking battery, or "C" battery which is connected in series with the "S" battery to provide 24 volts to the cranking motor. When the engine is running, the "C" battery receives a low charge rate from the TR unit to maintain its full state of charge.

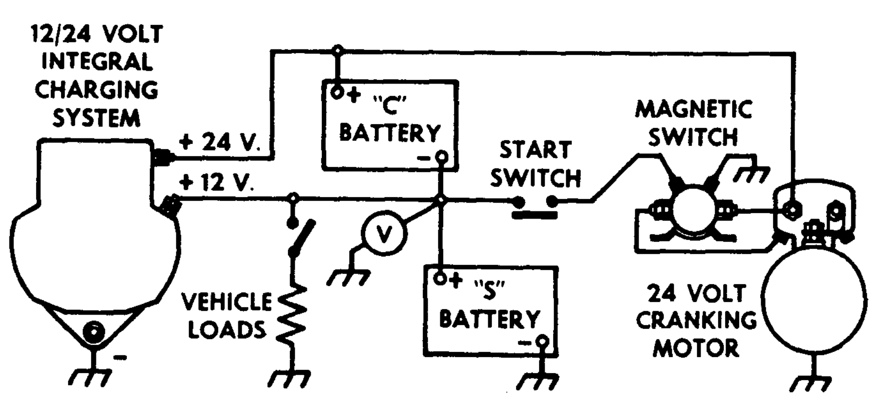


Figure 14—Typical 30-SI/TR circuit

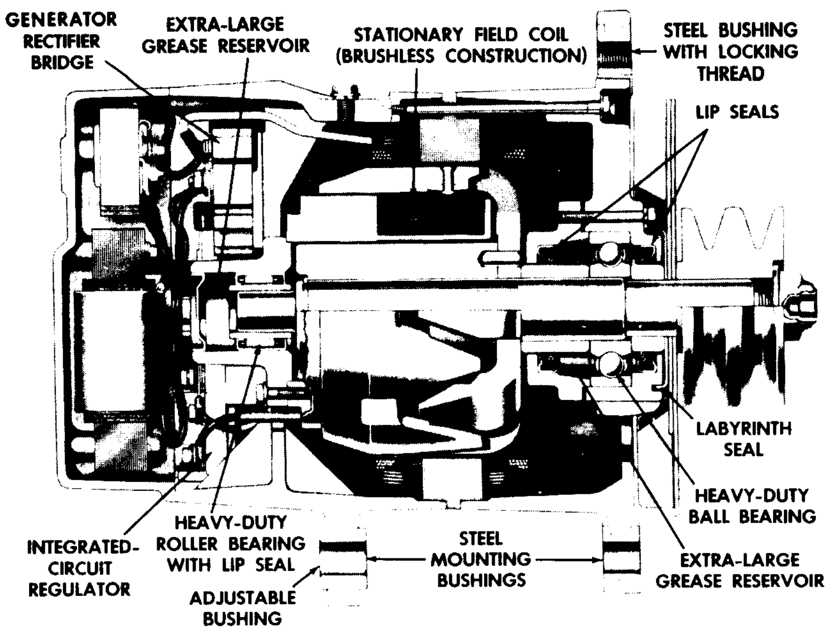


Figure 15—Cross-sectional view typical 30-SI/TR

If either battery is undercharged or overcharged, observe the following procedure:

1. DO NOT ALLOW LEADS OR TERMINALS TO TOUCH GROUND!
2. Completely remove the TR unit from the 30-SI generator as follows:
   a. Remove attaching screws.
   b. Pull TR unit away from the 30-SI generator to expose lead connections.
   c. Detach three transformer leads from the three studs on the 30-SI rectifier bridge. Reassemble nuts onto 30-SI rectifier bridge studs.
   d. If there is a remaining TR single lead connected from the TR rectifier bridge heat sink to the 30-SI rectifier bridge heat sink, **detach this lead** from the 30-SI 12-volt heat sink. (Some models may not use this lead).
3. The circuit is now a regular 12-volt 30-SI charging system connected to the "S" battery.
4. Return to page 3 and check the 30-SI as covered in the "TROUBLESHOOTING PROCEDURES" section.
5. If a defect is found, repair as required and reinstall the TR unit.
6. If no defect is found, check the rectifier bridge on the TR unit as follows:

   Disconnect transformer leads from rectifier bridge. Connect the ohmmeter to a heat sink and one of the three terminals (Step A, Fig. 16). Then reverse the lead connections to the same terminal.

   If both readings are the same, replace the rectifier bridge by detaching the necessary screws and nuts. A good rectifier bridge will give one high and one low reading. Repeat this same test between the same heat sink and the other two terminals, and between the other heat sink and each of the three terminals. This makes a total of six checks, with two readings taken for each check. If rectifier bridge is constructed with flat metal clips at the three studs, press down very firmly onto flat metal clips and not onto threaded stud.

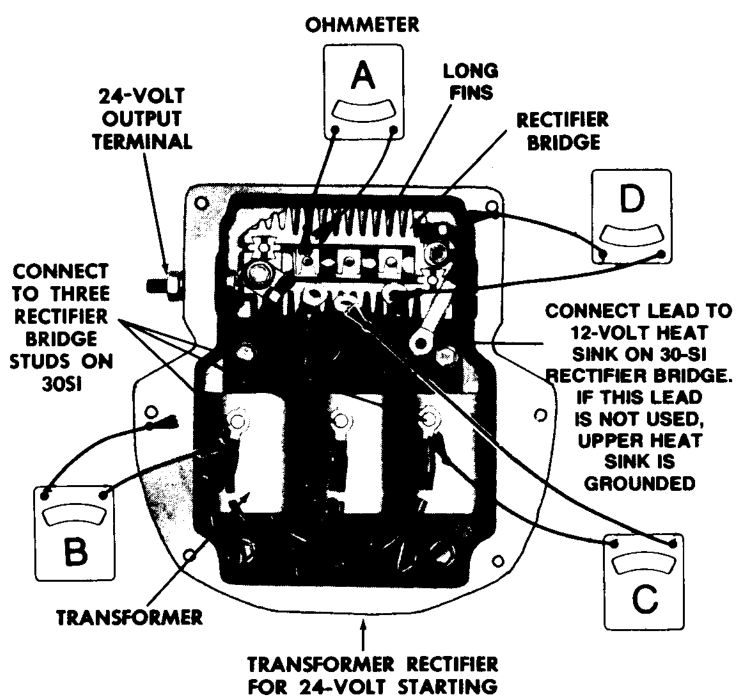


Figure 16—Ohmmeter checks of transformer and rectifier bridge diodes in TR unit

IMPORTANT—When replacing **rectifier bridge**, note stackup of parts so unit can be properly re-assembled. For **negative ground** systems, bridge is assembled with **long** cooling fins next to end frame, and **short** fins next to transformer, as shown in Figure 16.

The **same** rectifier bridge is used on **positive ground** systems, but turned 180°, so short fins are next to end frame and long fins are next to transformer (not illustrated).

7. Check the transformer on the TR unit as follows: Connect ohmmeter three ways as shown in Step B, Step C and Step D, Figure 16. Each reading should be very high (infinite). If not, replace transformer.
8. Reinstall the TR unit onto the 30-SI generator.
9. Detach 24-volt lead from generator. DO NOT ALLOW LEAD TO TOUCH GROUND.
10. Connect ammeter between 24-volt TR terminal and disconnected lead.
11. Connect a 5-20-ampere load, such as one or two 12-volt headlamps across the 12-volt cranking or "C" battery.
12. Operate generator at speed sufficient to produce maximum output.
13. TR unit output to "C" battery and load should be 5 amperes or more. If less than 5 amperes, replace transformer.
14. If 5 amperes or more, TR unit is not defective, and it will charge "C" battery when engine is run a sufficient length of time.

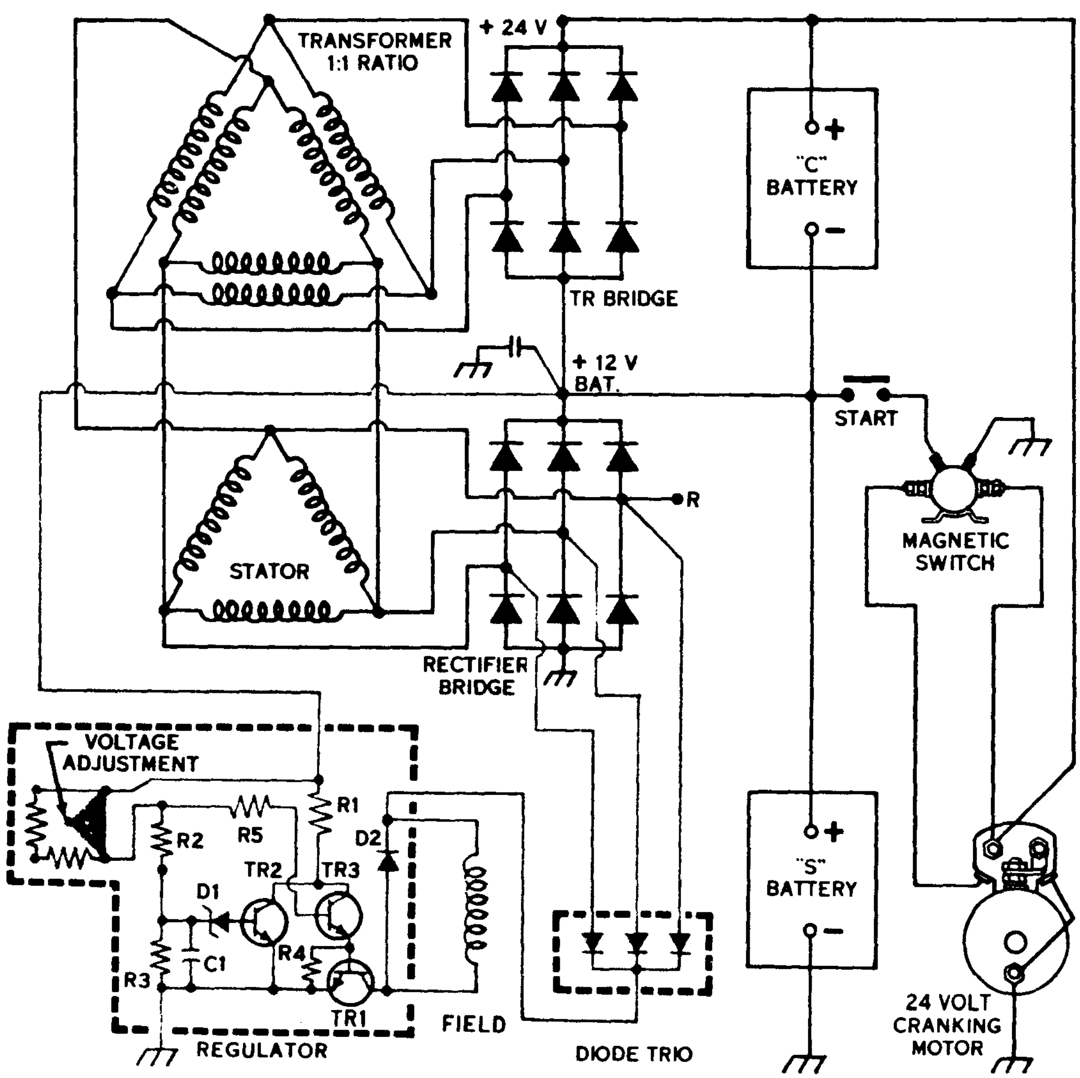


Figure 17—Typical 30-SI/TR circuit, negative ground

OPERATING PRINCIPLES

(30-SI/TR Series)

Typical circuits showing the 30-SI/TR are illustrated in Figures 17 and 18. (Negative ground and positive ground).

The lower portion of each circuit, with the system or "S" battery, is the same as the circuits in Figures 3 and 4. The operating principles are explained on Page 2.

A transformer-rectifier, or TR unit, is mounted on the rectifier end frame, and is connected to the cranking, or "C" battery, as shown. The two batteries are connected in series to provide 24 volts for cranking or starting.

The delta primary of the transformer is connected to the delta stator. The a.c. voltages in the stator cause an a.c. current to flow in the primary. This changing, or a.c. current, creates magnetic fields which induce voltages in the transformer secondary winding. The secondary then provides current through the rectifier bridge to charge the "C" battery.

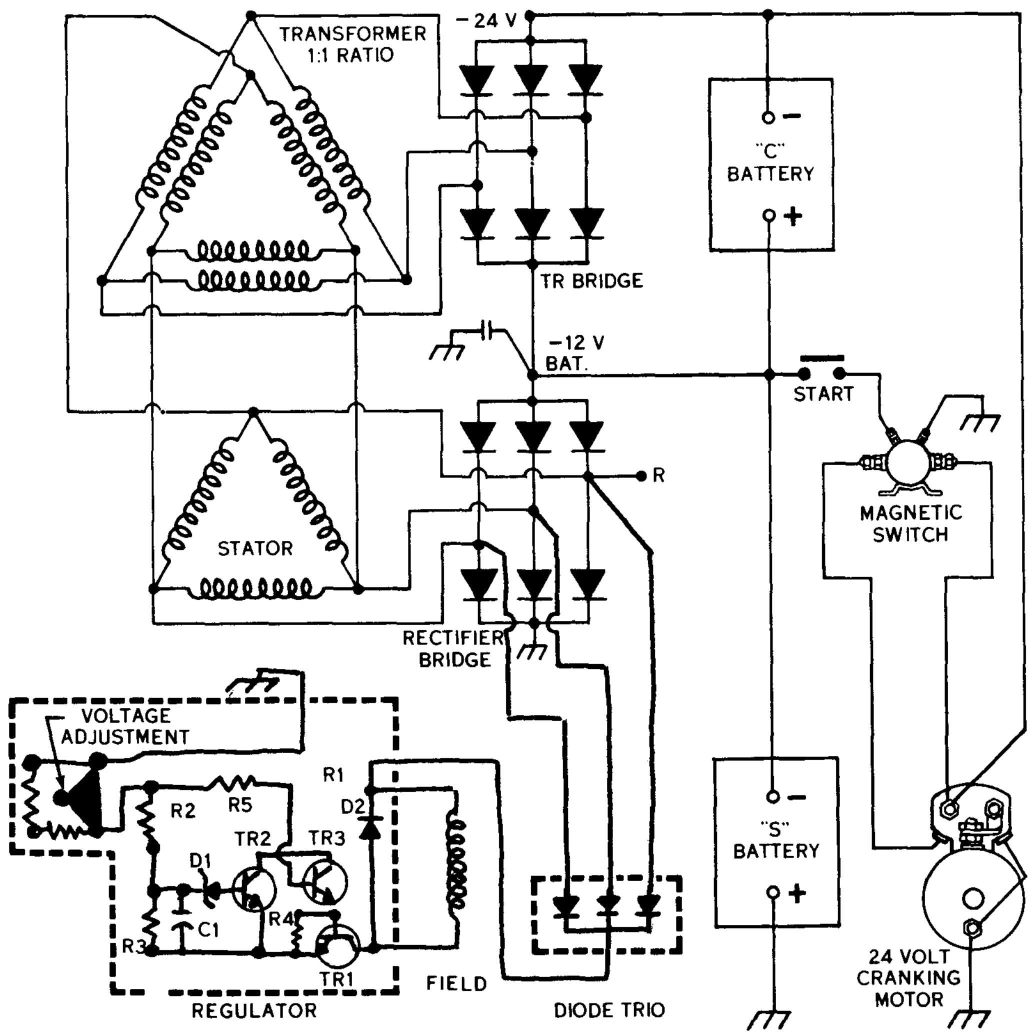


Figure 18—Typical 30-SI/TR circuit, positive ground

Service Bulletin 1M-130

Pages: 6

Delco Remy

Dyer Drive

CRANKING MOTORS

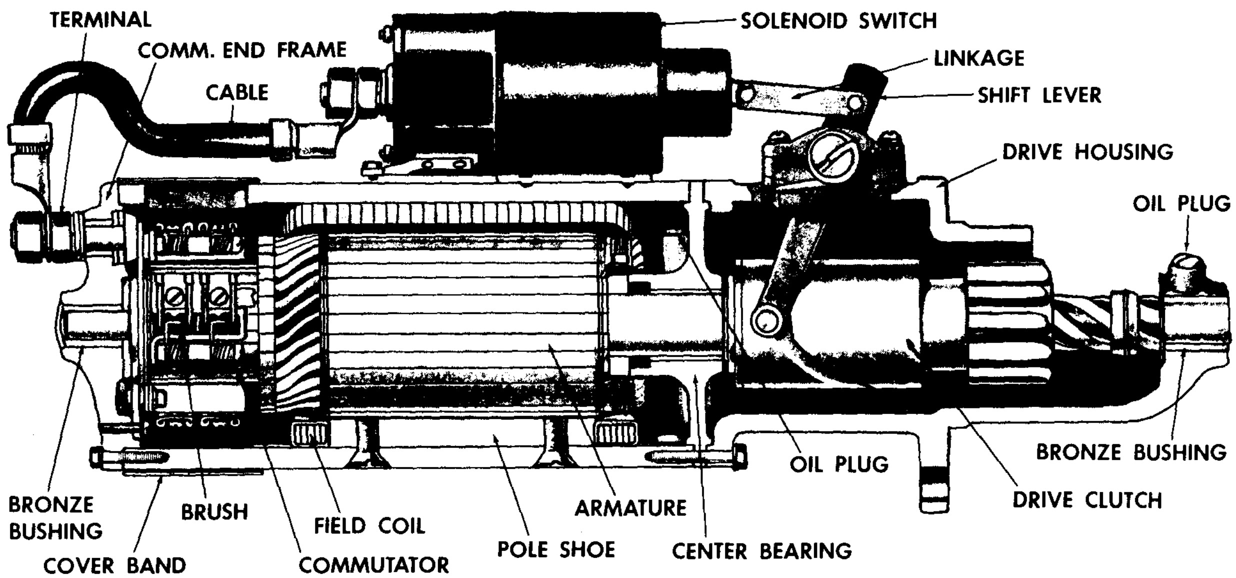


Figure 1—Dyer drive cranking motor with solenoid-operated shift lever.

A typical Dyer drive cranking motor is illustrated in Figure 1, and a basic circuit is shown in Figure 2. When the start switch is closed, the solenoid windings are energized, and the resulting plunger and shift lever movement cause the pinion to engage the engine flywheel ring gear. The solenoid contacts then close, and cranking takes place. When the engine starts, the motor pinion is backed out of mesh with the ring gear to prevent excessive armature speeds.

CRANKING MOTOR LUBRICATION

Some motors do not require lubrication except during overhaul, whereas others are provided with lubrication fittings. If a means for lubricating is provided, the motor should be lubricated at periodic intervals as dictated by operating conditions by adding 8-10 drops of medium grade engine oil to hinge cap oilers and oil tubes sealed with pipe plugs.

When the motor is disassembled for any reason, lubricate as follows:

1. Oil wicks, if present, should be resaturated. Bushings should be coated with medium grade engine oil.
2. The armature shaft and bushings should be coated with Delco-Remy Lubricant No. 1960954.
3. The drive should be wiped clean and coated with a medium grade engine oil.
4. Avoid excessive lubrication.

TROUBLESHOOTING THE CRANKING CIRCUIT

Before removing any unit in a cranking circuit for repair, the following checks should be made:

Battery: To determine the condition of the battery, follow the testing procedure outlined in Service Bulletin 1B-115 or 1B-116. Insure that the battery is fully charged.

Wiring: Inspect the wiring for damage. Inspect all connections to the cranking motor, solenoid or magnetic switch, ignition switch or any other control switch, and battery, including all ground connections. Clean and tighten all connections as required.

Magnetic Switch or Solenoid and Control Switches: Inspect all switches to determine their condition. Connect a jumper lead around any switch suspected of being defective. If the system functions properly using this method, repair or replace the bypassed switch.

Motor: If the battery, wiring and switches are in satisfactory condition, and the engine is known to be functioning properly, remove the motor and follow the test procedures outlined below.

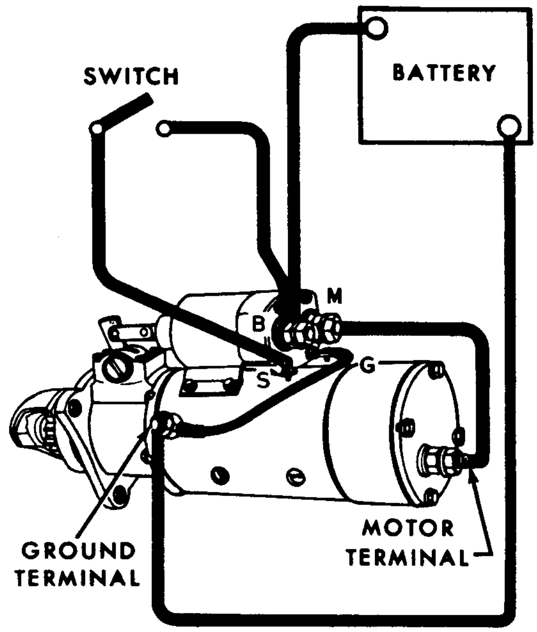


Figure 2—Typical wiring circuit.

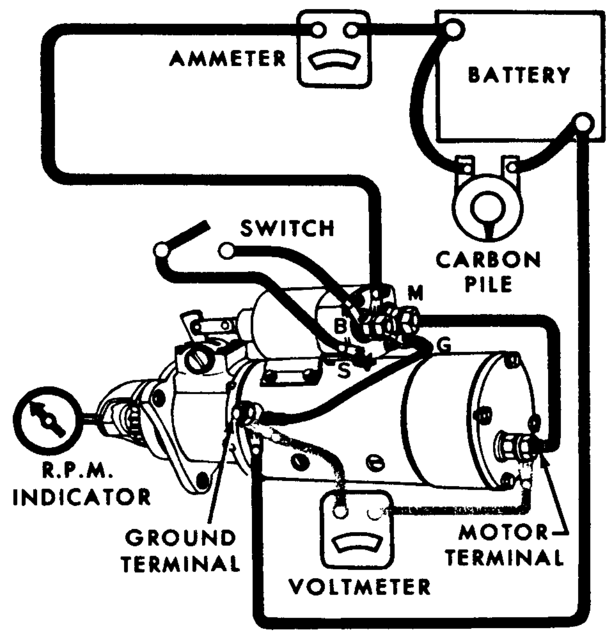


Figure 3—No-load test circuit.

The motor should never be operated for more than 30 seconds at a time without pausing to allow it to cool for at least two minutes. Overheating caused by excessive cranking will seriously damage the cranking motor.

CRANKING MOTOR TESTS

With the cranking motor removed from the engine, the armature should be checked for freedom of rotation by prying the pinion with a screwdriver. Tight bearings, a bent armature shaft, or a loose pole shoe screw will cause the armature to not turn freely. If the armature does not turn freely the motor should be disassembled immediately. However, if the armature does rotate freely, the motor should be given a no-load test before disassembly.

No-Load Test (Fig. 3)

Connect a voltmeter from the motor terminal to the motor frame or return terminal, and use an r.p.m. indicator to measure armature speed. Connect the motor and an ammeter in series with a fully charged battery of the specified voltage, and a switch in the open position from the solenoid battery terminal to the solenoid switch terminal. Close the switch and compare the r.p.m., current, and voltage readings with the specifications in Service Bulletins 1M-180, 1M-185, 1M-186, or 1M-187. It is not necessary to obtain the exact voltage specified in these bulletins, as an accurate interpretation can be made by recognizing that if the voltage is slightly higher the r.p.m. will be proportionately higher, with the current remaining essentially unchanged. However, if the exact voltage is desired, a carbon pile connected across the battery can be used to reduce the voltage to the specified value. If more than one battery is used in series, connect the carbon pile across only one of the batteries. If the specified current draw does not include the solenoid, deduct from the ammeter reading the specified current draw of the solenoid hold-in winding. Make disconnections only with the switch open. Interpret the test result as follows:

1. Rated current draw and no-load speed indicate normal condition of the cranking motor.
2. Low free speed and high current draw indicate:
   a. Too much friction—tight, dirty, or worn bearings, bent armature shaft or loose pole shoes allowing armature to drag.
   b. Shorted armature. This can be further checked on a growler after disassembly.
   c. Grounded armature or fields. Check further after disassembly.
3. Failure to operate with high current draw indicates:
   a. A direct ground in the terminal or fields.
   b. "Frozen" bearings (this should have been determined by turning the armature by hand).
4. Failure to operate with no current draw indicates:
   a. Open field circuit. This can be checked after disassembly by inspecting internal connections and tracing circuit with a test lamp.
   b. Open armature coils. Inspect the commutator for badly burned bars after disassembly.

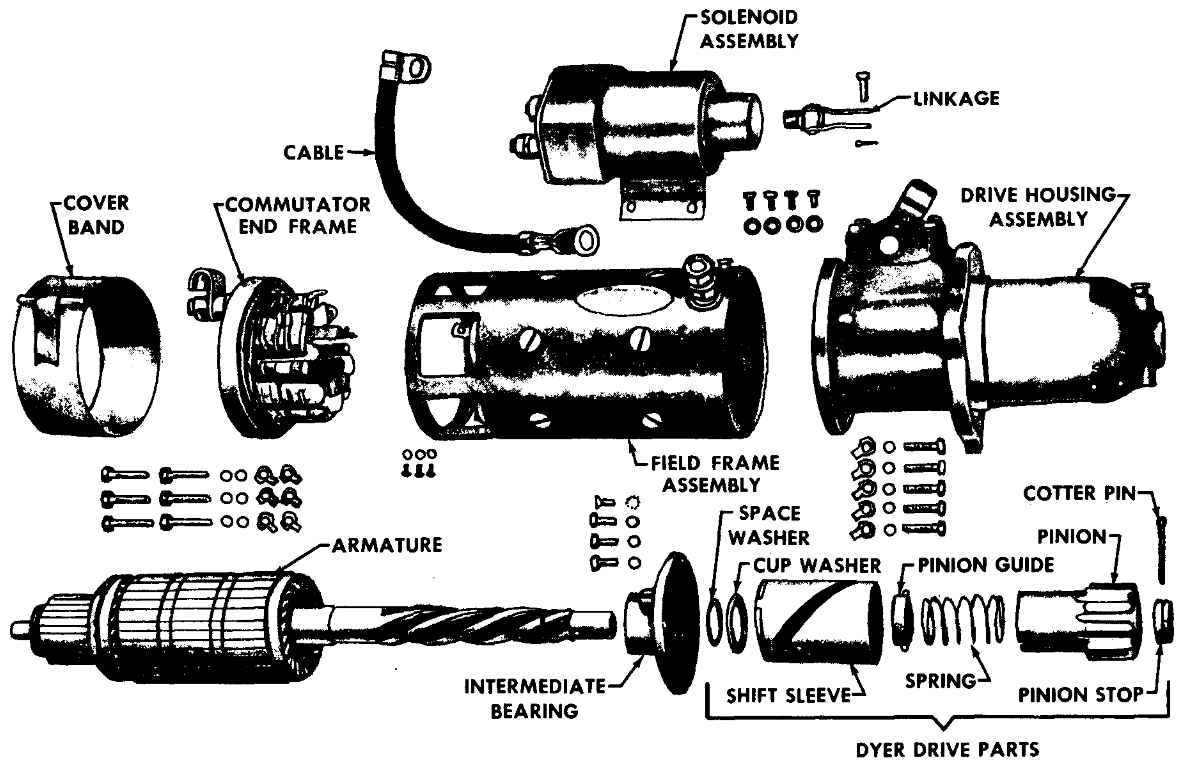


Figure 4—Disassembled view of heavy duty Dyer drive cranking motor.

c. Broken brush springs, worn brushes, high insulation between the commutator bars or other causes which would prevent good contact between the brushes and commutator.

5. Low no-load speed and low current draw indicate:

   a. High internal resistance due to poor connections, defective leads, dirty commutator and causes listed under Number 4.

6. High free speed and high current draw indicate shorted fields. If shorted fields are suspected, replace the field coil assembly and check for improved performance.

DISASSEMBLY

If the motor does not perform in accordance with published specifications, it may need to be disassembled for further testing of the components. Normally the cranking motor should be disassembled only so far as is necessary to make repair or replacement of the defective parts. As a precaution it is suggested that safety glasses be worn when disassembling or assembling the cranking motor. Following are general instructions for disassembling a typical Dyer drive type cranking motor:

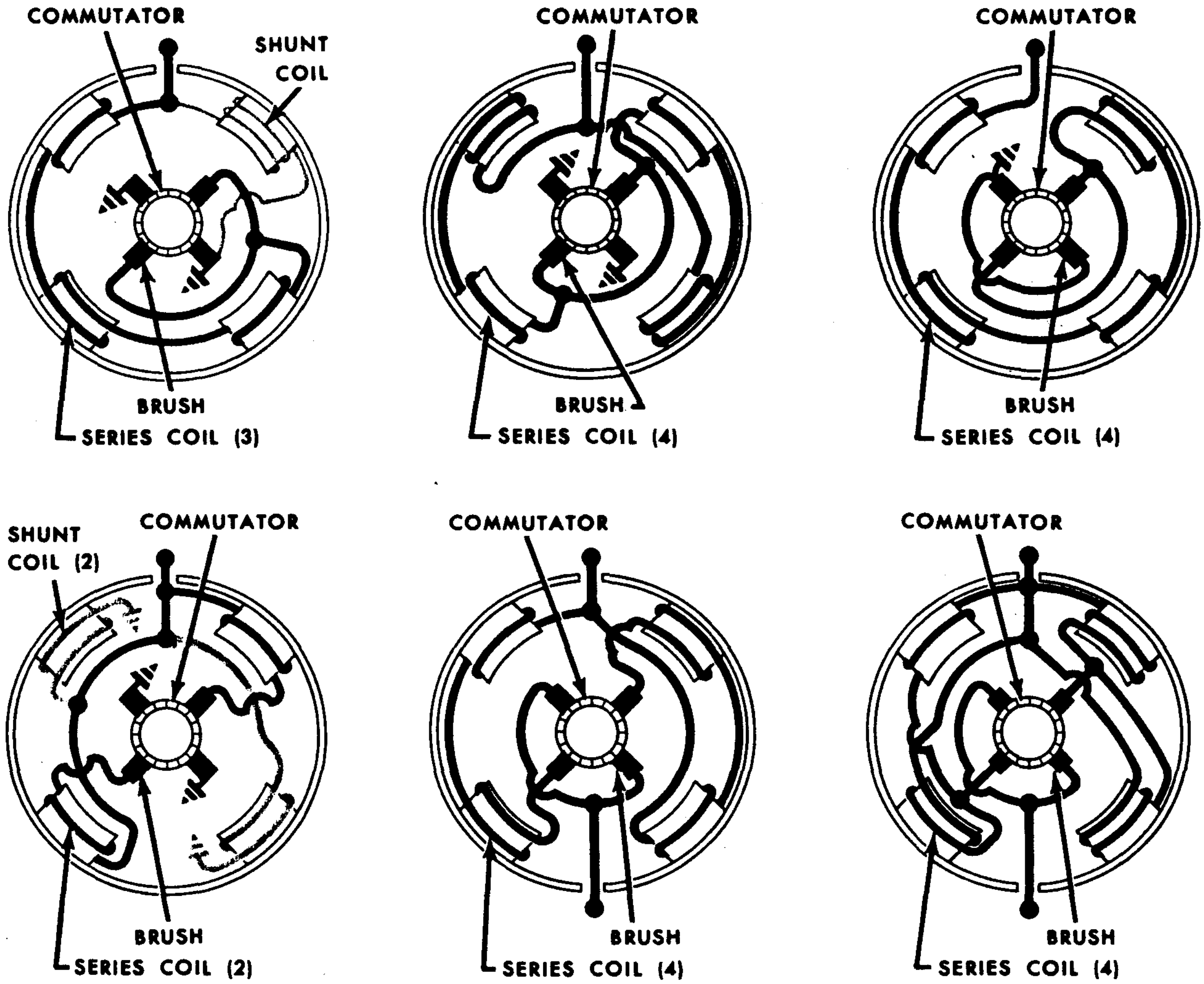
1. Remove the manual or solenoid switch from the field frame and linkage.
2. Remove the bolts from the drive end and commutator end frames. Discard the tang lock washers.
3. Remove the cover band and detach the field coil leads from the brush holders.
4. Remove the commutator and drive end frames from the field frame assembly.
5. Remove the pinion stop from the shaft.
6. Remove the pinion, spring, pinion guide, shift sleeve, cup washer, space washer, and intermediate bearing from the armature shaft (Fig. 4). IMPORTANT: Note carefully the location of the tang on the pinion guide so it can be reassembled in the correct manner.
7. Remove the armature from the field frame.

COMPONENT INSPECTION AND REPAIR

A. Brushes and Brush Holders—Inspect the brushes for wear. If they are excessively worn when compared with a new brush they should be replaced. Make sure the brush holders are clean and the brushes are not binding in the holders. The full brush surface should ride on the commutator to give proper performance. Check by hand to insure that the brush springs are giving firm contact between the brushes and commutator. If the springs are distorted or discolored, they should be replaced.

B. Armature—If the commutator is excessively worn, dirty, out of round, or if it has high insulation, it should be turned down in a lathe and the insulation undercut 1/32" wide and 1/32" deep. IMPORTANT: Do not undercut insulation on motors having Test Specifications 3501 and 3564 as listed in Delco-Remy Service Bulletins 1M-186 and 1M-187.

   The armature should be checked for short circuits, opens, and grounds as follows:



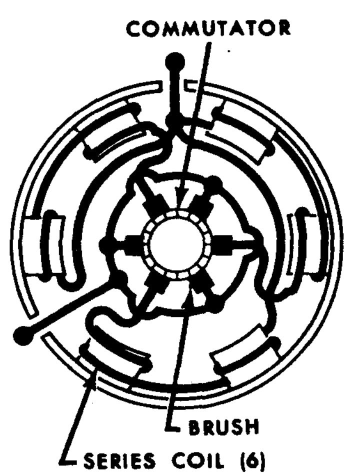


Figure 5—Typical motor circuits.

1. Short circuits are located by rotating the armature in a growler with a steel strip, such as a hacksaw blade, held on the armature. The steel strip will vibrate on the area of the short circuit. Shorts between bars are sometimes produced by brush dust or copper between the bars. Undercutting the insulation will eliminate these shorts as outlined above.
2. Opens—Inspect the points where the conductors are joined to the commutator for loose connections. Poor connections cause arcing and burning of the commutator. If the bars are not badly burned, leads originally soldered to the riser bars can be resoldered.
3. Grounds in the armature can be detected by the use of a test lamp. If the lamp lights when one test prod is placed on the commutator and the other test prod on the armature core or shaft, the armature is grounded.

If the commutator is worn, dirty, out of round, or has high insulation, the commutator should be turned down and undercut as previously described.

C. Field Coils—The field coils should be checked for grounds and opens using a test lamp. Typical circuits are shown in Figure 5.

1. Grounds — Disconnect field coil ground connections. Connect one test prod to the field frame and

the other to the field connector. If the lamp lights the field coils are grounded and must be repaired or replaced. This check cannot be made if the ground connection cannot be disconnected.

2. Opens—Connect test lamp prods to field coils. If lamp does not light, the field coils are open.

If the field coils need to be removed for repair or replacement, a pole shoe spreader and pole shoe screwdriver should be used. Care should be exercised in replacing the field coils to prevent grounding or shorting them as they are tightened into place. Where the pole shoe has a long lip on one side, it should be assembled in the direction of armature rotation.

D. Solenoid—A basic solenoid circuit is shown in Figure 6. Solenoids may differ in appearance, but can be checked electrically by connecting a battery of the specified voltage, a switch, and an ammeter to the two solenoid windings. With all leads disconnected from the solenoid, make test connections as shown to the solenoid switch (S or SW) terminal and to ground (G), or to the second switch terminal, if present, to check the hold-in winding (Fig. 7). Use the carbon pile across the battery to decrease the battery voltage to the value specified in Service Bulletins 1S-180, 1S-186, or 1S-187, and compare the ammeter reading with specifications. A high reading indicates a shorted or grounded hold-in winding, and a low reading excessive resistance. To check the pull-in winding connect to the solenoid switch terminal (S or SW), and to the solenoid motor (M or MOT) terminal. NOTE: If needed to reduce the voltage to the specified value, connect the carbon pile between the battery and "M" terminal as shown in dashed red lines instead of across the battery as shown in solid red lines. If not needed, connect a jumper directly from the battery to the "M" terminal as shown in dashed red lines. CAUTION: To prevent overheating, do not leave the pull-in winding energized more than 15 seconds. The current draw will decrease as the winding temperature increases.

REASSEMBLY

1. Place the armature in the field frame assembly.

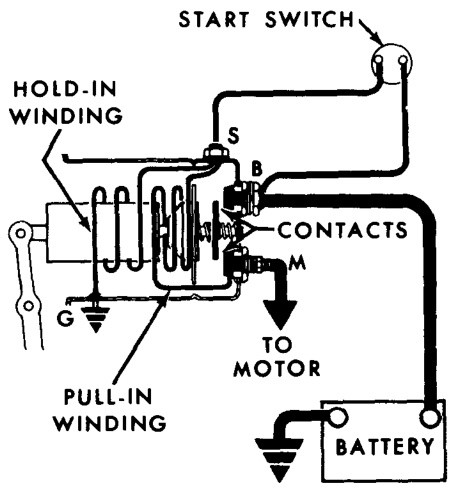


Figure 6—Basic solenoid circuit.

2. Replace, and in this order, the intermediate bearing, space washer, cup washer, and shift sleeve. Figure 4 illustrates the proper positioning of the Dyer drive parts.
3. The pinion guide, spring, and pinion must be replaced as an assembly as shown in Figure 8. IMPORTANT: If the pinion guide has an identifying letter "T" stamped on the side, the pinion guide must be assembled with the tangs or lugs **away from** the pinion.
4. Replace the pinion stop using a new cotter pin.
5. Place the drive housing over the shaft and Dyer drive. Position the housing linkage properly into the shift sleeve (Fig. 1).
6. Attach the drive and commutator end frames to the field frame using bolts and new tang type lock washers.

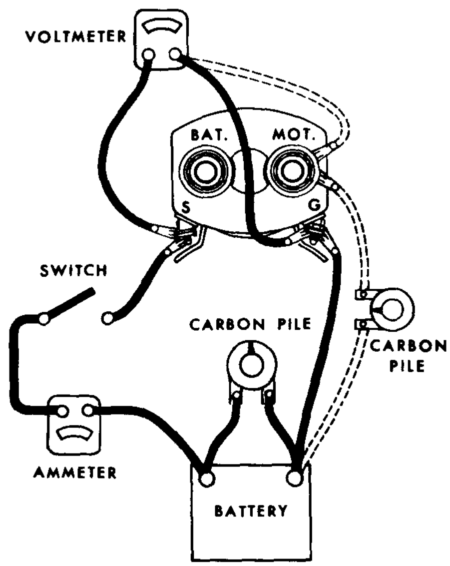


Figure 7—Circuit for checking hold-in and pull-in windings. (Note: Terminal locations may vary.)

7. Attach the manual or solenoid switch to the field frame.
8. Reconnect the terminals and leads as necessary.

PINION TRAVEL

Pinion travel should be checked after reassembly of the motor to insure proper adjustment.

To check pinion travel follow the steps listed below. If the motor is manually operated, shift the pinion by hand and start with step Number 4.

1. Disconnect the motor field coil con-

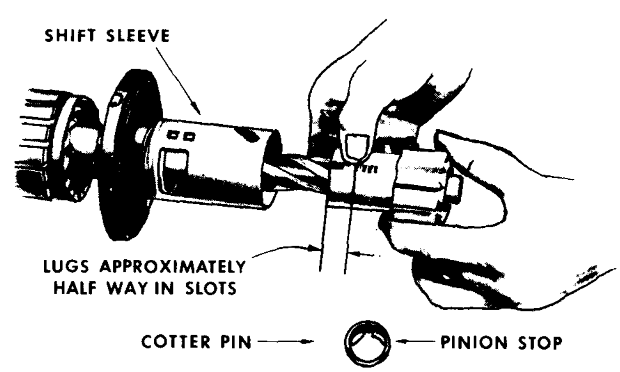


Figure 8—Procedure of reassembling pinion, pinion guide, and spring in Dyer drive assembly.

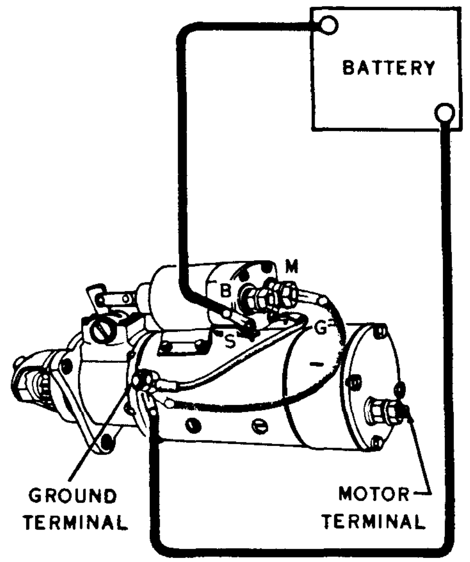


Figure 9—Shifting the drive into mesh in order to check pinion clearance.

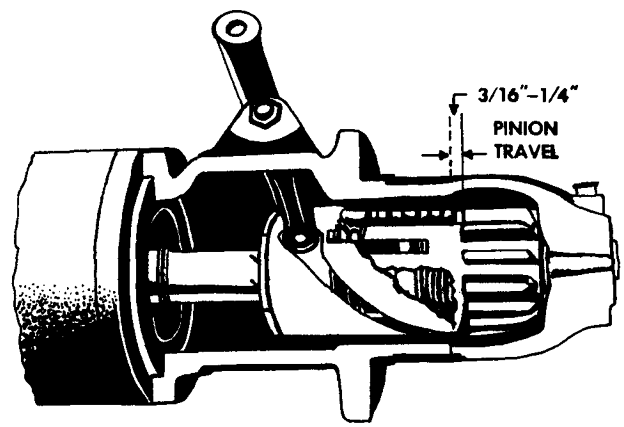


Figure 10—Pinion travel check in Dyer drive assembly.

nection from the solenoid motor terminal and insulate carefully.

2. Connect a battery of the same voltage as the solenoid, from the solenoid switch terminal to the solenoid frame or ground terminal (Fig. 9).
3. MOMENTARILY flash a jumper lead from the solenoid motor terminal to the solenoid frame or ground terminal. The pinion will now shift into cranking position and remain so until the battery is disconnected.
4. Push the pinion back toward the commutator end to eliminate slack movement.
5. Measure the pinion travel (Fig. 10).
   a. Pinion travel should be 3/16"-1/4".
   b. Pinion travel may be adjusted by turning the threaded solenoid plunger shaft in or out. Manually operated units may be adjusted by turning the shift lever adjusting stud in or out.

CHAMFERS OF RING GEAR TEETH

Figure 11 illustrates the importance of matching drive pinion and flywheel ring gear teeth properly. The left view shows the action of an overrunning clutch or Bendix pinion as it engages with the correct type ring gear. However, if a Dyer drive pinion is used with a ring gear chamfered on the nonpressure side (center view), then difficulty is likely to be encountered in engagement. In this case, when the teeth butt, the pinion must move back and up as shown by the arrows before engagement can take place. It must be remembered that with the Dyer drive cranking motor, pinion movement for engagement is in one direction while pinion movement during cranking is in the opposite direction.

The action of a Dyer drive pinion engaging with a Dyer drive type ring gear after teeth butt is shown to the right in Figure 11. It will be noted that the chamfer on the ring gear teeth used in connection with a Dyer drive cranking motor must be the reverse of the chamfer on a ring gear used with an overrunning clutch or Bendix drive. If the wrong type of ring gear is used, repeated attempts will be required for engagement, and burring of the teeth is likely to occur.

NOTE: Recommended hardness for ring gears used in connection with Dyer drive cranking motors is Rockwell "C" scale 45-52.

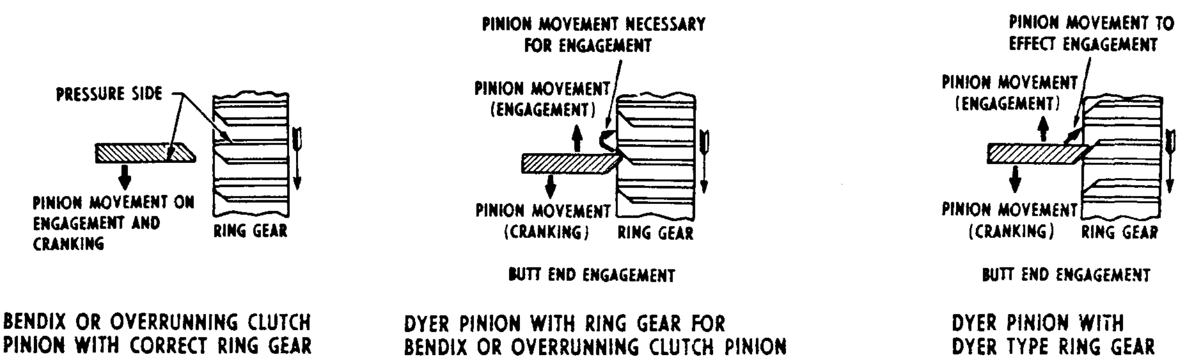


Figure 11—Action of Dyer drive type pinion in engaging with flywheel teeth of different chamfers.

Delco Remy

CRANKING MOTORS

30-MT, 35-MT, 40-MT, 50-MT Series

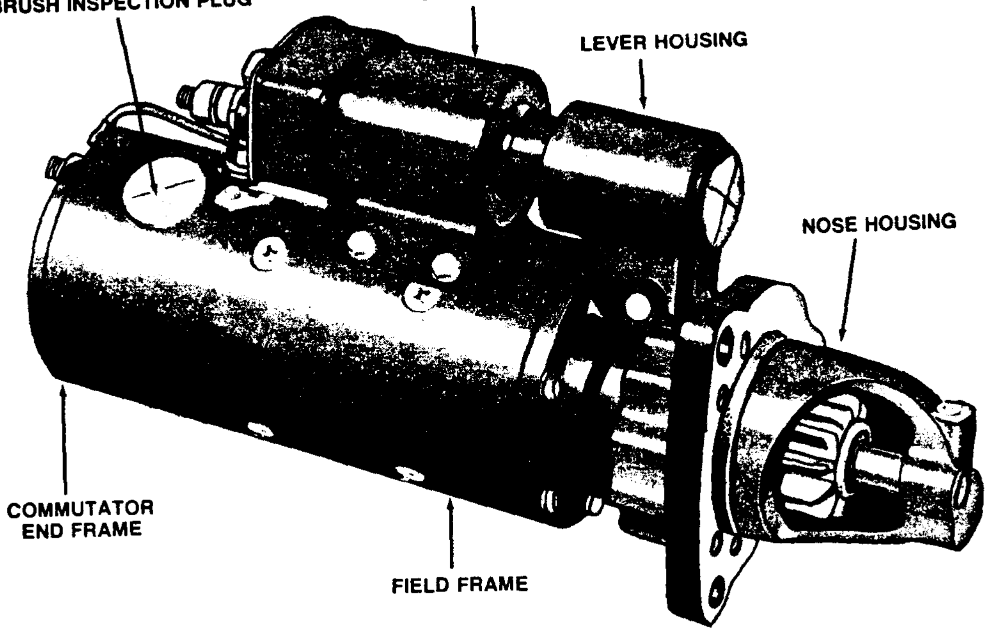


Figure 1—Typical 50-MT Series heavy duty cranking motor.

The heavy duty cranking motors covered in this bulletin have a shift lever and solenoid plunger that are totally enclosed to protect them from exposure to dirt, icing conditions and splash. The nose housing can be rotated to obtain a number of different solenoid positions with respect to the mounting flange, which is a feature that makes these motors universally adaptable to a wide variety of different mounting applications.

Positive lubrication is provided to the bronze bushings by an oil saturated wick that projects through the bushings and contacts the armature shaft. Oil can be added to each wick by removing a pipe plug which is accessible on the outside of the motor.

Available as an optional feature are oil reservoirs for the bronze bearings which makes available a larger oil supply thereby extending the time required between lubrication periods. Another optional feature is "O" rings which can be added to resist entry of dirt and moisture into the entire motor assembly. When the oil reservoirs and "O" rings are included, the motor will provide long periods of attention-free operation.

Many models feature a seal between the shaft and lever housing and all models have a rubber boot or linkage seal over the solenoid plunger. The seal and the boot, when used together, prevent entry of oil into the motor main frame and solenoid case, allowing the motor to be used on wet clutch applications.

Four kinds of clutches, a heavy duty sprag, a Positork drive, an intermediate duty type and a splined drive, may be used with enclosed heavy duty type cranking motors. All four types are moved into mesh with the ring gear by the action of the solenoid. The pinion remains engaged until starting is assured and the solenoid circuit is interrupted. In case of a butt engagement with the heavy duty sprag clutch or Positork drive, the motor will not be energized to prevent damage to the pinion and gear teeth. The spline drive is normally used on gas turbine applications, and can be engaged into the turbine spline gear before the turbine gear has coasted to a stop.

CRANKING MOTORS

1M-153 Service Bulletin

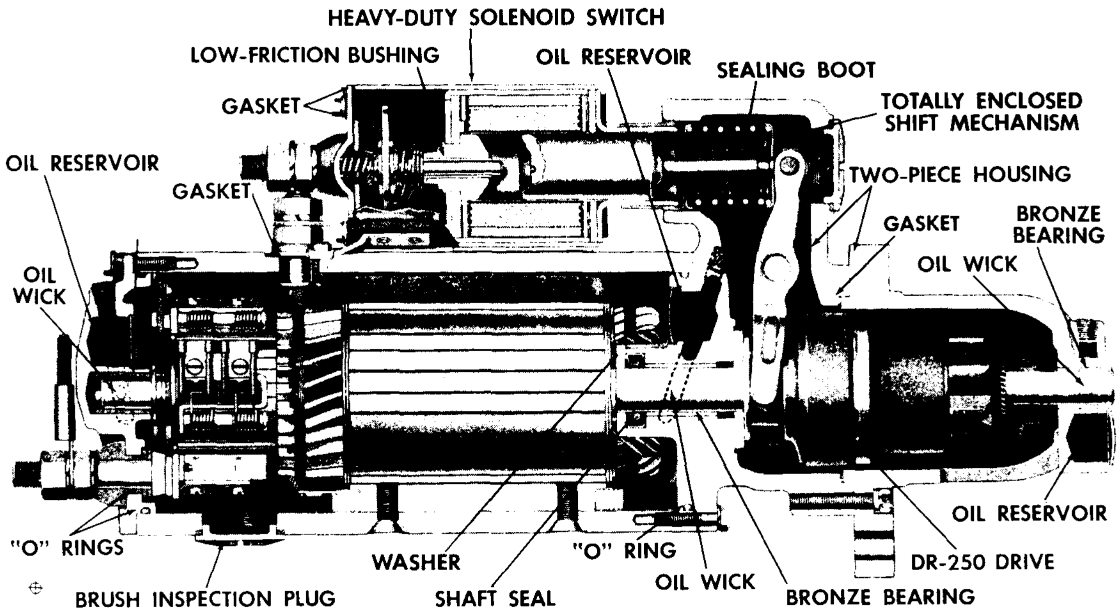


Figure 2—Cross-sectional view of motor with DR-250 heavy duty drive (50-MT). (Some models use heavy duty sprag clutch illustrated in Figures 14 and 15.)

MAINTENANCE

Under normal operating conditions, no maintenance will be required between engine overhaul periods. At time of engine overhaul, motors should be disassembled, inspected, cleaned, and tested as described in succeeding paragraphs.

ADJUSTABLE NOSE HOUSING

Two methods are employed to attach the nose housing to the lever housing. As shown in the cross-sectional views of Figure 2, Figure 3, and Figure 4, one method attaches the nose housing to the lever housing by means of bolts located around the outside of the housing. To relocate the housing, it is only necessary to remove the bolts, rotate the housing to the desired position, and reinstall the bolts. The bolts should be torqued to 13-17 lb. ft. during reassembly. In this type of assembly, the lever housing and the commutator end frame are attached to the field frame independently by bolts entering threaded holes in the field frame.

In the second method, where the intermediate duty clutch is used, the lever housing and commutator end frame are held to the field frame by thru-bolts extending from the commutator end frame to threaded holes in the lever housing. The nose housing is held to the lever housing by internal attaching bolts extending from the lever housing to threaded holes in

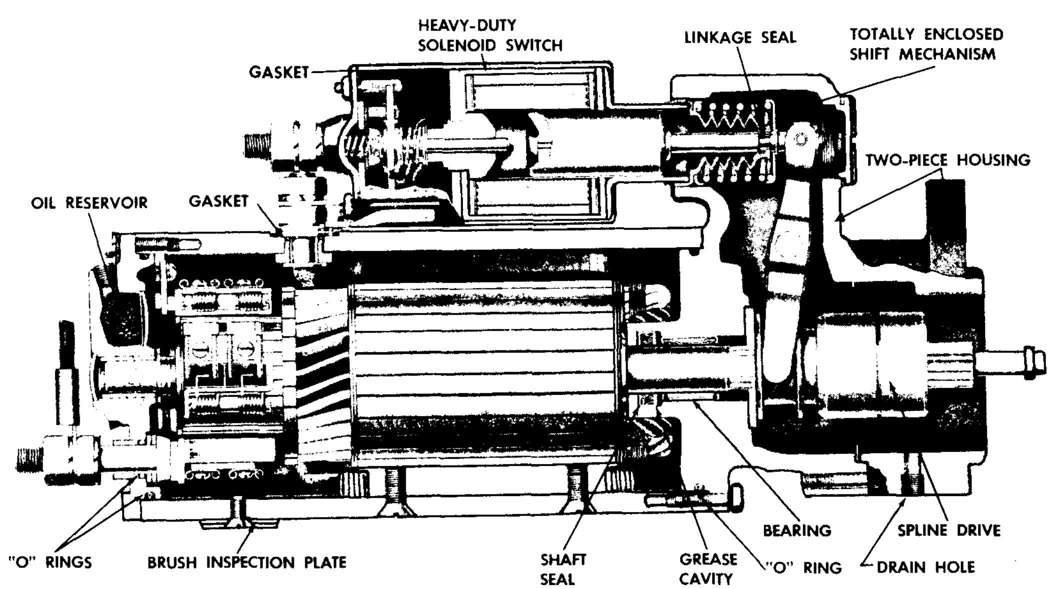


Figure 3—Cross-sectional view of motor with spline drive (50-MT).

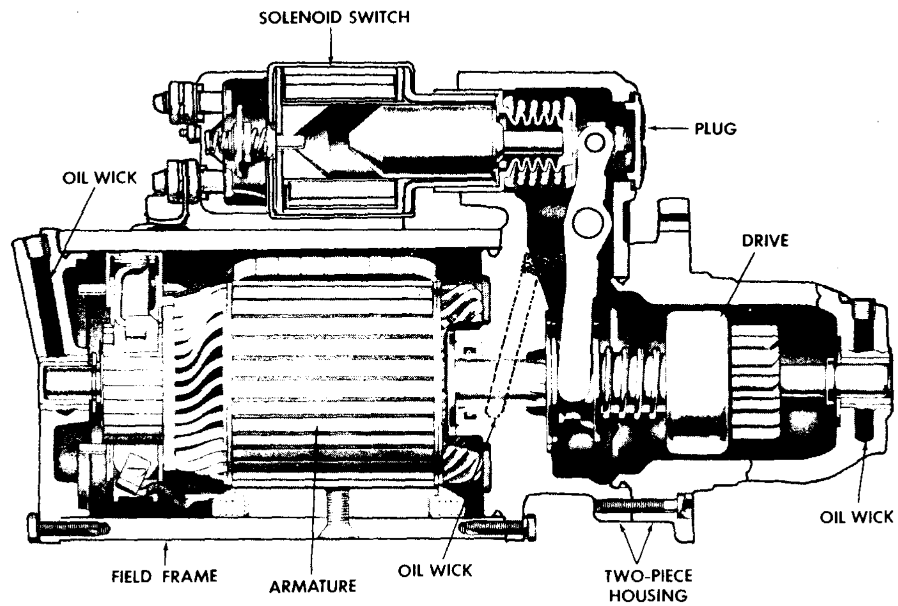


Figure 4—Cross-sectional view of motor with intermediate duty clutch. (35-MT) Note different attaching bolt construction than Figure 5.

the nose housing (Fig. 5). With this arrangement, it is necessary to partially disassemble the motor to provide access to the attaching bolts when relocating the nose housing.

To accomplish this, remove the electrical connector and the screws attaching the solenoid assembly to the field frame and then remove the thru-bolts from the commutator end frame. Separate the field frame from the remaining assembly, and pull the armature away from the lever housing until the pinion stop rests against the clutch pinion. This will clear the nose housing attaching bolts so they can be removed with a box or open end wrench, permitting relocation of the nose housing. During reassembly, torque the nose housing attaching bolts to 11-15 lb. ft.

OPERATION

There are many different cranking motor circuits used on various applications. The cranking circuit may contain a key start switch or push switch, or both, a relay, magnetic switches, solenoids, oil pressure switch, fuel pressure switch and other protective devices, such as an "ALDO" relay.

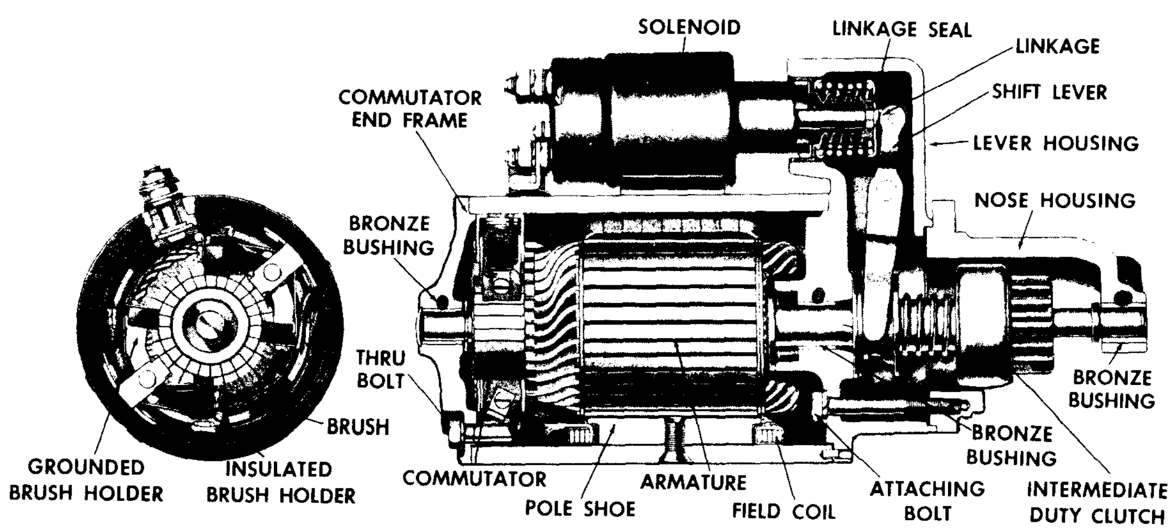


Figure 5—Cross-sectional view of motor with intermediate duty clutch. Note different attaching bolt construction than Figure 4

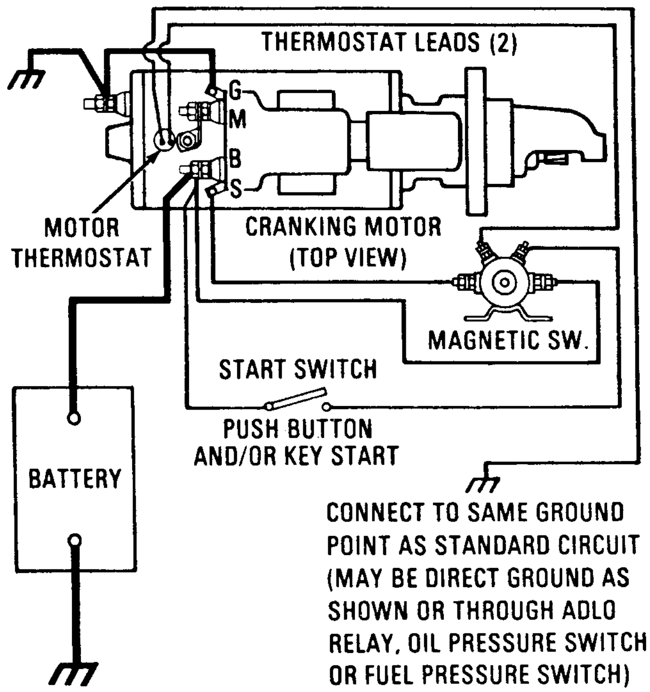


Figure 6—Basic wiring circuit.

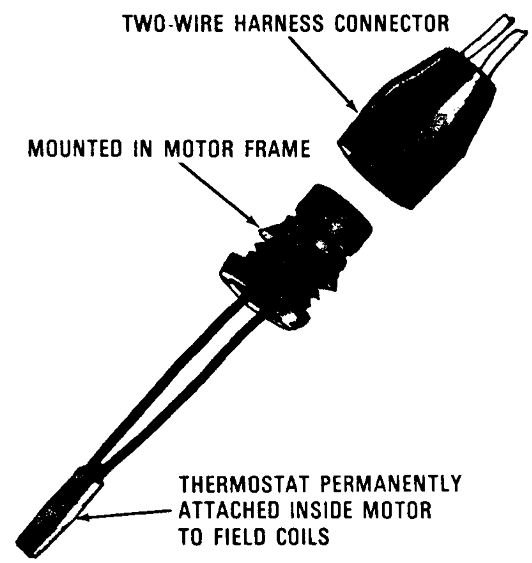


Figure 7—Typical thermostat.

Reference should be made to the vehicle manufacturer's wiring diagram for the complete cranking circuit.

A typical circuit is shown in Figure 6. The motor shown has a built-in thermostat to protect against damage due to over-cranking for excessively long periods of time. Thermostat components separated from the field coils and motor frame are shown in Figure 7. Also a motor with harness disconnected from the thermostat is shown in Figure 8.

When the start switch is closed, battery current flows through the magnetic switch winding and the thermostat to ground, as shown in Figure 6. The magnetic switch closes, connecting the motor solenoid "S" terminal to the battery.

The solenoid windings are energized and the resulting plunger and shift lever movement causes the pinion to engage the engine flywheel ring gear and the solenoid main contacts to close, and cranking takes place. When the engine starts, pinion overrun protects the armature from excessive speed until the switch is opened, at which time the return spring causes the pinion to disengage. To prevent excessive overrun and damage to the drive and armature windings, the switch must be opened immediately when the engine starts.

A cranking period for all types of motors should never exceed 30 seconds without stopping to allow the motor to cool. If over-cranking should occur, the thermostat will open and the cranking cycle will stop to protect the motor. After the cranking motor cools, usually 1-6 minutes, the thermostat will close and then a new starting attempt can be made.

A circuit without the motor thermostat would be the same as Figure 6, except the magnetic switch winding terminal would be grounded directly to the point noted in Figure 6, without passing through a thermostat.

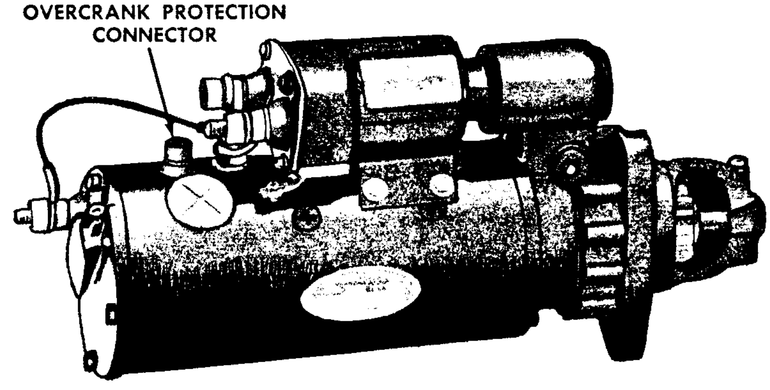


Figure 8—Typical motor showing thermostat connector.

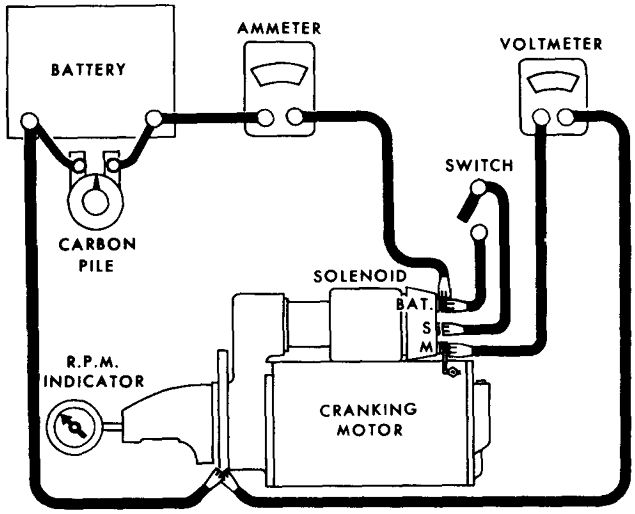


Figure 9—No-load test circuit.

TROUBLESHOOTING THE CRANKING CIRCUIT

Before removing any unit in a cranking circuit for repair, the following checks should be made:

Battery: To determine the condition of the battery, follow the testing procedure outlined in Service Bulletin 1B-115 or 1B-116. Insure that the battery is fully charged.

Wiring: Inspect the wiring for damage. Inspect all connections to the cranking motor, solenoid, magnetic switch, ignition switch or any other control switch, and battery, including all ground connections. Clean and tighten all connections as required.

Magnetic Switch, Solenoid and Control Switches: Inspect all switches to determine their condition. From the vehicle wiring diagram, determine which circuits should be energized with the starting switches closed. Use a voltmeter to detect any open circuits.

Thermostat, or Overcrank Protection:

To check the thermostat for continuity, detach wiring harness connector and connect an **ohmmeter** to the two thermostat terminals on the motor. (Fig. 8). The ohmmeter should read zero. If not, thermostat is open circuit. DO NOT check thermostat when hot, since it is supposed to be open-circuit above certain temperatures.

Motor: If the battery, wiring and switches are in satisfactory condition, and the engine is known to be functioning properly, remove the motor and follow the test procedures outlined below.

CRANKING MOTOR TESTS

Regardless of the construction, never operate the cranking motor more than 30 seconds at a time without pausing to allow it to cool at least two minutes. On some applications, 30 seconds may be excessive. Overheating, caused by excessive cranking will seriously damage the cranking motor (without thermostat).

With the cranking motor removed from the engine, the armature should be checked for freedom of rotation by prying the pinion with a screwdriver. Tight bearings, a bent armature shaft, or a loose pole shoe screw will cause the armature to not turn freely. If the armature does not turn freely the motor should be disassembled immediately. However, if the armature does rotate freely, the motor should be given a no-load test before disassembly.

No-Load Test (Fig. 9)

Connect a voltmeter from the motor terminal to the motor frame, and use an r.p.m. indicator to measure armature speed. Connect the motor and an ammeter in series with a fully charged battery of the specified voltage, and a switch in the open position from the solenoid battery terminal to the solenoid switch terminal. Close the switch and compare the r.p.m., current, and voltage reading with the specifications in Service Bulletins 1M-186, 1M-187, or 1M-188. It is not necessary to obtain the exact voltage specified in these bulletins, as an accurate interpretation can be made by recognizing that if the voltage is slightly higher the r.p.m. will be proportionately higher, with the current remaining essentially unchanged. However, if the exact voltage is desired, a carbon pile connected across the battery can be used to reduce the voltage to the specified value. If more than one 12-volt battery is used, connect the carbon pile to only one of the 12-volt batteries. If the specified current draw does not include the solenoid, deduct from the ammeter reading the specified current draw of the solenoid hold-in winding. Make disconnections only with the switch open. Interpret the test results as follows:

Interpreting Results of Tests

1. **Rated current draw and no-load speed indicates normal condition of the cranking motor.**
2. **Low free speed and high current draw indicate:**
   a. Too much friction—tight, dirty, or worn bearings, bent armature shaft or loose pole shoes allowing armature to drag.

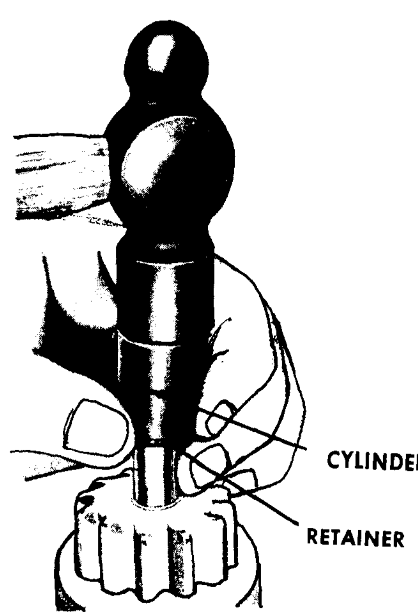


Figure 10—Removing retainer from snap ring.

b. Shorted armature. This can be further checked on a growler after disassembly.

c. Grounded armature or fields. Check further after disassembly.

3. **Failure to operate with high current draw indicates:**

a. A direct ground in the terminal or fields.

b. "Frozen" bearings (this should have been determined by turning the armature by hand).

4. **Failure to operate with no current draw indicates:**

a. Open field circuit. This can be checked after disassembly by inspecting internal connections and tracing circuit with a test lamp.

b. Open armature coils. Inspect the commutator for badly burned bars after disassembly.

c. Broken brush springs, worn brushes, high insulation between the commutator bars or other causes which would prevent good contact between the brushes and commutator.

5. **Low no-load speed and low current draw indicate:**

a. High internal resistance due to poor connections, defective leads, dirty commutator and causes listed under Number 4.

6. **High free speed and high current draw indicate shorted fields.** If shorted fields are suspected, replace the field coil assembly and check for improved performance.

DISASSEMBLY

Normally the cranking motor should be disassembled only so far as is necessary to make repair or replacement of the defective parts. As a precaution, it is suggested that safety glasses be worn when disassembling or assembling the cranking motor.

Intermediate Duty Clutch Motor

1. Note the relative position of the solenoid, lever housing, and nose housing so the motor can be reassembled in the same manner.
2. Disconnect field coil connector from solenoid motor terminal, and remove solenoid mounting screws.
3. Remove thru-bolt or cap screws.
4. Remove commutator end frame from field frame and field frame from lever housing.

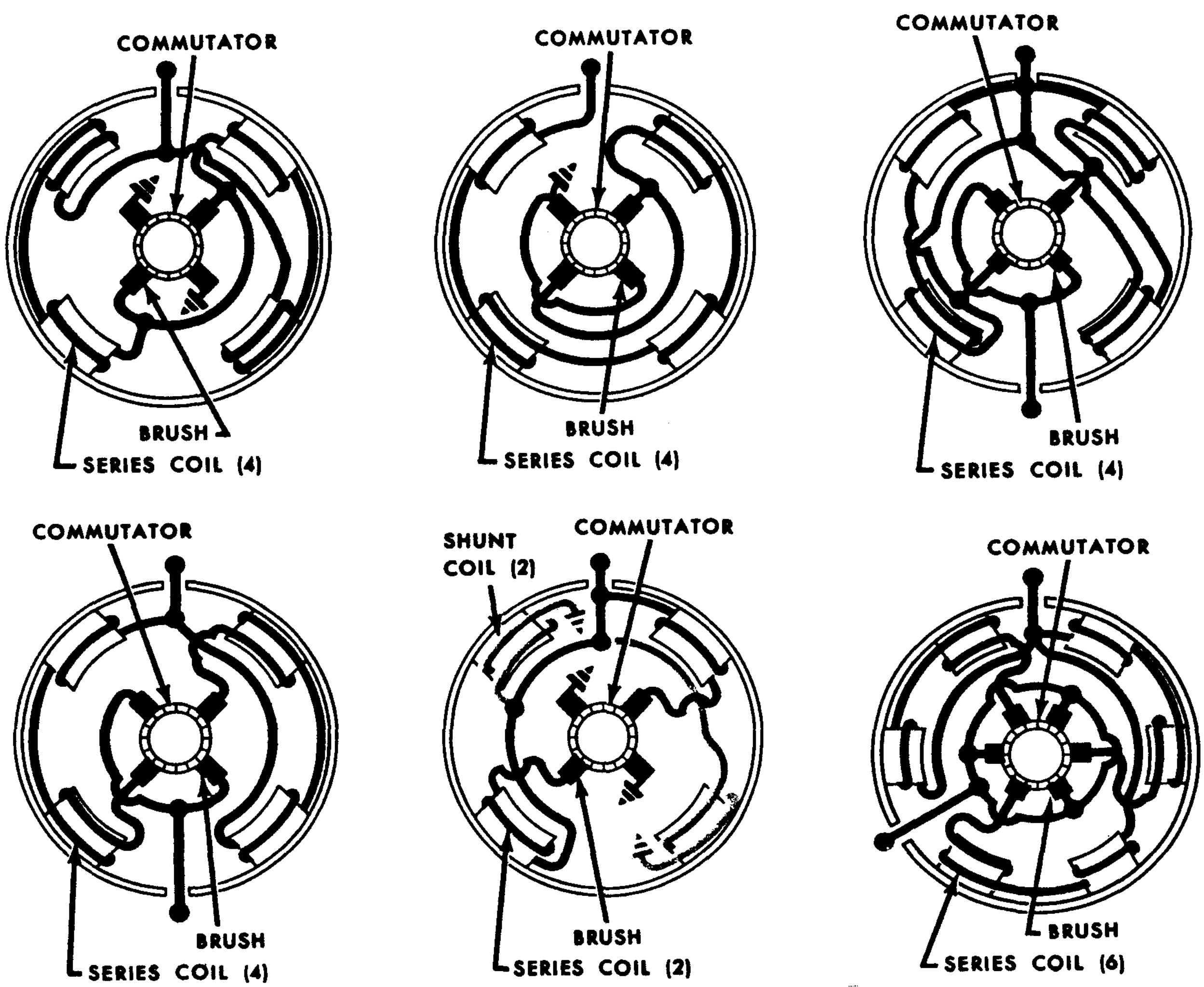


Figure 11—Typical motor circuits.

2. Disconnect field coil connector from solenoid motor terminal, and lead from solenoid ground terminal.
3. On motors which have brush inspection plates, remove the plates and then remove the brush lead screws. This will disconnect the field leads from the brush holders.
4. Remove the attaching bolts and separate the commutator end frame from the field frame.
5. Separate the nose housing and field frame from lever housing by removing attaching bolts.
6. Remove armature and clutch assembly from lever housing.
7. Separate solenoid from lever housing by pulling apart.

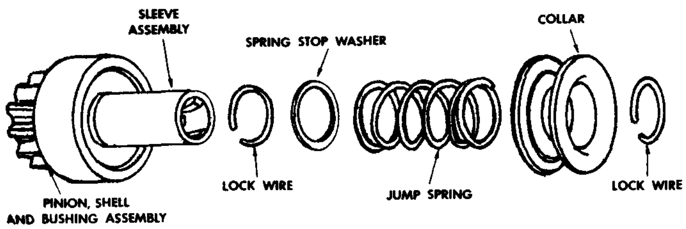


Figure 12—Disassembled view of early type intermediate duty sprag clutch drive assembly.

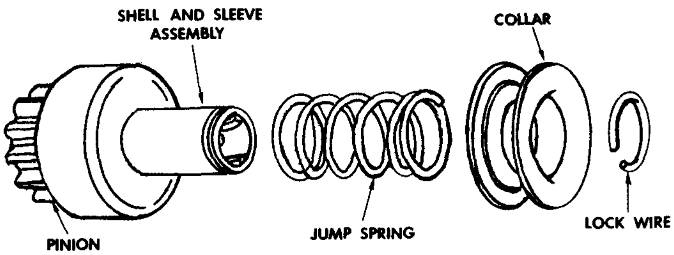


Figure 13—Disassembled view of late type intermediate duty sprag clutch drive assembly.

5. Remove nose housing attaching bolts and separate nose housing from lever housing.
6. Slide a standard half-inch pipe coupling or other metal cylinder of suitable size (an old pinion of suitable size can be used if available) onto shaft so end of coupling or cylinder butts against edge of retainer. Tap end of coupling with hammer, driving retainer towards armature and off snap ring (Fig. 10).
7. Remove snap ring from groove in shaft using pliers or other suitable tool. If snap ring is too badly distorted during removal it may be necessary to use a new one when reassembling clutch.
8. Remove the armature and clutch from the lever housing.
9. Separate the solenoid from the lever housing.

Heavy Duty Clutch, Positork Drive, and Spline Drive Motors

1. Note the relative position of the solenoid, lever housing, and nose housing so the motor can be reassembled in the same manner.

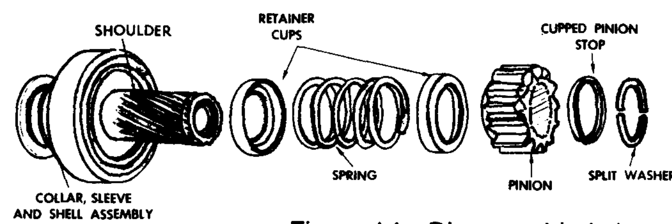


Figure 14—Disassembled view of early type heavy duty sprag clutch drive assembly.

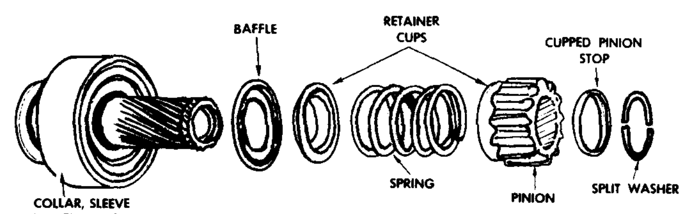


Figure 15—Disassembled view of late type heavy duty sprag clutch drive assembly.

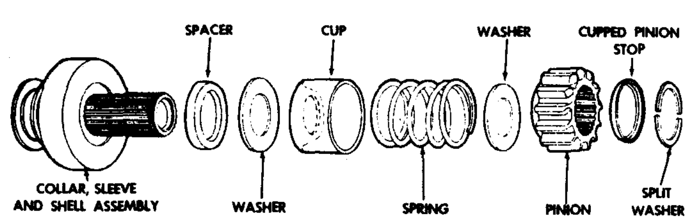


Figure 16—Disassembled view of DR-250 drive.

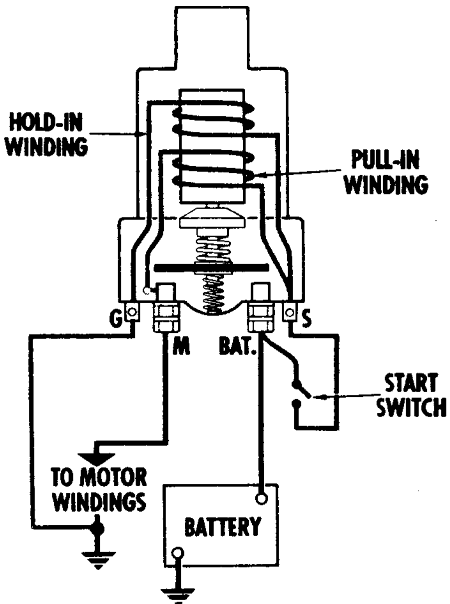


Figure 17—Basic solenoid circuit. (Types shown in Figures 1, 2, and 3.)

CLEANING

The drive, armature and fields should not be cleaned in any degreasing tank, or with grease dissolving solvents, since these would dissolve the lubricant in the drive and damage the insulation in the armature and field coils. All parts except the drive should be cleaned with mineral spirits and a brush. The drive can be wiped with a clean cloth.

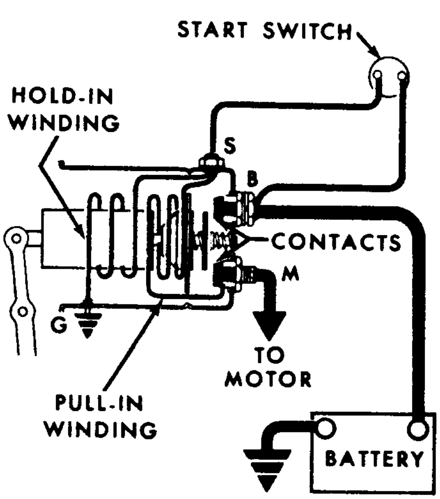


Figure 18—Basic solenoid circuit. (Types shown in Figures 4 and 5.)

If the commutator is dirty it may be cleaned with No. 00 sandpaper. NEVER USE EMERY CLOTH TO CLEAN COMMUTATOR.

Brushes and Holders

Inspect the brushes for wear. If they are worn excessively when compared with a new brush, they should be replaced. Make sure the brush holders are clean and the brushes are not binding in the holders. The full brush surface should ride on the commutator to give proper performance. Check by hand to insure that the brush springs are giving firm contact between the brushes and commutator. If the springs are distorted or discolored, they should be replaced.

ARMATURE SERVICING

If the armature commutator is worn, dirty, out of round, or has high insulation, the armature should be put in a lathe so the commutator can be turned down. The insulation should then be undercut 1/32 of an inch wide and 1/32 of an inch deep, and the slots cleaned out to remove any trace of dirt or copper dust. As a final step in this procedure, the commutator should be sanded lightly with No. 00 sandpaper to remove any burrs left as a result of the undercutting procedure. **NOTE**: The undercut operation must be omitted on cranking motors having Test Specifications 2412, 2415, 3501, 3564 and 3574 as listed in Delco Remy Service Bulletins 1M-186, 1M-187, and 1M-188. **Do not** undercut commutators on motors having these specifications.

The armature should be checked for opens, short circuits and grounds as follows:

1. Opens—Opens are usually caused by excessively long cranking periods. The most likely place for an open to occur is at the commutator riser bars. Inspect the points where the conductors are joined to the commutator bars for loose connections. Poor connections cause arcing and burning of the commutator bars as the cranking motor is used. If the bars are not too badly burned, repair can often be effected by resoldering or welding the leads in the riser bars (using rosin flux), and turning down the commutator in a lathe to remove the burned material. The insulation should then be undercut except as noted above.

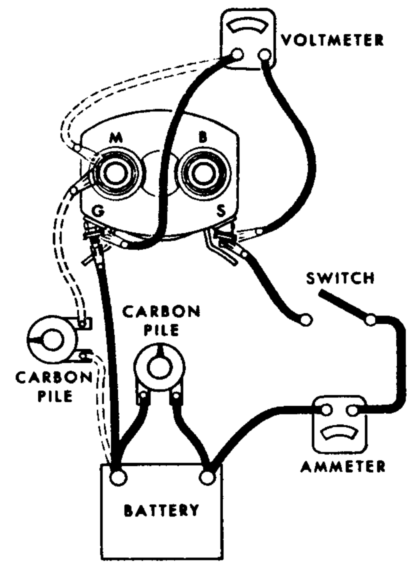


Figure 19—Checking solenoid hold-in and pull-in windings. (Note: Terminal locations may vary.)

2. Short Circuits—Short circuits in the armature are located by use of a growler. When the armature is revolved in the growler with a steel strip such as a hacksaw blade held above it, the blade will vibrate above the area of the armature core in which the short circuit is located. Shorts between bars are sometimes produced by brush dust or copper between the bars. These shorts can be eliminated by cleaning out the slots.
3. Grounds—Grounds in the armature can be detected by the use of a 110-volt test lamp and test points. If the lamp lights when one test point is placed on the commutator with the other point on the core or shaft, the armature is grounded. Grounds occur as a result of insulation failure which is often brought about by overheating of the cranking motor produced by excessively long cranking periods or by accumulation of brush dust between the commutator bars and the steel commutator ring.

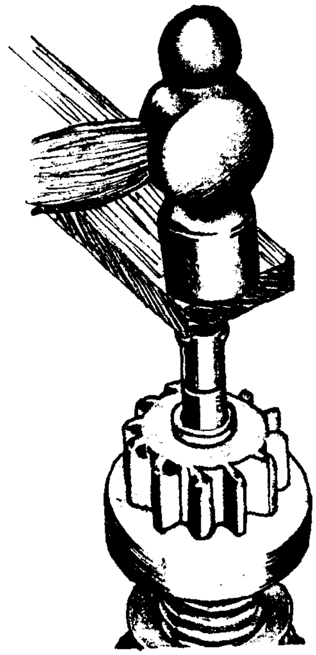


Figure 20—Forcing snap ring over shaft.

FIELD COIL CHECKS

The various types of circuits used are shown in the wiring diagrams of Figure 11. The field coils can be checked for grounds and opens by using a test lamp.

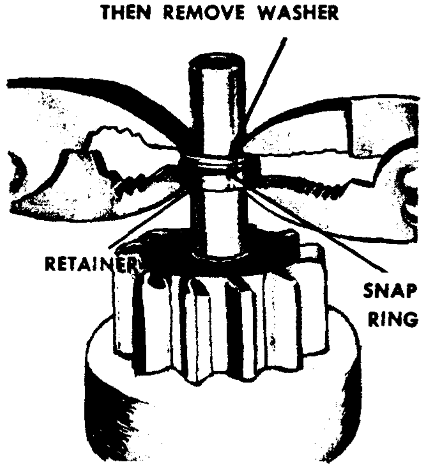


Figure 21—Forcing retainer over snap ring.

Grounds—If the motor has one or more coils normally connected to ground, the ground connections must be disconnected during this check. Connect one lead of the 110-volt test lamp to the field frame and the other lead to the field connector. If the lamp lights, at least one field coil is grounded which must be repaired or replaced. This check cannot be made if the ground connection cannot be disconnected.

Opens—Connect test lamp leads to ends of field coils. If lamp does not light, the field coils are open.

FIELD COIL REMOVAL

Field coils can be removed from the field frame assembly by using a pole shoe screwdriver. A pole shoe spreader should also be used to prevent distortion of the field frame. Careful installation of the field coils is necessary to prevent shorting or grounding of the field coils as the pole shoes are tightened into place. Where the pole shoe has a long lip on one side and a short lip on the other, the long lip should be assembled in the direction of armature rotation so it becomes the trailing (not leading) edge of the pole shoe.

CLUTCH ASSEMBLY

Diassembly procedures for the various types of clutches are outlined below.

A. Intermediate Duty Sprag Clutch.

An early type clutch and late type clutch are shown in Figures 12 and 13.

1. Remove the lock wire, collar, and jump spring from the sleeve assembly.
2. Remove the spring stop washer and second lock wire from the early type clutch (Fig. 12).
3. Remove the retainer ring and large washers. Do not remove the sleeve assembly or sprags from the shell assembly.
4. Lubricate the sprags and saturate the felt washer with No. 5W20 oil. Heavier oil must not be used.
5. Assembly is the reverse of disassembly.

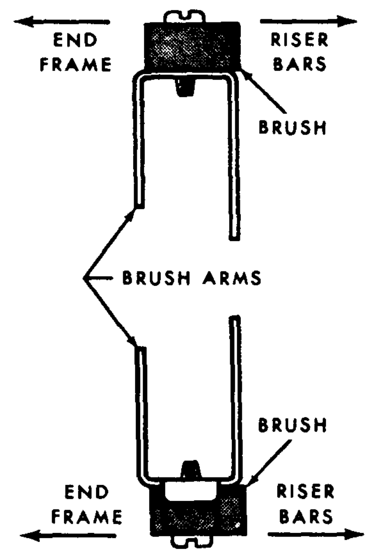


Figure 22—Brush with offset hole assembled to brush arm.

B. Heavy Duty Sprag Clutch and DR-250 Drive.

An early type and a late type heavy duty sprag clutch are shown in Figures 14 and 15 and the DR-250 drive is shown in Figure 16.

1. Remove the cupped pinion stop and split washer. In removing the cupped pinion stop, it will probably be damaged. A new one will be required at time of reassembly.
2. Remove the other parts as illustrated.
3. **Do not** lubricate the sprags on heavy duty clutches, as they are lubricated for life with special oil at the factory.
4. Assembly is the reverse of disassembly.

C. Spline Drive and Positork Drive.

These types of drive assemblies are serviced by complete replacement only.

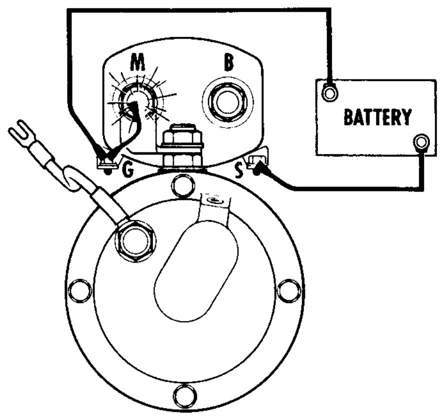


Figure 23—Circuit for checking pinion clearance. (Types shown in Figures 1, 2 and 3.)

SOLENOID CHECKS

A basic solenoid circuit is shown in Figures 17 and 18. Solenoids may differ in appearance but can be checked electrically by connecting a battery of the specified voltage, a switch, and an ammeter to the two solenoid windings. With all leads disconnected from the solenoid, make test connections as shown to the solenoid switch (S or SW) terminal and to ground, or to the second switch terminal, (G), if present, to check the hold-in winding (Fig. 19). Use the carbon pile to decrease the battery voltage to the value specified in Service Bulletins 1S-180, 1S-186, 1S-187 and 1S-188 and compare the ammeter reading with specifications. A high reading indicates a shorted or grounded hold-in winding, and a low reading excessive resistance. To check the pull-in winding connect from the solenoid switch terminal (S) to the solenoid motor (M or MOT) terminal.

NOTE: If needed to reduce the voltage to the specified value, connect the carbon pile between the battery and the "M" terminal as shown in dashed red instead of across the battery as shown in solid red lines. If the carbon pile is not needed, connect a jumper directly from the battery to the "M" terminal as shown by the dashed red line.

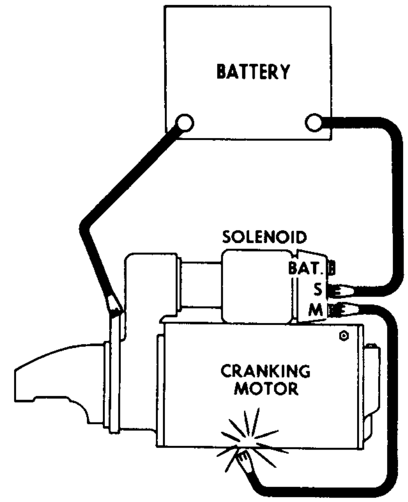


Figure 24—Circuit for checking pinion clearance. (Types shown in Figures 4 and 5.)

CAUTION: To prevent overheating, do not leave the pull-in winding energized more than 15 seconds. The current draw will decrease as the winding temperature increases.

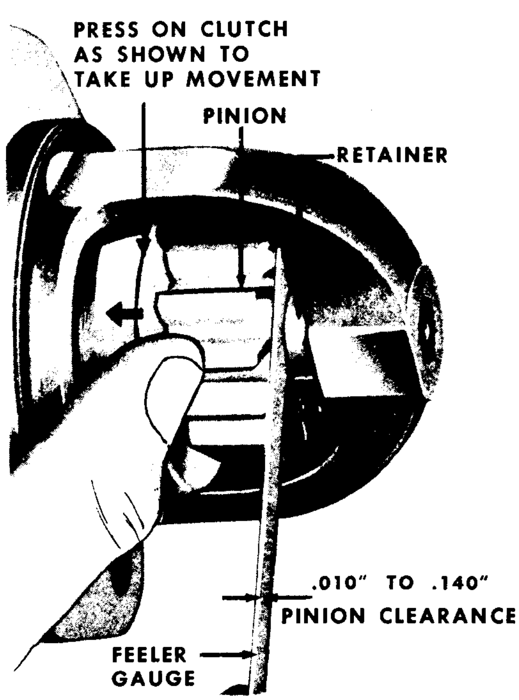


Figure 25—Checking pinion clearance on intermediate duty clutch motor.

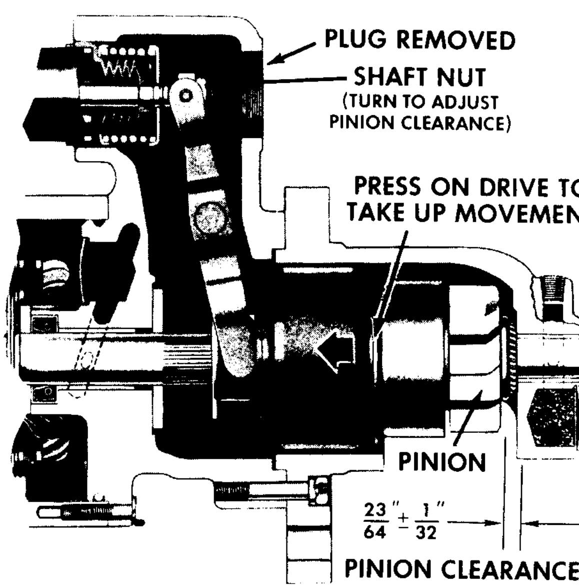


Figure 26—Checking pinion clearance on heavy duty motor.

A magnetic switch can be checked in the same manner by connecting across its winding.

REASSEMBLY

The reassembly procedure for each type of motor is the reverse of disassembly.

On motors using a snap ring and retainer on the shaft as a pinion stop, the ring and retainer can be assembled in the manner shown in Figures 20 and 21. With the retainer placed over the shaft with the cupped surface facing the end of the shaft, force the ring over the shaft with a light hammer blow and then slide the ring down into the groove (Fig. 20). To force the retainer over the snap ring, place a suitable washer over the shaft and squeeze with pliers (Fig. 21). REMOVE THE WASHER.

To reassemble the end frame having eight brushes onto the field frame, pull the armature out of the field frame just far enough to permit the brushes to be placed over the commutator. Then push the commutator end frame and the armature back against the field frame.

On intermediate duty clutch motors, be sure to assemble all brushes to the brush arms so the long side of the brush is toward the riser bars. See Figure 22.

LUBRICATION

All bearings, wicks and oil reservoirs should be saturated with SAE No. 20 oil. Place a light coat of lubricant Delco Remy No. 1960954 on the washer located on the shaft between the armature and shift lever housing. Washer is identified in Figure 2.

Sintered bronze bearings used in these motors have a dull finish, as compared to the early type machined, cast bronze bearings which had a shiny finish.

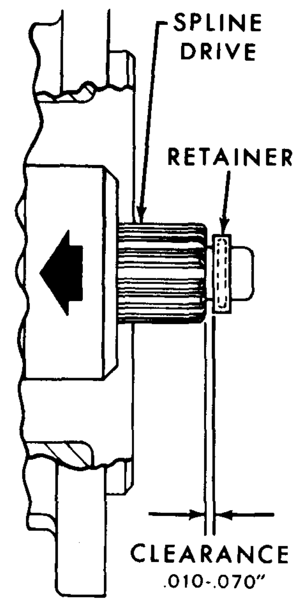


Figure 27—Checking pinion clearance on spline drive motor.

Before pressing the bearing into place, dip it in SAE No. 20 oil. Also, tangent wicks (if present) should be soaked with SAE No. 20 oil. Insert the wick into place first, and then press in the bearing.

DO NOT DRILL, REAM or MACHINE sintered bearings in any way! These bearings are **supplied to size.** If drilled or reamed, the I.D., (inside diameter) will be too large, also the bearing pores will be sealed over.

It is not necessary to cross-drill a sintered bearing when used with a tangent wick. Because the bearing is so highly porous, oil from the wick touching the outside bearing surface will bleed through and lubricate the shaft.

Middle bearings are **support** bearings and prevent armature deflection during cranking. As compared to end frame bearings, the clearance between middle bearing and shaft is large and the clearance provides a loose fit when assembled.

PINION CLEARANCE

There are no provisions for adjusting pinion clearance on motors using the intermediate duty clutch (Fig. 5). However, all types should be checked after reassembly to make sure the clearance is within specifications. Incorrect clearance where not adjustable indicates excessive wear, and worn parts should be replaced.

To check pinion or drive clearance follow the steps listed below.

1. Make connections as shown in Figure 23 or Figure 24.
2. **Momentarily** flash a jumper lead shown in blue color in Figure 23 or Figure 24. The drive will now shift into cranking position and remain so until the battery is disconnected.
3. Push the pinion or drive back towards the commutator end to eliminate slack movement.
4. Measure the distance between drive and drive stop (Figs. 25, 26, and 27).
5. Adjust clearance by removing plug and turning shaft nut (Figs. 26 and 27). **Although typical specifications are shown, always refer to 1M-188, 1M-187, or 1M-186 for specifications applying to specific models.**