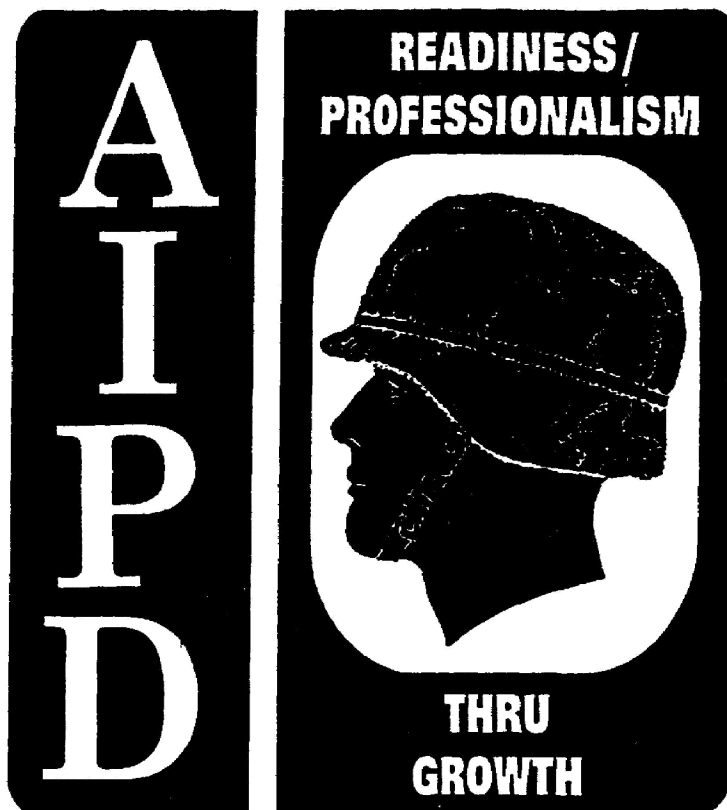


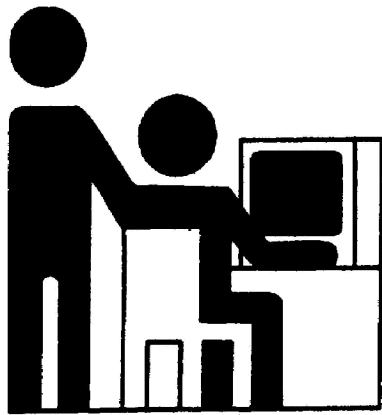
**SUBCOURSE
OD0010**

**EDITION
5**

**ELECTRICAL SYSTEM COMPONENT
REPAIR**



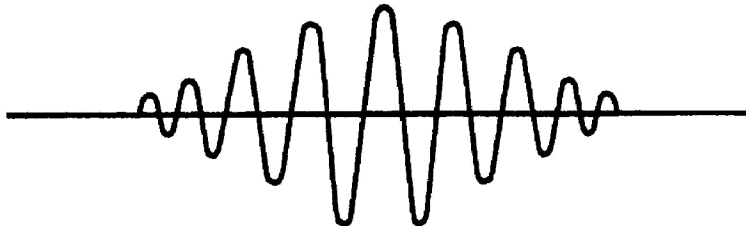
**THE ARMY INSTITUTE FOR PROFESSIONAL DEVELOPMENT
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ELECTRICAL SYSTEM COMPONENT REPAIR

**OD0010
EDITION 5**

**23 CREDIT HOURS
REVIEWED: 1988**

**United States Army Combined Arms Support Command
Fort Lee, VA 23801-1809**

INTRODUCTION

This instructional package contains material to be used as a guide for Ordnance Corps maintenance personnel responsible for electrical system component repair of military vehicles. It is aimed toward supervisory personnel to enhance their abilities in the operation of an automotive fuel and electric repair shop.

This subcourse consists of nine lessons and an examination organized as follows:

- Lesson 1 Construction and Operation of the AC Charging System (Multioutput)
Scope - An explanation of basic fundamentals of AC and DC electricity, detailed construction, and operation of the 40/60-ampere AC generator.
- Lesson 2 Overhaul of 40/60-Ampere AC Generator
Scope - An explanation of disassembly, inspection, basic tests, and reassembly of the 40/60-ampere AC generator.
- Lesson 3 Operation of 500-Ampere Starter Generator Test Stand
Scope - An explanation of the function of meters and varidrives, purpose of controls, and preoperational checks of the 500- ampere starter generator test stand.
- Lesson 4 Testing and Adjusting AC Generators and Regulators
Scope - An explanation of using the 500-ampere test stand to test the 40/60-ampere AC generator.
- Lesson 5 Testing and Adjusting DC Regulators
Scope - An explanation of the purposes, principles of operation, bench testing, and testing with the 500-ampere test stand.
- Lesson 6 Testing and Overhaul of the Prestolite Starter Motor
Scope - An explanation of DC motor fundamentals, disassembly, and inspections, including basic tests, repair, reassembly, and testing with the 500-ampere test stand.
- Lesson 7 Maintenance of 500-Ampere Test Stand
Scope - An explanation of the maintenance requirements for the 500- ampere test stand to include lubrication, varidrive adjustment, and battery charging.

- Lesson 8 Maintenance of Electrical System Test Equipment
- Scope - An explanation of the maintenance requirements for small
 electrical test equipment to include meters, growlers, magnet test
 stands, and LVCT's.
- Lesson 9 Setup of Fuel and Electrical Shop Van
- Scope - An explanation of the three shop sets (basic set, No 1
 supplemental, and No 2 supplemental) to include appropriate
 publications.

Passing grade for all ACCP material is 70%.

CHECKLIST OF TESTS AND MATERIALS FURNISHED

Ordnance Subcourse OD0010
February 1975

No texts, other than the Attached Memorandums are used in support of this subcourse. Therefore you are not required to return any texts to the US Army Ordnance Center and School.

This subcourse may contain errata sheets. Make certain that you post all necessary changes before beginning.

Note. - Any references cited in this subcourse are general references and are not furnished. The publications listed below were used to prepare this subcourse and should be consulted when additional information is required.

TM 9-2320-211-35, w/C1, 2, and 3	DS, GS, and Depot Maintenance Repair for Truck Chassis, 5-Ton, 6x6	Sep 64
TM 9-2320-218-20, w/C2	Organizational Maintenance Manual: Truck, Utility, 1/4-Ton, 4x4	Sep 71
TM 9-2320-244-34, w/C1 and 2	DS and GS Maintenance Manuals: Truck, Cargo, 1-1/4-Ton, 4x4	Oct 71
TM 9-2920-225-34	DS and GS Maintenance Manual: Generator, Engine, and Regulator Assemblies	Nov 73
TM 9-2920-248-35	DS, GS and Depot Maintenance Manual: Starter Engine	Aug 68
TM 9-4910-410-12, w/C1	Operator and Organizational Manual: Tester, Engine Distributor	Jan 64
TM 9-4910-431-12, w/C1	Organizational Maintenance Manual: Test Stand, Ignition Magneto	Sep 64
TM 9-4910-456-14, w/C1 and 2	Operator and Organizational, DS and GS Maintenance Manual, Test Stand, Generator, and Voltage. Regulator	Oct 71
TM 9-4910-458-12, w/C1	Operator and Organizational Maintenance Manual: Test Stand, Automotive Generator, Alternator, and Starter (United Mfd.)	Nov 66
TM 9-4910-485-12, w/C1 and 2	Operator and Organizational Maintenance Manual: Test Stand, Automotive Generator, Alternator, and Starter (Sun Elect.)	May 70
TM 11-6625-366-15, w/C1 and 2	Operator, Organizational, DS, GS and Depot Maintenance Manual: TS 352 B/U	Jan 67
TB ORD 444-18, w/C1	Shop Set, Field Automotive Fuel and Elect., Supplemental No 2	Jan 62

TB ORD 444-22	Shop Set, Field Automotive Fuel and Elect., Supplemental No 1	Oct 63
SC 4910-95-CL-A01, w/C1	Shop Set, Fuel and Electrical System (Basic)	Mar 69
SC 4910-95-CL-A64	Shop Set, Fuel and Electrical System (Supplemental No 2)	Dec 67
SC 4910-95-CL-A65	Shop Set, Fuel and Electrical System (Supplemental No 1)	Apr 70

C O R R E S P O N D E N C E C O U R S E
o f t h e
U S A R M Y O R D N A N C E
C E N T E R A N D S C H O O L



LESSON ASSIGNMENT

Ordnance Subcourse No 010..... Electrical System Component Repair

Lesson 1..... Construction and Operation of the AC Charging System (Multioutput)

Credit Hours..... Two

Lesson Objective..... After studying this lesson you will be able to:

1. State the purpose of the AC charging system (multioutput).
2. Describe the major components of the AC charging system (multioutput) and their functions.
3. Explain the operating principles of the AC charging system (multioutput).

Text..... Attached Memorandum

Materials Required..... Answer sheet and response list

Suggestions..... None

ATTACHED MEMORANDUM

1. INTRODUCTION.

a. The AC charging system (multioutput) supplies electrical power for charging the battery and operating the accessories of gasoline and diesel engine electrical systems. It develops three-phase (30) AC voltage and by rectification converts it to a DC output voltage. Good regulation of the DC output voltage is maintained by a transistorized regulator.

b. The AC charging system utilizes principles with which you are no doubt already familiar. However, a brief review of the fundamental principles will add to your understanding of the system.

2. OHM'S LAW (CURRENT, VOLTAGE, AND RESISTANCE).

a. Persons working in the electronics field will encounter two theoretical concepts of current when reading technical material. Conventional current flow is concerned with the theoretical movement of positive charges. It is the older of the two concepts. Electron current flow is concerned with the theoretical movement of negative charges. Advances in the understanding of atomic theory have caused the electron current flow concept

to be used more frequently in recent years. Technically proficient persons are able to use either concept. Explanations involving the movement of positive charges in one direction are no more valid than explanations involving the movement of negative charges in the opposite direction.

b. The movement of electrons through a conductor, such as copper wire, is an example of electron current flow (fig 1). Current flow is measured in amperes. When 6.28 billion billion electrons pass a certain point in a conductor in 1 second, the current flow is one ampere. Electrons do not move through a conductor of their own free will. There must be a force exerted to cause electron movement.

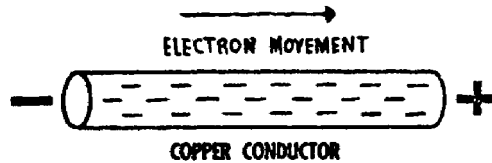


Figure 1. Copper conductor.

c. The force which causes electrons to flow in a conductor is called voltage. Voltage is the difference in electrical pressure measured between two points in a circuit. Thus, using a 12-volt battery as an example, the voltage measured between the two battery posts is 12 volts. Voltage potential at a specific point in an electrical circuit is an important concept. This simply means the voltage or electrical pressure at a particular point with respect to another point. If the voltage potential of one post of the 12-volt battery is zero, the voltage potential at the other post is 12 volts with respect to the first post.

d. Polarity is another important concept. One post of a battery is said to be positive and the other negative. By conventional theory the direction of current flow in a circuit is from the battery or generator positive terminal, through the external circuit, and then back to the negative terminal of the battery or generator. This direction is opposite to the direction of electron flow. Electron flow is generally used to explain electronic circuitry. Conventional current flow is used to explain magnetic properties in motors and generators (fig 2).

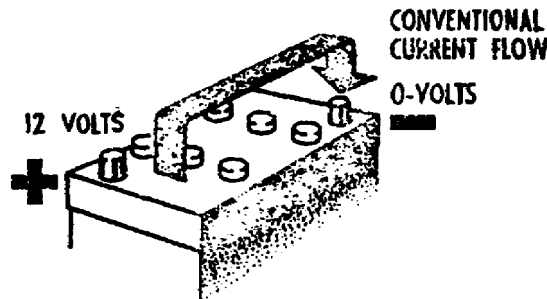


Figure 2. Conventional-current flow.

e. The voltage or electrical pressure needed to produce current flow in a circuit is necessary to overcome the resistance in the circuit. Resistance to the flow of current is measured in ohms. One volt will cause one ampere to flow through a resistance of one ohm. This is an expression of Ohm's law (fig 3). A resistor is an electrical device, often of metallic wire or carbon composition, that presents a resistance or opposition to the flow of electric current. The resistance is measured in ohms. When current passes through a resistor, a voltage drop appears across the resistor. Ohm's law applies to an entire circuit or to any part of a circuit.

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

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

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

Figure 3. Ohm's law.

f. When three resistors are connected to a battery as shown in figure 4, the total circuit resistance is six ohms. In applying Ohm's law to the entire circuit, the current flow through each resistor is two amperes. Applying Ohm's law to the one-ohm resistor, the voltage drop across the resistor is two volts. The voltage potentials across this resistor and the other resistors are shown. Note that electron current flow is shown in figure 4. Negative charges are assumed to flow from the negative terminal of the battery, through the external circuit, and back to the positive terminal of the battery. There are three important things to remember about a resistor:

- (1) A resistor will limit current flow according to Ohm's law.
- (2) Voltage drop occurs across each resistor according to Ohm's law.
- (3) The voltage drops across the resistors determine the potentials on each side of the resistors.

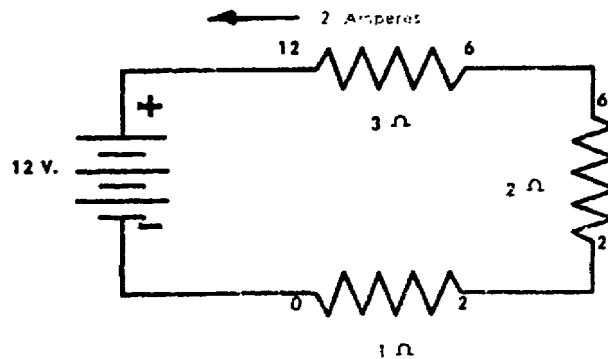


Figure 4. Series circuit.

g. Figure 5 illustrates a simple circuit in which one milliampere (1mA) of electron current will flow. The zero center scale current meter deflects to the right and indicates a 1mA reading. If the battery potential is reversed (fig 6), 1mA of electron current will flow through the resistor in the opposite direction. The zero center scale current meter will be deflected to the left and indicate 1mA of current. You should note that for this discussion one current has been called forward current (fig 5) and the other reverse current (fig 6). Recording the voltage current relationship which exists illustrates the linearity of resistive circuits (fig 7).

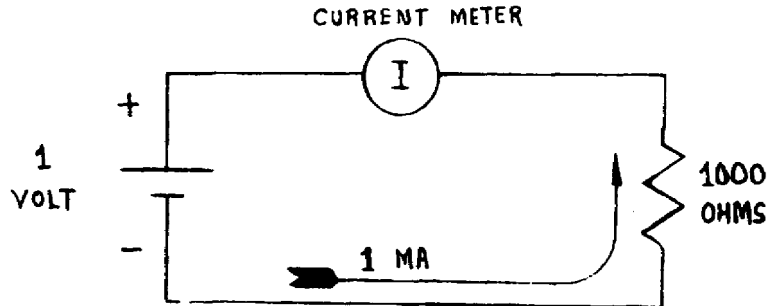


Figure 5. Forward current.

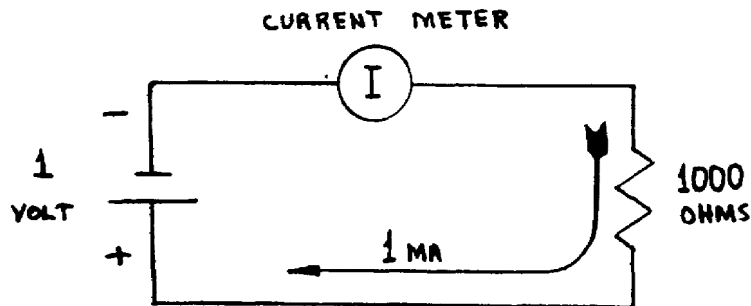


Figure 6. Reverse current.

3. DIODES.

a. The conventional diode is an electrical device whose resistance varies nonlinearly with the voltage applied to it (fig 8). When the diode is forward biased it passes maximum current. When it is reverse biased it passes minimum current. The extremes between maximum and minimum currents are so great that for all practical purposes it is said the diode will only pass current in the forward biased direction. Figure 9 is the performance curve of a typical diode showing forward and reverse current characteristics. The plot of the 1,000-ohm resistor is included for comparison.

b. The curve in the lower left portion shows that some reverse current will flow when the diode is reverse biased. The amount is very small and the current increases very little until the breakdown voltage is reached. For the conventional diode rectifier this breakdown voltage occurs at several hundreds of volts. Overheating will occur when the breakdown voltage is reached in a conventional diode. The heat generated causes the diode to

destroy itself. This breakdown point is the operating point for zener diodes (fig 10). The zener is a specially designed type of diode. It is heavily doped during manufacture which controls the actual zener voltage point.

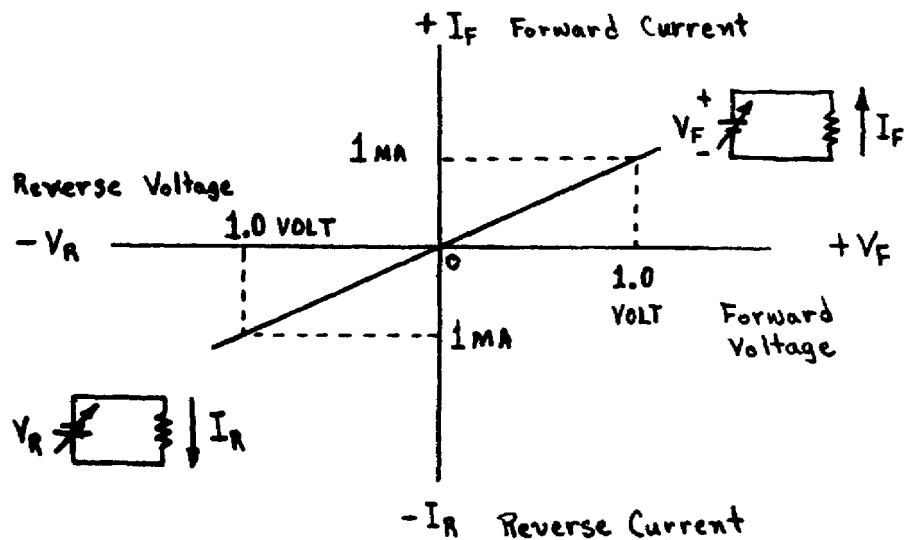


Figure 7. Resistance plot.

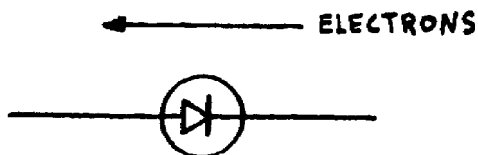


Figure 8. Conventional diode symbol.

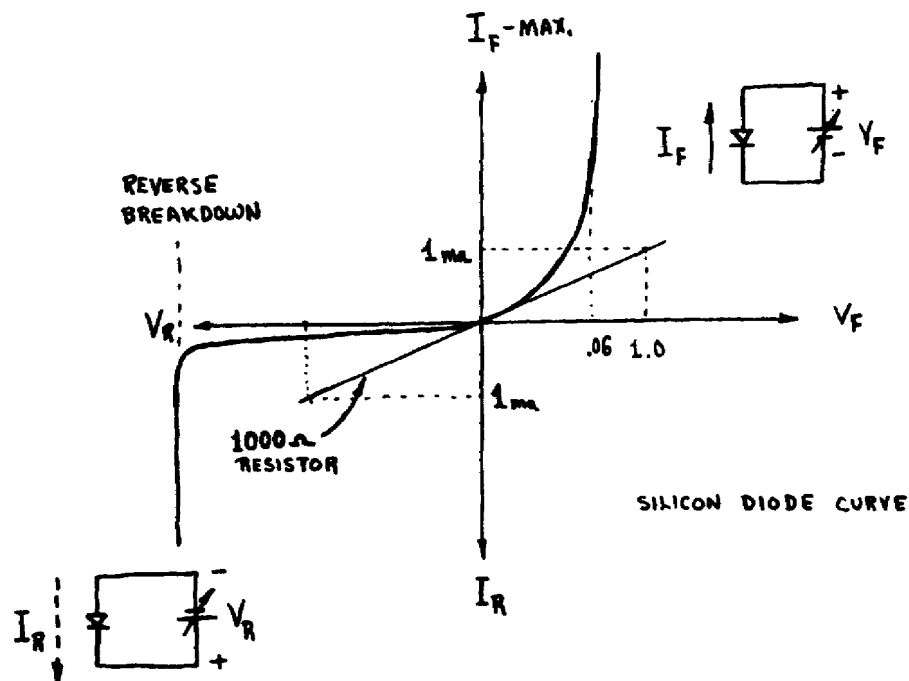


Figure 9. Silicon diode curve.

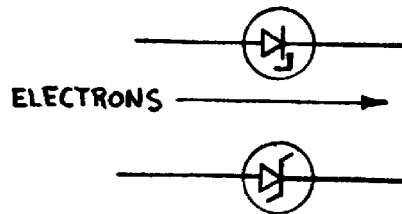


Figure 10. Zener diode symbols.

c. Zener diodes are used in control circuits as reference voltages. Connecting a zener in series with a resistor and power supply will cause a zener regulated voltage. Providing that the battery potential is of a voltage greater than the zener voltage, for any variation of the battery voltage the zener voltage will remain constant (fig 11).

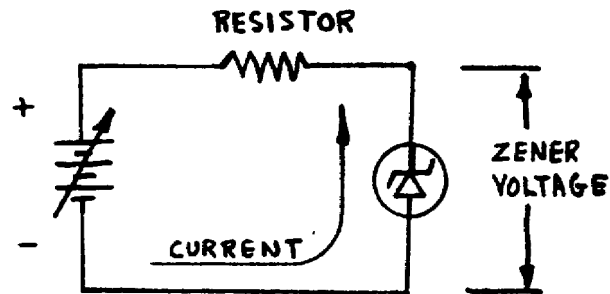


Figure 11. Zener diode circuit.

4. MAGNETISM.

a. Magnetism, like electricity, is invisible. Its effects, however, are well known. An example is the attraction of a bar magnet for iron filings. A magnet has a North pole, designated as "N," and a South pole, designated as "S." The space around the magnet in which iron filings are attracted is called the "field of force" or magnetic field, and is described as lines which come out of the North pole and enter the South pole (fig 12).

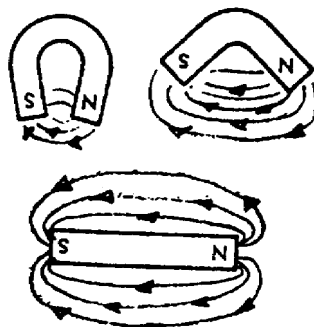


Figure 12. Bar magnets.

b. Electricity and magnetism are very closely associated, because when electric current passes through a wire a magnetic field is created around the wire (fig 13).

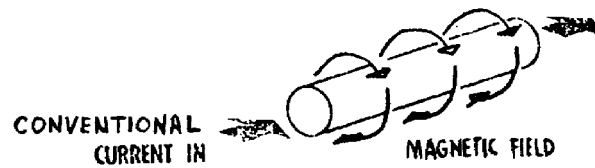


Figure 13. Magnetic field around wire.

c. When a wire carrying electric current is wound into a coil, a magnetic field with N and S poles is created just as in a bar magnet. Using the "Right-Hand Rule"--wrapping the fingers around the coil in the direction of current flow--the thumb will point toward the North or N pole (fig 14).

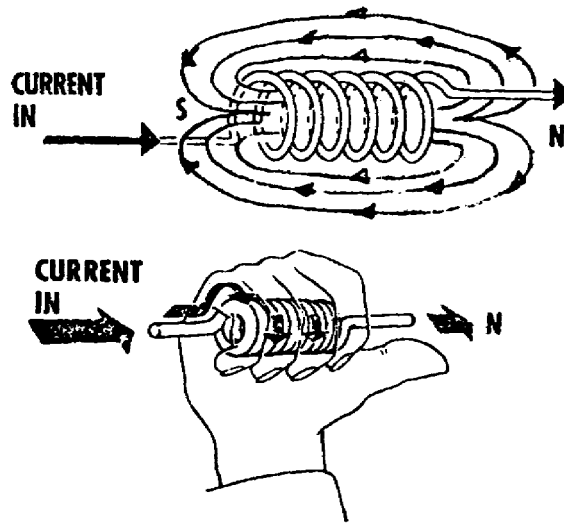


Figure 14. Right-hand rule.

d. If an iron core is placed inside the coil, the magnetic field becomes much stronger because iron conducts magnetic lines much easier than air (fig 15). This arrangement, called an electromagnet, is used in generators to create strong magnetic fields by winding many turns of current-carrying wire around iron cores called pole pieces.

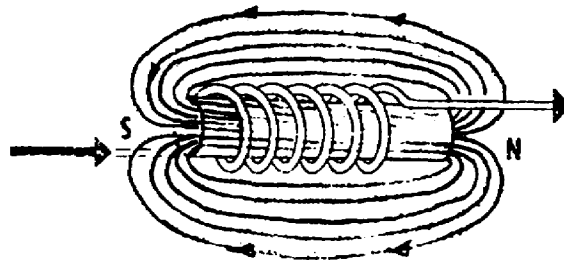


Figure 15. Iron core coil.

e. We have seen that a magnetic field, made up of lines of force, is created around a wire when current is passed through it. If a magnetic field is moved so that the lines of force cut across a wire conductor (fig 16), a voltage will be induced in the conductor. The induced voltage will cause current to flow when an electrical load, such as a resistor, is connected across the conductor.

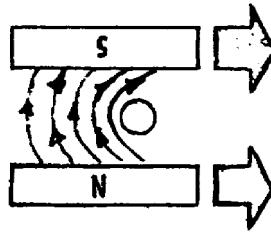


Figure 16. Magnet field moving about a wire.

(1) The direction of current flow is determined by the direction of the magnetic lines of force and the direction of motion of the magnetic field with respect to the conductor. To visualize this, note the illustration (fig 16). Magnetic pole pieces are being moved so that the magnetic lines of force are cutting across a conductor.

(2) The direction of the magnetic lines of force is upward, since magnetic lines leave the North pole and enter the South pole. The direction of motion of the magnetic field is toward the right, as indicated by the arrows. With this direction of motion, the magnetic lines are striking the conductor on its left side,, which is called the leading side.

(3) The direction of current flow can be determined by applying the Right-Hand Rule as follows: grasp the conductor with the right hand with the fingers on the leading side of the conductor and pointed in the direction of the magnetic lines of force. The thumb will then point in the direction of current flow (fig 17).



Figure 17. Application of Right-Hand Rule.

(4) Voltage is generated in Delcotron generators by moving strong magnetic fields across stationary conductors.

f. Although this coverage of basic principles has been limited and rather brief, it will serve as a useful background for the next paragraph covering the operating principles of generators.

5. GENERATOR OPERATING PRINCIPLES.

a. In the review of electrical fundamentals, it was observed that a voltage will be induced in a conductor when a magnetic field is moved across the conductor. For example, consider a bar magnet with its magnetic field rotating inside a loop of wire (fig 18). With the magnet rotating as

indicated, and with the S pole of the magnet directly under the top portion of the loop and the N pole directly over the bottom portion, the induced voltage, as determined by the Right-Hand Rule, will cause conventional current to flow in the circuit in the direction shown. Since conventional current flows from positive to negative through the external or load circuit, the end of the loop of wire marked "A" will be positive (+) polarity and the end marked "B" will be negative (-).

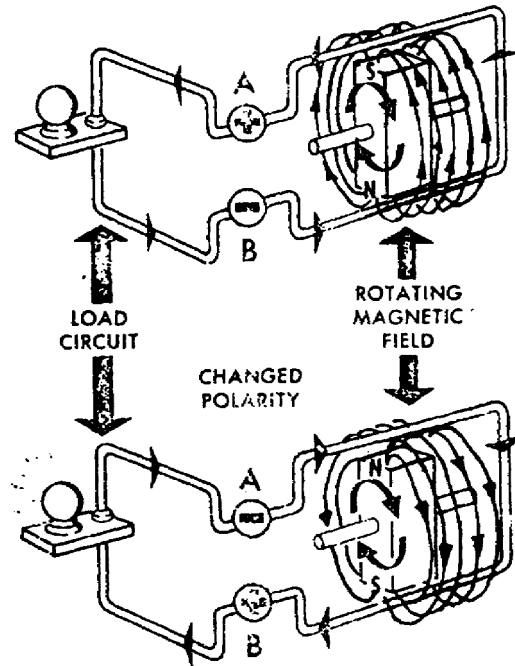


Figure 18. Rotating field.

b. After the bar magnet has moved through one-half revolution, the N pole will have moved directly under the top conductor and the S pole directly over the bottom conductor. The induced voltage as determined by the Right-Hand Rule will now cause current to flow in the opposite direction. The end of the loop of wire marked "A" will become negative (-) polarity and the end marked "B" will become positive (+). Therefore, the polarity of the ends of the wire has changed. After a second one-half revolution, the bar magnet will be back at the starting point where "A" is positive (+) and "B" negative (-). Consequently, current will flow through the load or external circuit first in one direction and then in the other. This is an alternating current which is developed by a generator.

c. A generator made with a bar magnet rotating inside a single loop of wire is not practical, since very little voltage and current are produced. The performance is improved when both the loop of wire and the magnet are placed inside an iron frame (fig 19). The iron frame not only provides a place onto which the loop of wire can be assembled, but also acts as a conducting path for the magnetic lines of force. Without the iron frame, magnetism, after leaving the N pole of the rotating bar magnet, must travel through air to get to the S pole. Because air has a high reluctance to magnetism, only a few lines of force will come out of the N pole and enter the S pole. Since iron conducts magnetism very easily, adding the iron frame greatly increases the number of lines of force between the N pole and S pole. This means that more lines of force will be cutting across the conductor which lies between the bar magnet and frame.

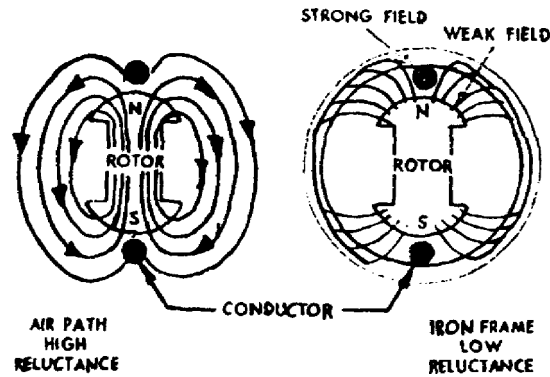


Figure 19. Magnetic field reluctance.

d. It is important to note that a very large number of magnetic lines of force are at the center of the tip of the magnet, whereas there are only a few lines of force at the leading and trailing edges of the tips. Thus, there is a strong magnetic field at the center and a weak magnetic field at the leading and trailing edges. This condition results when the distance, called the airgap, between the magnet and field magnet frame is greater at the leading and trailing edges than at the center of the magnet.

e. The amount of the voltage induced in a conductor is proportional to the number of lines of force which cut across the conductor in a given length of time. Therefore, if the number of lines of force are doubled, the induced voltage will be doubled. The voltage will also increase if the bar magnet is made to turn faster, because the lines of force will be cutting across the wire in a shorter period of time (fig 20).

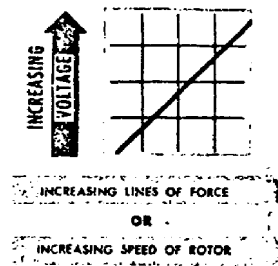


Figure 20. Induced voltage.

f. It is important to remember that either increasing the speed of rotation of the bar magnet, or increasing the number of lines of force cutting across the conductor, will result in increasing the voltage. Similarly, decreasing the speed of rotation or decreasing the number of lines of force will cause the voltage to decrease. The rotating magnet in a generator is called the rotor, and the loop of wire and outside frame assembly is called the stator.

6. SINGLE PHASE GENERATOR.

a. Pictured in figure 21 are different positions of the rotor as it rotates at constant speed. In the top portion of the illustration is a curve showing the magnitude of the voltage which is generated in the loop of wire as the rotor revolves. The voltage curve shows the generated voltage or electrical pressure which can be measured across the ends of the wire, Just as voltage can be measured across the terminal posts of a battery.

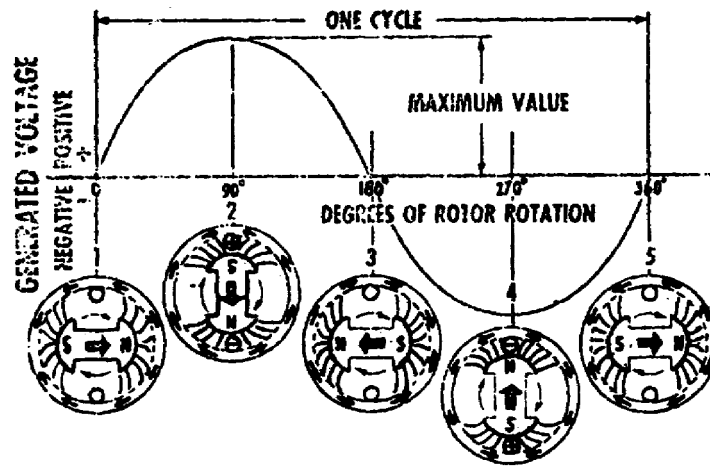


Figure 21. Single phase.

b. With the rotor in the first position (1) there is no voltage being generated in the loop of wire, because there are no magnetic lines of force cutting across the conductor. As the rotor turns and approaches position (2), the rather weak magnetic field at the leading edge of the rotor starts to cut across the conductor and the voltage increases. When the rotor reaches position (2), the generated voltage has reached its maximum value as shown above the horizontal line in the illustration. The maximum voltage occurs when the rotor poles are directly under the conductor. It is in this position that the conductor is being cut by the heaviest concentration of magnetic lines of force.

c. It should be noted in particular that the magnitude of the voltage varies because the concentration of magnetic lines of force cutting across the loop of wire varies. The voltage curve shown is not a result of a change in rotor speed, because in the illustration the rotor is considered to be turning at a constant speed.

d. By applying the Right-Hand Rule (fig 22) to position (2), it is seen that the direction of current in the loop of wire will be out of the top end of the conductor and into the bottom end. Thus, the top end of the conductor will be positive and the bottom end negative. The voltage curve which is shown above the horizontal line represents the positive voltage at the top end of the wire loop which is generated as the rotor turns from position (1) to position (3). As the rotor turns from position (2) to position (3), the voltage decreases until at position (3) it again becomes zero.

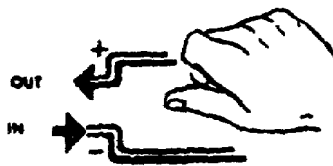


Figure 22. Right-Hand Rule.

e. When the rotor turns from position (3) to position (4), note that the N pole of the rotor is now passing under the top part of the wire loop and the S pole under the bottom part. From the Right-Hand Rule the top end of the loop of wire is now negative and the bottom end positive. The negative voltage at the top end of the loop is pictured in the illustration by

the curve which is below the horizontal line. The voltage again returns to zero when the rotor turns from position (4) to position (5). The voltage curve in the illustration represents one complete turn or cycle of the rotor.

f. With the rotor making 60 complete turns in 1 second, there will be 60 such curves, one coming right after the other, resulting in 60 cycles per second. The number of cycles per second is called the frequency. Since the generator speed varies in automotive type applications, the frequency also varies.

7. THREE-PHASE (3Ø) GENERATOR.

a. The single loop of wire acting as a stator winding, and the bar magnet acting as the rotor, serve to illustrate how an AC voltage is produced in a basic generator. When two more separate loops of wire, spaced 120° apart, are added to our basic generator, two more separate voltages will be produced (fig 23).

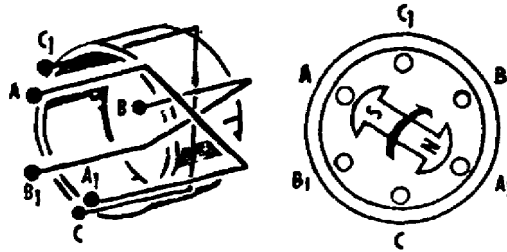


Figure 23. Three-phase operation.

b. With the S pole of the rotor directly under the A conductor the voltage at A will be maximum in magnitude and positive in polarity. After the rotor has turned through 120° , the S pole will be directly under the B conductor and the voltage at B will be maximum positive. Similarly, 120° later, the voltage at C will be maximum positive. This means that the peak positive voltages at A, B, and C in each loop of wire occur 120° apart. These loop voltage curves are shown in figure 24.

c. When the ends of the loops of wire marked A, B, and C are connected to the ends marked B, C, and A respectively (fig 25), a basic three-phase "delta"-connected stator is formed. The three AC voltages available from the delta-connected stator are identical to the three voltages previously discussed, and may now be denoted as the voltages from B to A, C to B, and A to C, or more simply BA, CB, and AC. An inspection of figure 25 will show the logic of this notation. The voltage formerly called AA may now be called BA.

d. When the ends of the loops of wire marked A_1 , B_1 , and C_1 are connected together, a basic three-phase "Y"-connected stator is formed. The three voltages available from the "Y"-connected stator may be labeled BA, CB, and AC. From figure 26, it may be seen that each of these voltages consists of the voltages in two loops of wire added together. For example, the voltage measured from B to A consists of the voltages in loops B_1B and A_1A added together. This addition yields a voltage curve BA similar in shape and form to the individual loop voltages, except that the voltage curve BA will be approximately 1.7 times as large in magnitude as an individual loop voltage. The addition of the loop voltages involves a mathematical process which will not be presented here, since it is only necessary to remember that three AC voltages spaced 120° apart are available from the "Y"-connected stator, as illustrated. These voltage curves will be considered in more detail in the following paragraphs.

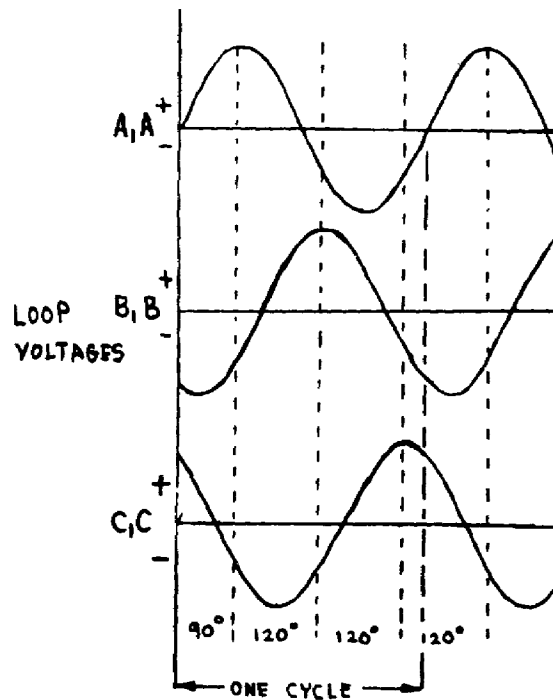


Figure 24. Three-phase loop voltage.

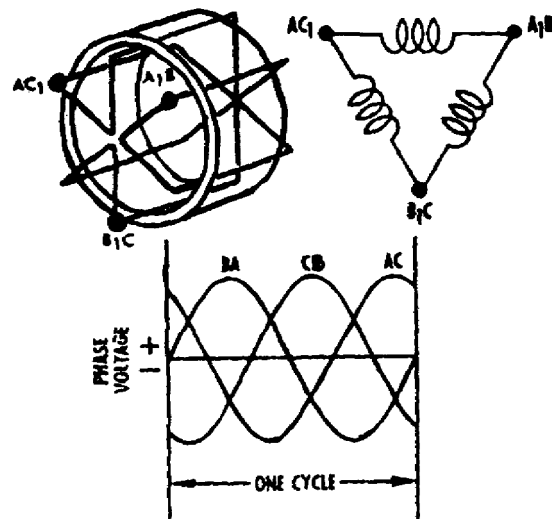


Figure 25. Delta connection.

e. At this point in our discussion we have developed the two basic types of stator windings, and have shown how three separate complete cycles of AC voltage spaced 120° apart are developed for each complete revolution of the rotor. We now turn to the diode and will see how six diodes connected to the stator winding change the three AC voltages to a single DC voltage needed for the DC electrical system.

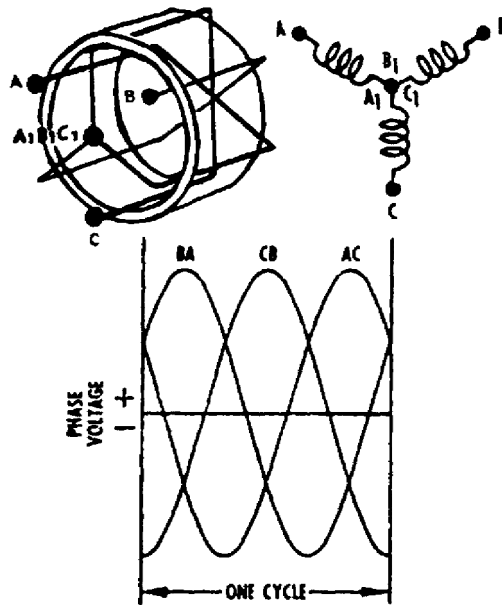


Figure 26. Wye "Y" connection.

8. RECTIFICATION.

a. Potential difference is measured between two points; therefore, a potential at one point is always measured with respect to another point. The chassis of a vehicle or an earth ground are normally considered as zero potential voltages and are the common fixed reference points for almost everything concerning electricity. An AC (alternating current) is a continually changing current with time--for a rotor turns in reference to time (RPM). No current can flow unless there is a potential pressure (voltage) to cause charges of electricity to move. An AC voltage is one that varies above and below ground potential or zero voltage.

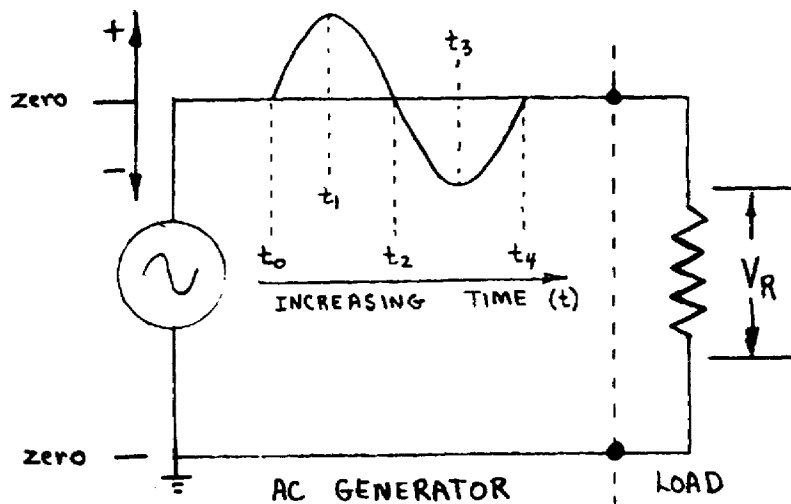


Figure 27. AC voltage.

b. Figure 27 shows an AC potential being applied to a resistor. This voltage potential forces an electron current through the resistor. The current through the resistor allows the voltage to be developed across the resistor.

(1) At time (t_1) the voltage with respect to ground will be positive (+) and an electron current will be flowing upward through the resistor.

(2) At time (t_3) the voltage with respect to ground will be negative (-) and an electron current will be flowing downward through the resistor.

(3) Here we can see that the direction of the voltage is controlling the direction of electron current through the resistor. So the current first flows in an upward direction; then, as time passes, it reverses. It alternates once each cycle or revolution of the rotor.

c. The amount of current through the resistor is determined by its value of resistance. With a very large resistive value, only a small current will flow. With a very small resistive value, a large current will flow. The values of resistance lay between two extremes. The maximum value of resistance is an open circuit; the minimum value of resistance is a short circuit. These extreme values of resistance are approached in the rectifying diode. When the diode is forward biased, it exhibits nearly a short circuit. When it is reverse biased, it approximates an open circuit.

d. Figure 28 shows an AC potential being applied to a resistor and diode connected in series. Since the voltage potential is alternating above and below ground or zero potential, the diode will experience times of forward bias at (t_1) and reverse bias at (t_2). The diode becomes forward biased any time after the voltage potential leaves zero and goes positive. The diode becomes reverse biased any time after the voltage potential leaves zero and goes negative.

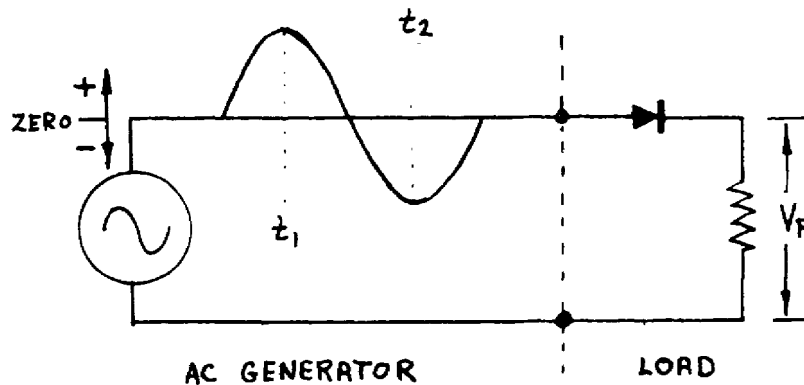


Figure 28. Half-wave rectifier.

(1) When the diode is forward biased, maximum current will be allowed to flow through the resistor thereby developing a positive half cycle.

(2) When the diode is reversed biased, minimum current will be allowed to flow through the resistor. If the minimum current approaches zero, then the voltage developed across the resistor will also approach zero. For all practical purposes it is said to be zero, since the value of positive voltage is much greater than negative.

(3) This circuit is called a half-wave rectifier because only half of the entire cycle of AC voltage is allowed to be developed across the resistor (fig 29).

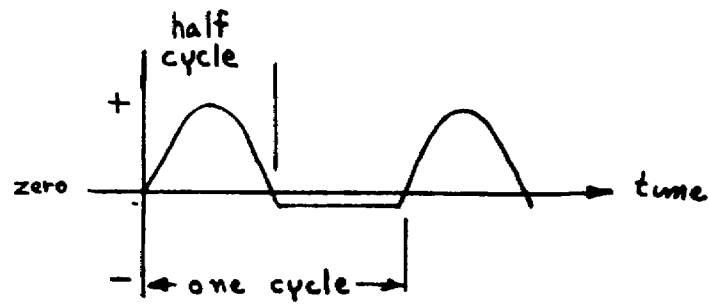


Figure 29. Half-wave rectifier.

e. Using four diodes, a circuit can be arranged to cause current to flow in the same direction through the resistor during both the positive and negative half cycles. The circuit is called a full-wave rectifier, for the whole cycle is developed across the resistor in the positive direction. (Study figures 30 and 31.)

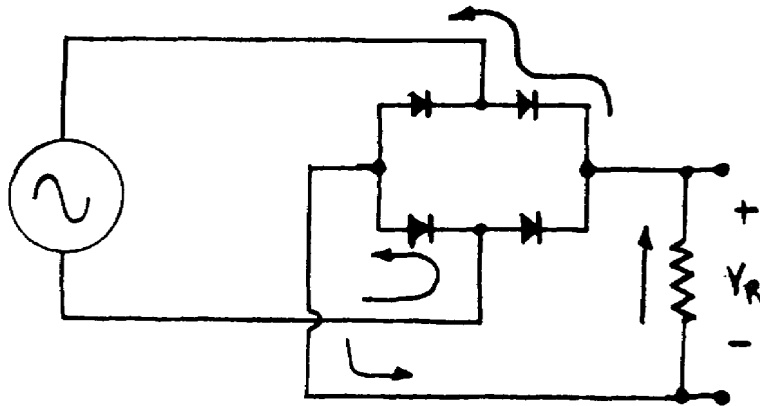


Figure 30. Full-wave rectifier t_1 .

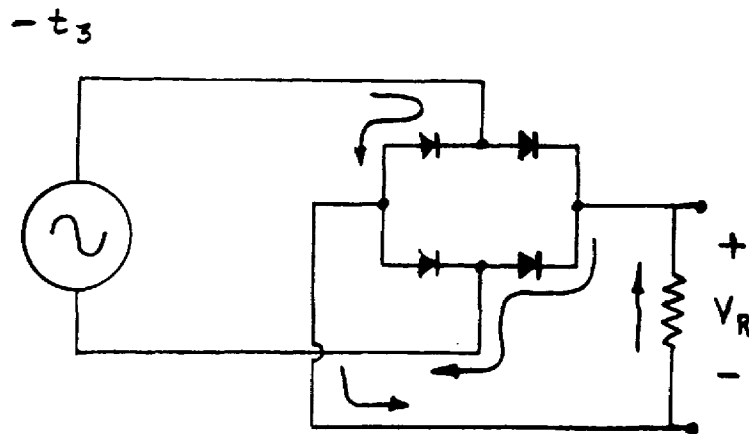


Figure 31. Full-wave rectifier t_3 .

f. The output is increased when four diodes are used to provide full wave rectification (fig 32). Note that the current is more continuous than with one diode, but that the current varies from a maximum value to a zero value. It is particularly important to observe that the current flow through the external load resistor is in one direction only (fig 30 and 31). The AC voltage and current have, therefore, been rectified to a unidirectional or DC voltage and current. This circuit arrangement could be used to charge a DC battery, but it does not produce the most output that can be obtained in a generator.

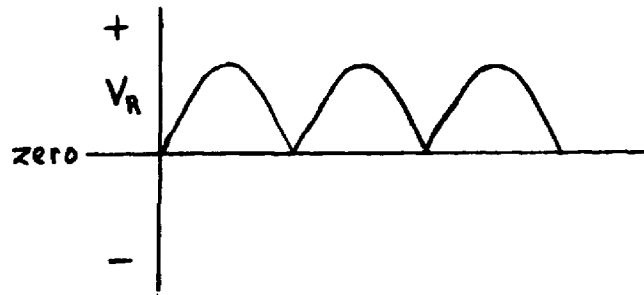


Figure 32. Full-wave rectified voltage.

g. In order to obtain a higher output and smoother voltage and current, a three-phase stator is connected to six diodes which together form a three-phase, full-wave bridge rectifier (fig 33). A battery connected to the DC output terminal will have its energy restored as the generator provides charging current. Note that the blocking action of the diodes prevents the battery from discharging directly through the rectifier.

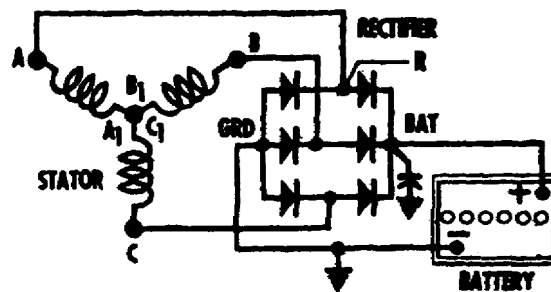


Figure 33. Three-phase, full-wave rectifier.

h. The voltage obtained from the stator-rectifier combination, when connected to a battery, is not perfectly "flat" but is so smooth that for all practical purposes the output may be considered a nonvarying DC voltage. The voltage is obtained from the phase voltage curves (fig 34).

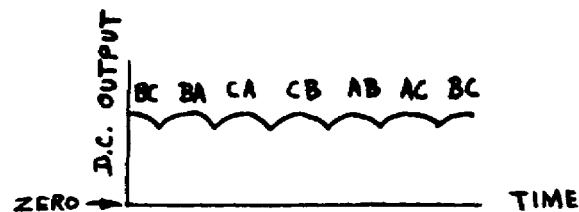


Figure 34. Three-phase, full-wave rectifier output voltage.

9. LEECE-NEVILLE GENERATORS (CONSTRUCTION).

a. The Leece-Neville generators, models 3002AC and 3002AD, develop three-phase AC voltage which is rectified to a single DC output voltage. The rotor assembly (fig 35A), which houses the exciter field coil, consists of two iron pole pieces with interlacing fingers. The fingers are mounted over the exciter field coil, which has many turns of wire. The core is mounted between the iron pieces and is electrically connected to two sliprings.

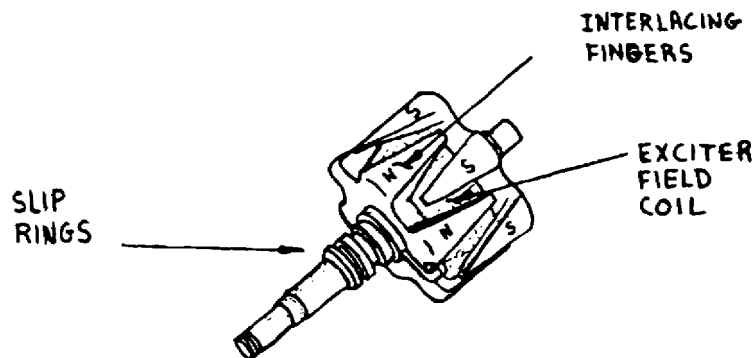


Figure 35A. Rotor assembly.

(1) The coil is energized with current through the brushes making contact with sliprings. The exciter coil develops the magnetic field; the intensity of which is controlled by the amount of current supplied to the sliprings. The magnetic field causes the two iron pole pieces with interlacing fingers to become magnetized.

(2) The interlaced fingers of the pole pieces produce alternate North and South poles between the fingers. The rotor shown has a total of 12 poles.

b. The stator assembly consists of three separate windings mounted on a laminated iron frame. The windings are connected together to form a "Y" or "Delta" connected stator.

(1) Each winding consists of six coils and each coil contains many turns of wire. A complete cycle of AC voltage will be generated in each coil as a North and South pole pass by the coil.

(2) With the six coils in series, each being influenced by a North and South pole simultaneously, there will be six coil voltages adding together to provide a complete winding voltage (fig 35B).

(3) Two more identical windings are mounted on the iron frame to complete the stator assembly. These windings are spaced so that the "Y"-connected stator delivers three-phase AC voltage.

(4) In paragraph 8 a two-pole magnet type of rotor was used to show that a complete cycle of AC voltage will be produced for each rotor revolution. With a 12-pole rotor, six complete cycles of AC voltage will be produced for each rotor revolution.

c. The stator voltage is connected to six diodes which are mounted internally. They convert the three-phase AC voltage into DC and are arranged as shown in figure 36.

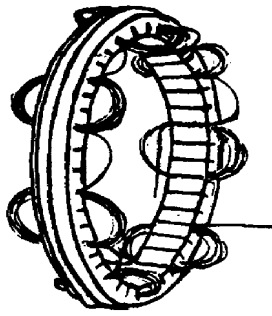


Figure 35B. Stator.

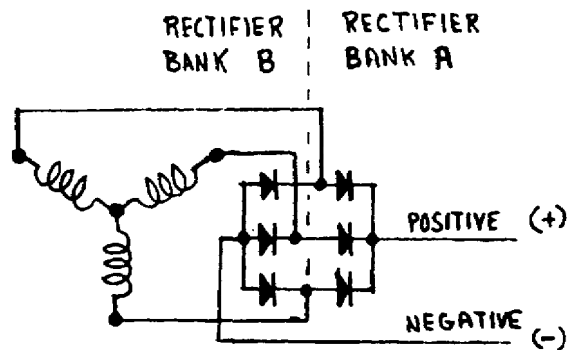


Figure 36. Three-phase rectifier.

(1) The diodes are divided into two banks of rectifiers: bank A and bank B.

CAUTION: The diode in each of the banks may look the same, but electrically they can be different (fig 37).



Figure 37. Silicon diodes.

(2) Rectifier bank A will have diodes that look identical to those in rectifier bank B. However, even though their cases look the same, electrically they are different and have different part numbers.

(3) The positive pulses of alternating current are passed through rectifier bank A to the positive lead; the negative pulses of alternating current are passed through rectifier bank B to the negative lead. Thus, alternating pulsations of current are converted to a pulsating flow of direct current.

d. Also internally mounted is a transistor operated regulator that controls the output voltage of the generator to the battery.

(1) The output voltage is sensed by the regulator where it is compared to the voltage reference of a zener diode.

(2) If the output voltage of the generator is higher than the zener reference voltage, it causes a transistor to turn ON which reduces the exciter field current. This brings the output voltage down.

(3) If the output voltage of the generator is lower than the zener reference voltage, it causes a transistor to turn OFF which increases the exciter field current. This brings the output voltage up since the magnetic flux in the rotor is increased.

10. LEECE-NEVILLE GENERATOR (OPERATION).

a. Basically, there are three components to be considered in the operation of the AC charging system: the AC generator, diode rectifier, and transistor regulator (fig 38). The AC generator is of the revolving field type (the rotor is the field) so that only two sliprings are needed. The sliprings and brushes are required to carry only low amperage current to control the exciter field winding flux on the rotor.

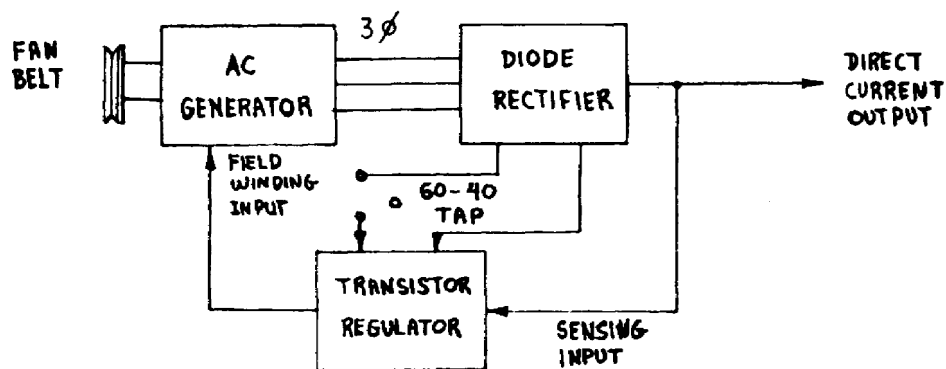


Figure 38. Block diagram of AC charging system.

(1) The higher the exciter field winding current, the higher the flux and the higher the three-phase (3Ø) output current and voltage.

(2) If the exciter field winding current is low, this will lower the three-phase (3Ø) output current and voltage.

b. The six diode rectifiers change the three-phase (3Ø) AC voltage into DC voltage. This is accomplished by means of silicon diodes that permit the passage of current in one direction only.

(1) The current capacity is controlled by parallel paths into the regulator circuit that supplies the exciter field winding with current.

(2) With only one of the paths connected, the current output will have a 40-ampere capability.

(3) With both paths connected to the regulator more current is available to the field winding through the regulator with a maximum of 60 amperes at the DC output.

c. The transistor regulator is a completely static unit containing no moving parts. It performs only one function in the charging circuit--to limit the generator voltage to a safe, preset value.

(1) A transistor is a device made of semiconductors. They can be large or small in size, depending upon the power they must handle.

(a) The symbol shown in figure 39 represents the electrical drawing of a transistor. It consists of a device with three leads which are the EMITTER, BASE, and COLLECTOR.

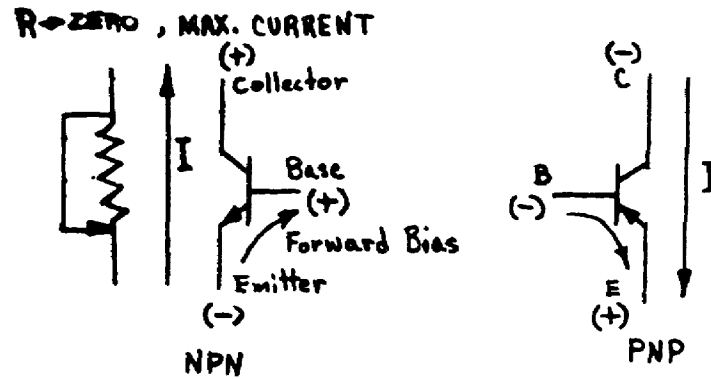


Figure 39. Transistor ON.

(b) Essentially, the transistor is a variable resistor whose resistance between emitter and collector is controlled by the current in the base lead (fig 40).



Figure 40. Variable resistor.

(c) The arrow on the emitter depicts a diode Junction between the base and the emitter, which is the controlling path of current for the transistor.

(d) If this diode junction between the emitter and base is forward biased, the resistance between the emitter and collector will be reduced.

(e) With a high value of forward bias current, the resistance between the emitter and collector approaches zero allowing maximum current flow. The transistor is said to be ON when forward biased.

(f) If the diode junction between the emitter and base is reversed biased, the transistor is said to be OFF and the resistance between the emitter and collector approaches that of an open circuit (fig 41).

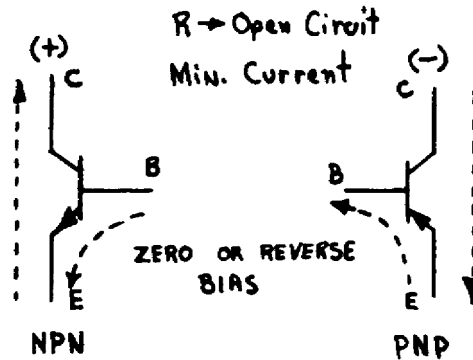


Figure 41. Transistor OFF.

(2) The silicon controlled rectifier (SCR) is like a conventional diode, except that it has a gate terminal which controls the rectifying function. The symbol is shown in figure 42.

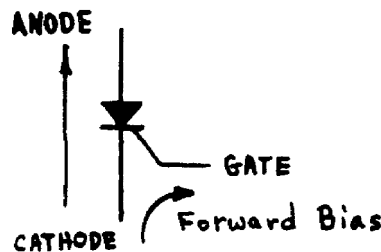


Figure 42. SCR.

(a) With the gate forward bias it operates as a conventional diode and will rectify.

(b) Once the gate bias has turned ON the SCR, it will remain ON even if the gate bias is removed, providing there is current between the cathode and anode.

(c) With no gate bias and current between the cathode and anode, it will eventually go to zero. When it does, it will turn itself OFF and remain OFF until the gate is forward biased once again.

(d) To turn the SCR OFF, the current between the cathode and anode must be interrupted. A large change in the associated circuits is normally responsible for the SCR's return to an OFF condition.

d. Generators are equipped with internally mounted regulators that control the output of the generator. The generator, rectifier, and regulator (models 3002AC and 3002AD) are illustrated schematically in figure 43. Operation of the regulator is as follows:

switches the transistor ON, and its emitter-to-collector saturation voltage decreases to a point below the voltage of zener diode Z1. Zener diode Z1 therefore blocks the flow of gate current in silicon controlled rectifiers SCR1 and SCR2 until the output voltage falls to a level which shuts OFF the base current of transistor TR as previously explained. As the phase terminals of silicon controlled rectifiers SCR1 and SCR2 become negative, the rectifiers are switched OFF and they remain switched OFF until gate current is again restored. This field current switching action is rapid enough to provide a level output voltage control.

11. SUMMARY. This lesson has covered the construction and operation of the multioutput AC charging system. The fundamentals of current flow and magnetism were reviewed along with transistors and diodes.

a. Specifically, the effects of voltage and current were analyzed to explain the process of rectification.

b. Transistor and SCR operations were analyzed to explain the electronic regulation.

c. The exercise will reinforce the discussion which was basically fundamental and necessary to learn the reasoning behind the testing and overhauling procedures which will be discussed in the next lesson.

LESSON EXERCISE QUESTIONS

Instructions for use of the answer sheet:

1. The procedure by which you will answer the exercise questions in this subcourse is probably new to you. The information is presented in a programmed instruction format where you immediately know whether or not you have answered the questions correctly. If you have selected an incorrect answer, you will be directed to a portion of the study text that will provide you with additional information.
2. Arrange this subcourse booklet and your answer sheet so that they are convenient. Each exercise question has three choices lettered a, b, and c. Your answer sheet has three groups of numbers for questions 1 through 200. The numbers indicated for each question represent the a, b, or c choices. The exercise response list is enclosed with this subcourse. It contains a listing of 3-digit numbers in numerical sequence. Each number is followed by a response that either reinforces a correct answer or gives you additional information for an incorrect answer.
3. To use this system proceed as follows:
 - a. Read the first exercise question and select the choice you think answers the question correctly. Go to the question 1 area of your answer sheet and circle the 3-digit number that corresponds with the choice you selected.
 - b. After you have identified the 3-digit number, locate it in the exercise response list. If you selected the right choice, the first word of the response will be "CORRECT. " This tells you that you have answered the question correctly. Read the rest of the response which tells why your choice was correct and then go to the next question.
 - c. If the word "CORRECT" is NOT the first word of the response, you have selected the wrong answer. Read the rest of the response and then turn to the area in your study text that is mentioned. There you will find the information necessary for you to make another choice. Be sure to read all of the response because it will help you select the correct answer and it also provides more information. Line out the incorrect 3-digit response on your answer sheet.
 - d. After you have reread the reference, select another answer and circle the 3-digit response for that choice. Again check the number of this second choice with the response list to see if your choice is now correct and to obtain more information about your choice. If your second choice is still not correct, line out the 3-digit response on the answer sheet and continue until the correct answer is selected. When you have answered all of the questions in an exercise, count the number of lined out responses and see how well you did.
4. You will notice that the lesson exercise question numbers continue consecutively from lesson to lesson. This allows you to use one answer sheet for the entire subcourse.
5. After you have finished the exercise questions for all lessons, fold and seal the answer sheet so that the USAOC&S address is on the outside. Drop the answer sheet in the mail so the school will know you have completed the study portion of the subcourse and are now ready for the examination.

EXERCISE

1. The AC charging system (multioutput) has a
 - a. half-wave rectified DC output.
 - b. full-wave rectified DC output.
 - c. three-phase AC output.
2. Electric current is measured in
 - a. volts.
 - b. watts.
 - c. amperes.
3. What current will flow through a 1,000-ohm resistor with 1 volt applied?
 - a. 1 milliamperes
 - b. 2 amperes
 - c. 1 ampere
4. When a 6-ohm resistor is connected to a battery the current flow is 2 amperes. What is the battery potential in volts?
 - a. 8
 - b. 12
 - c. 24
5. Which device is used to establish a reference voltage in control circuits?
 - a. Zener diode
 - b. Electromagnet
 - c. Full-wave rectifier
6. When a diode is reverse biased it exhibits
 - a. resistance approaching a short circuit.
 - b. resistance approaching an open circuit.
 - c. minimum resistance until breakdown.
7. When a diode is rectifying an AC voltage, what develops the DC output voltage?
 - a. Reverse bias current in the load
 - b. Forward bias voltage across the diode
 - c. Forward bias current through the load
8. What is a stator assembly?
 - a. Rotating magnet
 - b. Exciter housing
 - c. Loops of wire in a frame
9. In a three-phase AC generator, the phase voltages are
 - a. 90° apart.
 - b. 120° apart.
 - c. 180° apart.

10. A 12-pole rotor will produce
 - a. 12 cycles per revolution.
 - b. 6 cycles per revolution.
 - c. 1 cycle per revolution.
11. A rotating field type generator has the exciter coil located in the
 - a. rotor.
 - b. stator.
 - c. regulator.
12. The intensity of the exciter magnetic field is controlled by the
 - a. battery current.
 - b. rectified current.
 - c. regulator.

Note. - Questions 13 through 15 refer to figure 44.

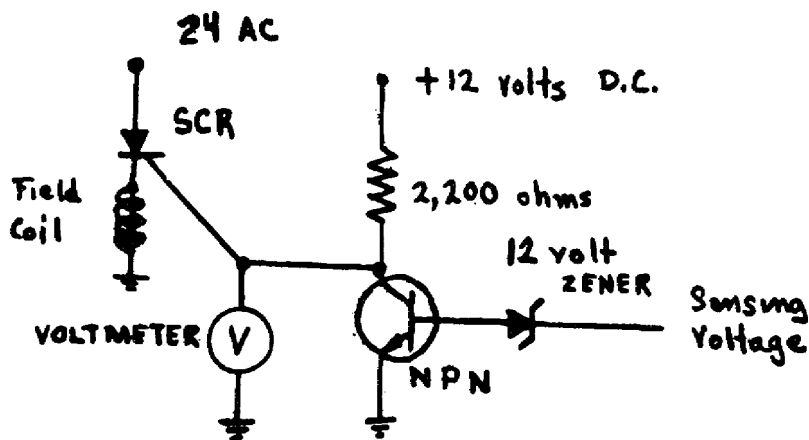


Figure 44. Electric regulator.

13. If the transistor is forward biased, the voltmeter will indicate
 - a. zero volts.
 - b. 2.2 volts.
 - c. 12 volts.
14. If the transistor is reversed biased, the
 - a. transistor is ON.
 - b. SCR is OFF.
 - c. field coil receives current.
15. The transistor will turn ON when the sensing voltage is
 - a. zero volts.
 - b. 12.5 volts positive.
 - c. 12.5 volts negative.

C O R R E S P O N D E N C E C O U R S E
o f t h e
U S A R M Y O R D N A N C E
C E N T E R A N D S C H O O L



LESSON ASSIGNMENT

Ordnance Subcourse No 010.....Electrical System Component Repair

Lesson 2.....Overhaul of 40/60-Ampere AC Generator

Credit Hours.....Two

Lesson Objective.....After studying this lesson you will be able to:

1. Describe the procedures in testing the individual components of the multioutput system.
2. Explain the most important considerations when performing the disassembly, assembly, cleaning, inspection, and testing of the multioutput system.

Text.....Attached Memorandum

Materials Required.....Answer sheet and response list

Suggestions.....None

ATTACHED MEMORANDUM

SECTION I. INTRODUCTION

1. INTRODUCTION. The 40/60-ampere AC generator consists of four housing assemblies: the drive end housing, intermediate housing, stator assembly, and end housing.

a. The drive end housing is fastened to the voltage regulator so when it is removed from the intermediate housing the voltage regulator comes with it. It is removed with a special puller.

Note. - Refer to foldout 1 in the back of this lesson.

(1) The back of the voltage regulator makes a watertight seal (34 and 35) with the rotor shaft and intermediate housing seal (18).

(2) The drive end housing also makes a watertight seal (21) with the rotor. So the entire voltage regulator and sliprings are encased between the intermediate housing and drive end housing, which, when properly sealed, forms a watertight assembly (B, foldout 1).

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(3) On the front of the drive end housing is a cover plate (26) which allows access to the 40/60-ampere regulator taps.

(4) On the circumference of the drive end housing is a pipe plug (24). Beneath this plug is the voltage output adjustment for the generator.

b. With the drive end housing removed, six rectifying diodes are exposed within the intermediate housing along with the brushes and sliprings on the rotor (fig 9).

c. From this point the stator assembly containing the DELTA connected coils can be removed.

d. The end housing then can be removed from the rotor with the puller.

SECTION II. GENERATOR TESTS

2. GENERATOR TESTS. In addition to checking the bearings in the generator housings, the following checks are performed.

a. Output voltage and current into specific loads to check the regulator and generator capabilities.

b. Rotor checks for shorts and opens.

c. Stator checks for opens and shorts.

d. Diode checks of forward to back resistance.

3. GENERATOR OUTPUT. To check the generator output, you must first know the voltage and current output specifications. The equipment required is an ammeter, voltmeter, battery, and a variable resistance load such as a carbon pile.

a. The generator has a BAT terminal and ignition terminal. The BAT terminal is the battery charging circuit. The ignition terminal is normally energized when the ignition switch is turned ON. Through the ignition terminal, the regulator circuit and exciter field winding receive their operating current and voltage.

b. When testing a generator on the bench, the ignition terminal and battery terminal are connected by a Jumper.

c. The ammeter is connected in series during the generator output check (fig 1).

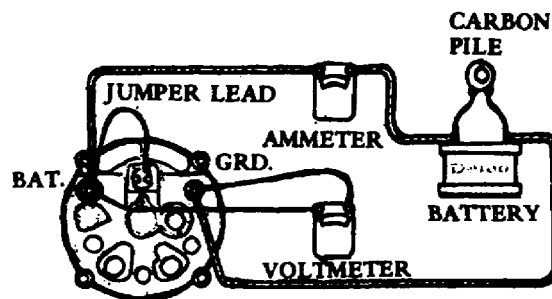


Figure 1. Output check.

(1) Remember, the ammeter is always connected in series with the circuit. An ammeter offers a very small amount of resistance to current flow, so current can be measured accurately.

(2) Also, the voltmeter is always connected in parallel. Normally, the voltmeter offers a very great amount of resistance to current flow, so it will not cause loading of the circuit.

(3) If an ammeter is connected across the battery, the battery will effectively be short circuited because of the very small amount of resistance of the meter. This will cause a great amount of current to flow and will damage the meter or the battery external connections.

(4) Since the voltmeter offers a very large amount of resistance, it may be connected in series without damage, providing polarities have been observed.

(5) It is important to observe polarity. If polarity is reversed, this will pin the needle against its peg and bend the needle, thereby requiring it to be recalibrated in order to certify accuracy.

d. The voltmeter is connected in the testing circuit across the generator to monitor its voltage. Connections are made between the BAT terminal and GRD, which is the case of the generator.

e. The battery and carbon pile (which is a variable load) are connected in parallel to form the load for the generator. They are connected to the generator through the current meter.

f. The generator is operated at specified speed and the variable load is adjusted to obtain specified voltage.

(1) Variation in the generator load should have minimum effect on the output voltage as observed on the voltmeter.

(2) Variation in the generator load should have a great effect on the output current as observed on the ammeter.

(3) A comparison of voltage regulation and maximum current, as stated in the specifications, should match the observed meter indications.

g. If the output does not meet specifications, disassemble the generator for checks of the rotor, stator, and diodes.

4. ROTOR CHECKS. The rotor windings may be checked by connecting a battery, ammeter, and voltmeter to the edge of the sliprings. If the current draw is above specifications, the windings are shorted; if the current draw is low, excessive resistance is indicated (fig 2).

a. An ohmmeter may be used in place of the battery and ammeter. The specified resistance may be calculated by dividing the voltage by the current listed in the specifications booklet. A low resistance indicates shorted windings, and a high resistance an open or poor connection (fig 3).

b. An ohmmeter connected from either slipring to the shaft should show a high resistance. A low resistance indicates the field windings are grounded.

c. A test light may be used in place of an ohmmeter to check for opens and grounds, but the test light will not check for shorts. When connected across the sliprings, failure to light indicates an open. The windings are grounded if the lamp lights when connected from either slipring to the shaft.

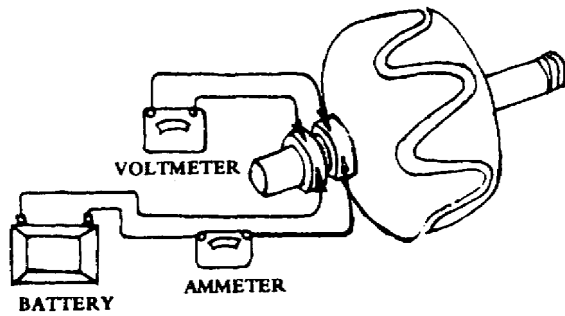


Figure 2. Rotor, operational.

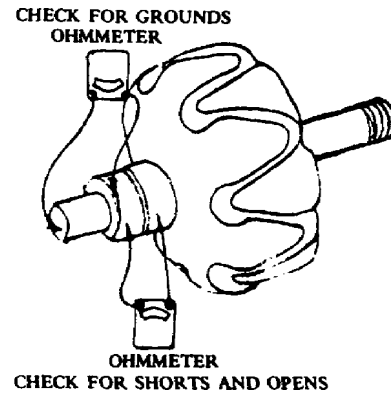


Figure 3. Rotor, ohmmeter.

5. STATOR CHECKS. Checks on the stator should be made with all diodes disconnected from the stator. It is not practical to check the stator for shorts due to the very low resistance of the windings. Also, it is not practical to check the delta stator for opens because the windings are connected in parallel.

a. To check the Y-connected stator for opens, connect an ohmmeter or test light across any two pairs of terminals. A high ohmmeter reading, or no light, will reveal an open winding (fig 4).

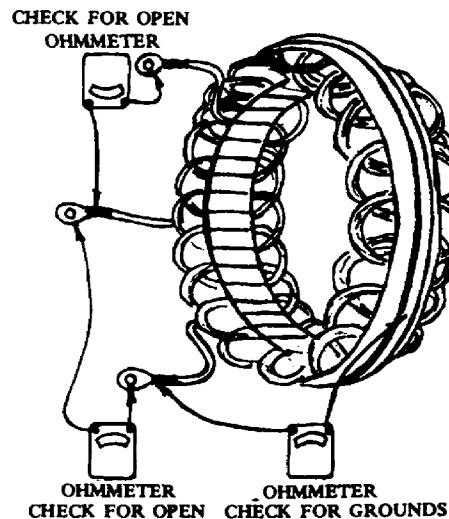


Figure 4. Y stator.

b. Either type of stator winding may be checked for grounds by connecting an ohmmeter or test light from either terminal to the stator frame. The windings are grounded if the ohmmeter reads low or if the lamp lights.

c. If all checks are satisfactory, including the diode tests listed below, but the generator fails to provide rated output, a shorted Y -or delta stator winding or an open delta winding can be suspected.

6. DIODE CHECKS. Diodes when disconnected from the stator can be checked for defects with an ohmmeter having a 1-1/2-volt cell. Using the lowest range scale, connect the ohmmeter leads to the diode case and the diode stem and then reverse the connections (fig 5). On push-in type diodes, if both readings are very low, the diode is shorted. If both readings are very high, the diode is open. On threaded-type diodes, if both readings are below 300 ohms or if both readings are above 300 ohms, the diode is defective. The 300-ohm value should be near midscale for accuracy. A good diode will give one very low and one very high reading.

CAUTION: Do not use high voltage such as a 110-volt test light to check diodes.

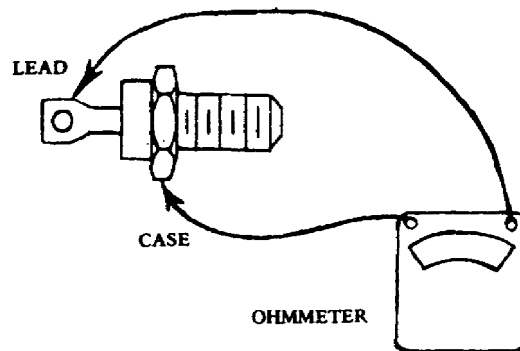


Figure 5. Diode checks.

SECTION III. DISASSEMBLY, TESTING, AND ASSEMBLY OF THE 40/60-AMPERE AC GENERATOR.

7. DISASSEMBLY.

- a. Remove pulley nut and washer.
- b. Remove pulley using puller (fig 6).
- c. Remove woodruff key from shaft.
- d. Remove six socket-head screws from drive end housing (fig 7).
- e. Remove drive end housing (using puller)(fig 8).

8. RECTIFIER TEST.

a. Positive heat sink test.

- (1) Select low ohmmeter range.
- (2) Zero the ohmmeter.

(3) Connect one ohmmeter lead to checkpoint 2 (fig 9) and the other ohmmeter lead to splice 1, then 2 and 3 (fig 10), while observing the meter. Note the readings obtained.

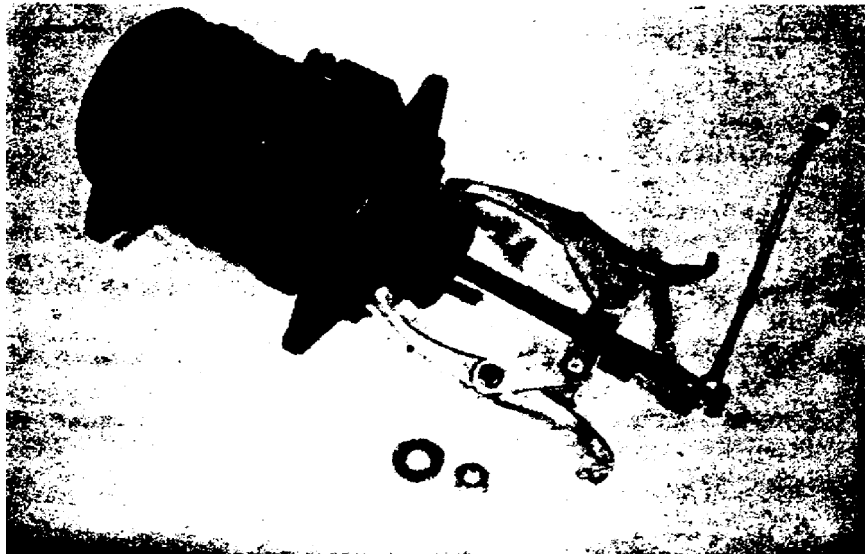


Figure 6. Removing pulley.

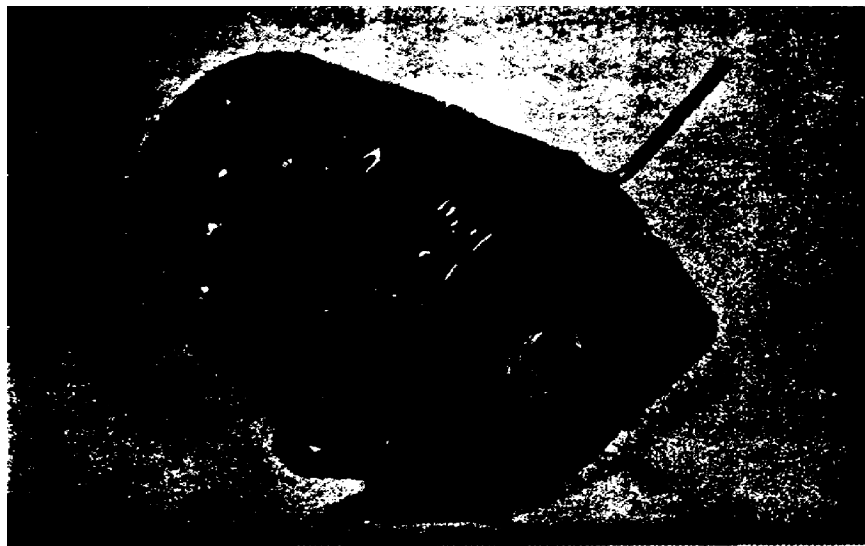


Figure 7. Drive end housing.

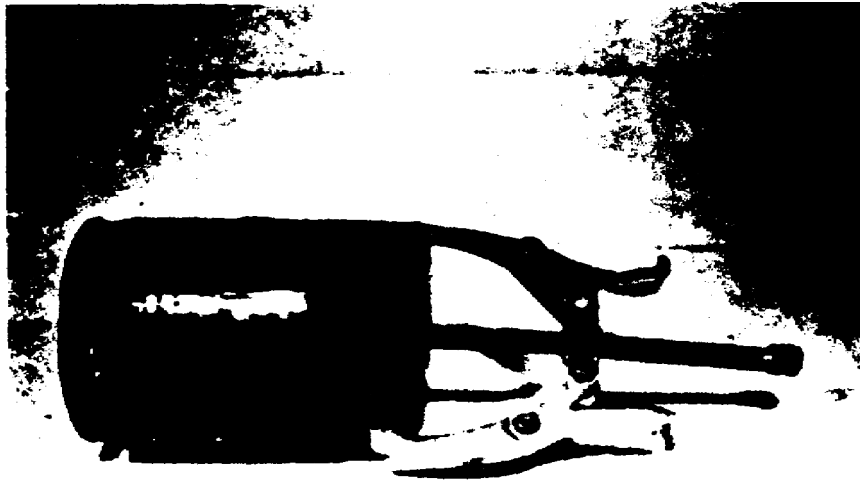


Figure 8. Removing housing.

(4) Reverse ohmmeter lead connections and repeat checks in (3) above.

(5) Readings obtained when connected one way should be low. When connected in reverse, readings should be near infinity if diodes are serviceable.

b. Negative heat sink test. Repeat tests in a above with one exception: connect one ohmmeter lead to checkpoint 1 (fig 9).

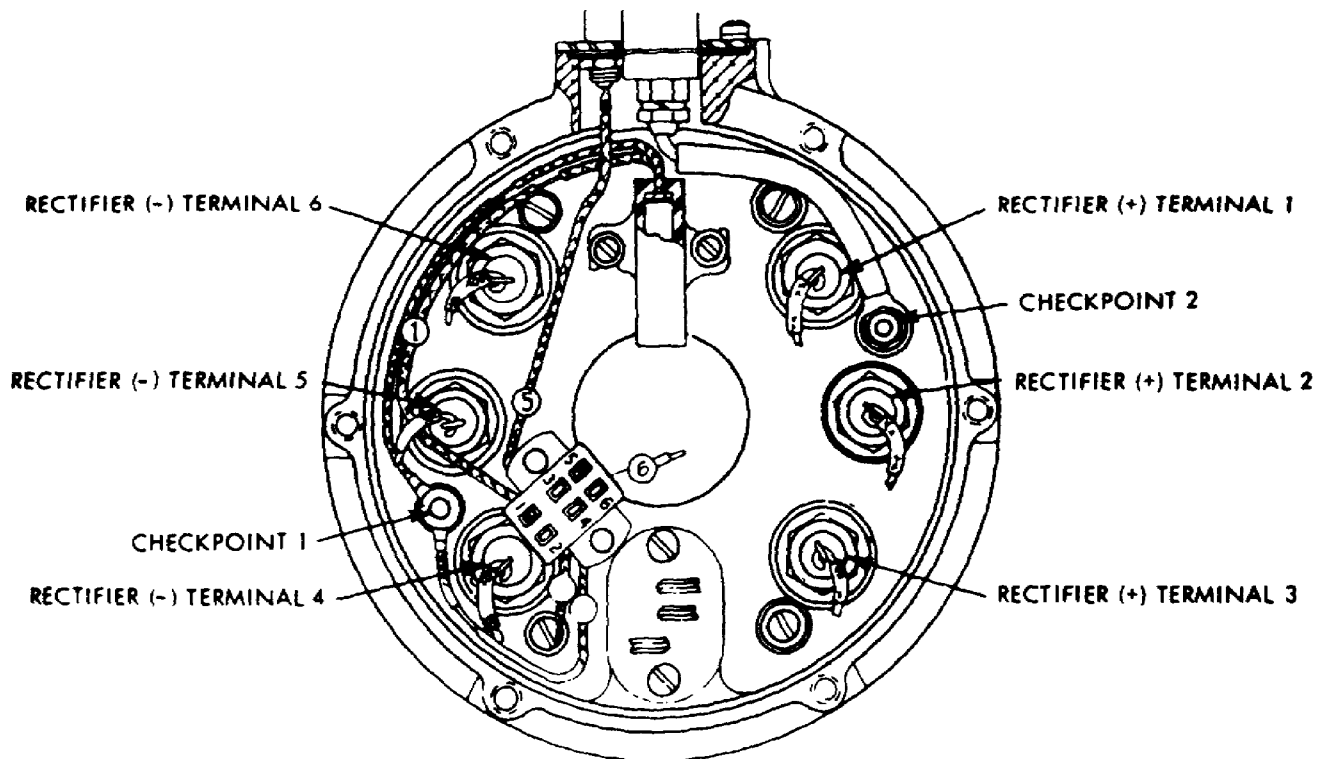


Figure 9. Rectifier test.

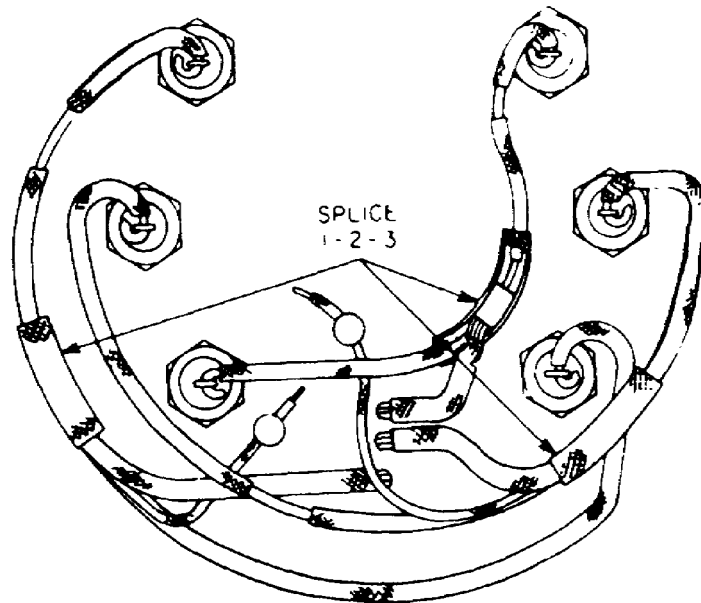


Figure 10. Continuity test.

9. STATOR CONTINUITY TEST.

Note. - The following ohmmeter connections should all obtain a zero reading if stator and all connections are good.

- a. One ohmmeter lead splice to 1, the other to splice 2.
- b. One ohmmeter lead to splice 2, the other to splice 3.
- c. One ohmmeter lead to splice 3, the other to splice 1.

10. STATOR GROUND TEST.

- a. Connect one ohmmeter lead to the generator housing.
- b. Touch the other ohmmeter lead to splices 1, 2, and 3 in succession while observing meter.
- c. A reading of less than infinity indicates faulty stator insulation (grounded stator).

11. ROTOR RESISTANCE TEST. Connect one ohmmeter lead to a slipring; the other ohmmeter lead to the remaining slipring. Resistance, for rotor to be serviceable, must be 7.0 to 7.9 ohms.

12. ROTOR GROUND TEST. Connect one ohmmeter lead to either of the sliprings and the other lead to the rotor shaft. For rotor to be good, resistance must be greater than 10,000 ohms.

13. CONTINUATION OF DISASSEMBLY.

- a. The voltage regulator may be removed from the drive end housing by removing four Allen screws.

Note. - The regulator also serves as a bearing retainer and must be removed when replacing the drive end bearing (B, foldout 1).

Note. - When pressing the bearing out of the housing, force should be applied to the outer race to avoid the possibility of damaging the bearing.

b. Remove the two roundhead screws and guard washers which secure the brush holder and lift the brush holder out of the way. Remove the brushes by pulling them out of the holder.

c. Remove the socket-head screw and washer that retain the fan; pull the fan off of the rotor shaft. Remove the key from the shaft.

d. Remove the six socket-head screws which secure the antidrive end housing and pull the housing and rotor assembly out of the stator and intermediate housing assembly.

Note. - In some cases the bearing may remain in the housing; in other cases it may remain on the shaft.

e. After visually inspecting the intermediate seal, replacement is accomplished by pressing the seal out of the housing. Discard seal after removal.

Note. - A new seal should always be used when reassembling alternator.

14. DIODE REPLACEMENT. If electrical tests indicate one or more defective diodes, the following procedures should be followed. Unsolder the lead from defective diode and push the lead aside. With a sharp knife, carefully remove the RTV rubber sealant from around the diode and unscrew the diode using an 11/16-inch deep well socket wrench. After the diode has been removed, check the mounting surface of the heat sink for burrs or foreign matter which would prevent the new diode from seating properly. It is very important that the diode seat firmly against the heat sink to insure proper heat transfer as well as electrical contact.

Note. - Diodes used in the negative (grounded) heat sink differ from those used in the positive (ungrounded) heat sink. If they are interchanged, serious damage will result. Consult figure 11 to insure proper diode identification and position. Insert the proper diode, tighten to 20 to 25 inch-pound torque and reconnect the lead. When resoldering, do not use excessive heat which could damage the diode. Reseal the diode by applying RTV sealant around the diode.

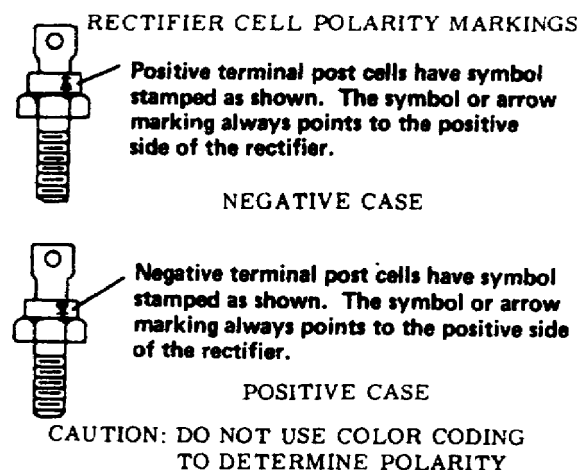


Figure 11. Diodes.

15. STATOR REPLACEMENT.

a. When tests indicate an open or grounded stator or if it is mechanically damaged, the stator must be replaced. Unsolder the three stator leads from the splices and cut the three stator leads on both sides of the intermediate housing. These leads should be cut as close to the housing as possible. The defective stator may now be removed from the intermediate housing by tapping it carefully with a soft hammer. Remove the two screws which retain the insulator and carefully pry the insulator off of the three leads.

b. Using a small drill or a punch and hammer, remove epoxy which seals the three leads into the housing. This must be done very carefully to avoid damage to the housing. When all epoxy has been removed from the hole, insert the new stator so that the three leads protrude through the housing and reinstall the fiber insulator around the leads. Replace the two screws which secure the insulator. Reconnect the three leads to the splices and solder them securely. Be sure to slip the insulating sleeving over the splices when completed. Place the stator and intermediate housing on the bench with the stator facing upward and apply epoxy around the stator leads. Sufficient epoxy should be used to completely fill the recess in the housing around the leads. Allow the epoxy to harden thoroughly before reassembling the alternator.

c. After the various electrical tests have been made and defects corrected, the alternator may be reassembled.

d. If the bearings are to be replaced, special care must be used to avoid damage. When pressing a bearing onto the shaft, apply pressure to the inner race with a suitable tool. When pressing a bearing into a housing, press only on the outer race. This will avoid applying force through the bearing balls, which could damage the bearing. When replacing the lip seal, pack with grease as shown in figure 12.

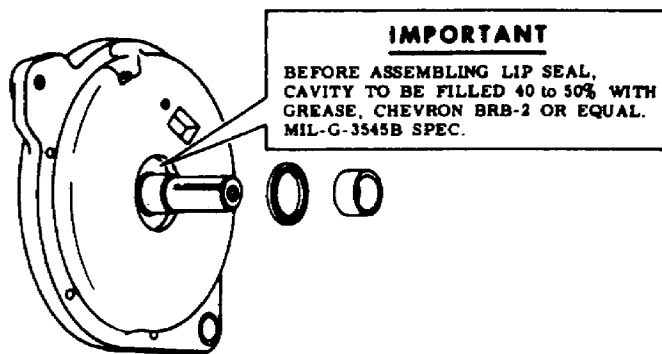


Figure 12. Stator housing.

16. REASSEMBLY.

a. Install new bearing on antidrive end of rotor and press housing onto bearing.

b. Install rotor and housing assembly into stator and intermediate housing. When installing the rotor, it is necessary to use a special tool to avoid damage to the seal. Details of the tool and installation are shown in figures 13, 14, 15, and 16. Insert the tapered end of the tool into the intermediate housing seal from the drive end or brush holder side of the housing. Be sure the surface of the tool that enters the seal is free from nicks and burs, which would damage the seal. Carefully slide the rotor into

the stator and housing assembly. The tool will be forced back out of the seal as the rotor shaft enters. The tool prevents the sliprings from catching on the edge of the seal and damaging the sealing lips.

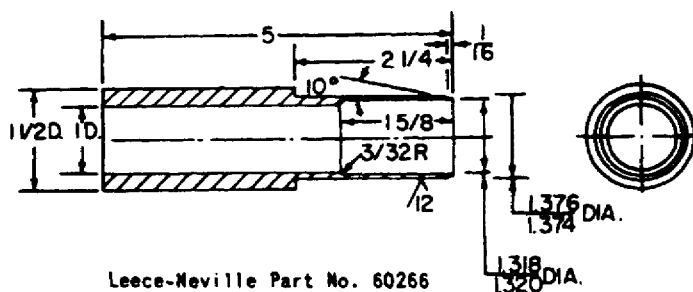
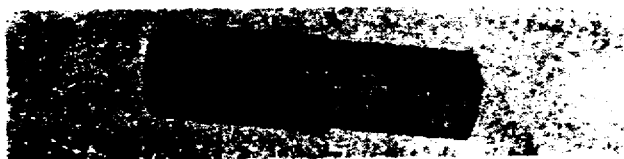
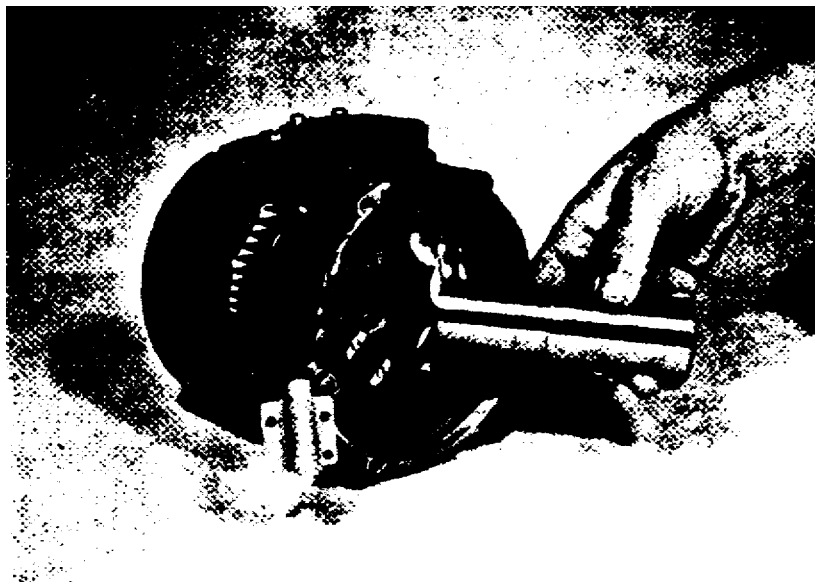


Figure 13.

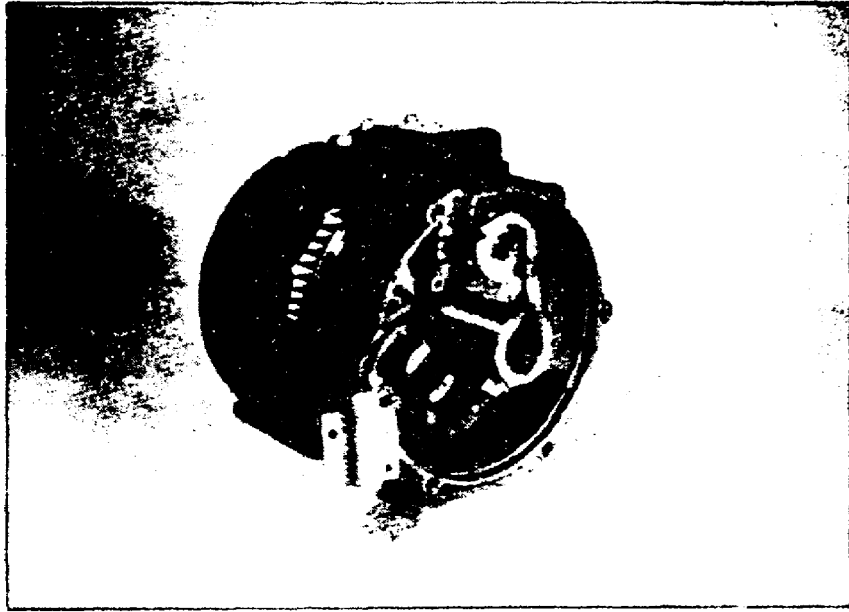


Figure 14.

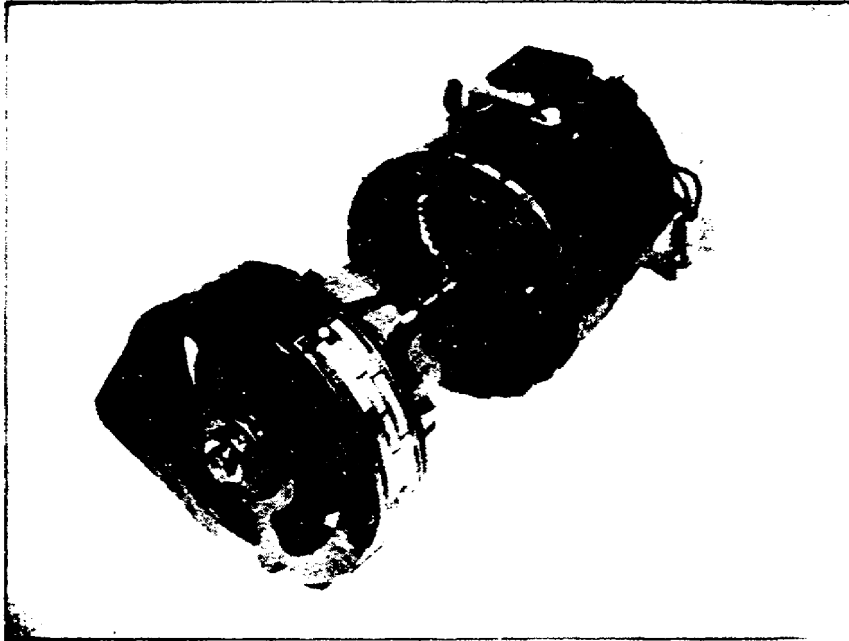


Figure 15.



Figure 16.

c. Install socket-head bolts which retain antidrive end housing to the stator and intermediate housing.

d. Install brushes in brush holder and install brush holder with the two screws that were originally removed.

e. Install new bearing in drive end housing and install voltage regulator with four socket-head screws.

f. Install spacer or seals on rotor shaft in reverse order of removal.

g. Press regulator and housing on rotor shaft.

Caution: The six-prong plug on the regulator must line up with its mate in the alternator. Use the guide pin to properly pilot the housing while pressing it on. Be sure the rubber "O" ring is in place on the drive end housing (fig 17).

h. Replace the six socket-head screws which retain the drive end housing.

i. Install key and fan using socket-head screw and retaining washer.

j. Install the pulley spacer, woodruff key, and pulley. Install the guard washer and pulley nut, torquing to 50 ft-lb. When possible, use a new pulley nut as its self-locking ability is reduced after the nut has been removed.



Figure 17.

SECTION V. CLEANING, INSPECTION, AND TESTING.

17. CLEANING.

a. Inspect screws, nuts, and plugs for worn or damaged threads and mutilated screw slots or wrench sockets. Inspect smaller hardware items such as flat washers, etc, for breaks and other obvious damage. Replace all defective hardware items.

b. Minor thread damage can be repaired by chasing threads with a tap or die of correct size.

c. Discard all preformed packings, gaskets, oil seals, and brushes, as these parts are to be replaced during assembly. Discard sliprings and bearings that have been removed.

d. Clean stator assembly, rotor, and brush holder with a cloth dampened in volatile mineral spirits or drycleaning solvent. Do not soak parts in solvent. Dry with compressed air. Take care not to damage insulation, cables, or windings.

e. Refer to TM 9-214 and clean and inspect bearings as outlined in the manual.

Note. - Ball bearings are sealed and packed with lubricant and will normally require cleaning only at repair periods. Cooling ducts in stator and rotor assemblies should be kept free of dirt and grease. A thin rod can be used to loosen caked dirt.

f. If sliprings are rough or have minor pits, polish them with No 000 or finer sandpaper. Clean rings and rotor with compressed air after polishing rings.

CAUTION. - Do not use emery cloth to polish sliprings. Fragments from emery cloth may short circuit rotor.

g. Clean all other metallic parts with drycleaning solvent and dry thoroughly.

18. INSPECTION.

a. Fan. Inspect vanes for cracks and damage.

b. Hub and clutch. Inspect for stripped threads, worn keyway, and worn, weak, or distorted springs.

c. Bearing retainers. Inspect for cracks and damage.

d. End housings. Inspect for cracks and damage. Inspect bearing bore for proper size (table 4-1, TM 9-2920-225-34). Check that mating face is not warped.

e. Bearings. Inspect bearings as directed in TM 9-214. Inspect for size (table 4-1, TM 9-2920-225-34).

Note. - If you have any doubt as to serviceability of bearings, replace them.

f. Brush holder. Inspect for cracks. Inspect terminal studs and screws for looseness and damaged threads.

g. Brush levers. Inspect for distortion and damage.

h. Brush lever springs.

(1) Inspect for cracks and distortion.

(2) Use a spring pressure checker to check spring pressure exerted by brush springs of generators. When loaded with 10 ounces, spring length must be 1 inch. Replace springs that fail to meet this requirement.

i. Stator assembly.

(1) Inspect for stripped threads in housing.

(2) Inspect for loose or frayed insulation.

(3) Inspect connector for loose or damaged pins.

j. Rotor.

(1) Inspect keys and key seats for damage.

(2) Inspect shaft for burred or stripped threads.

(3) Place rotor in V-blocks, and check each slipring with dial indicator (fig 18). Maximum allowable distortion is 0.001 inch.

k. Flexible coupling. Inspect shaft for worn splines. Inspect holder and cover for cracks and damage. Inspect blocks for wear, distortion, and loss of resiliency.

l. Screws and washers. Inspect all screws for stripped threads and damaged heads. Inspect all washers for cracks and distortion.

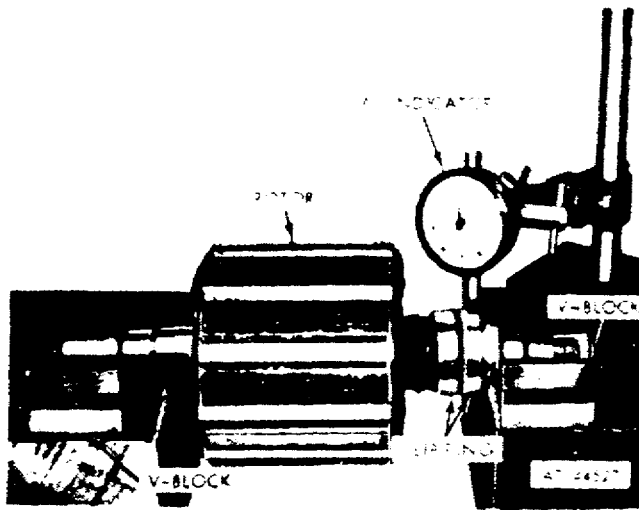


Figure 18. Testing sliprings for distortion.

19. TESTING. After the generator has been assembled, you must test it for proper performance.

a. Test setup with regulator removed. To check generator output without regulation, remove the regulator from the generator. Connect two Jumpers between terminals 1 and 5 and 2 and 3 of the connector as shown in A, Foldout 2. Install the drive end housing on the generator. Connect the generator as shown in B, Foldout 2. Operate the generator at the speeds indicated in C, Foldout 2. Then adjust the variable resistor until the generator is producing the indicated voltage at the rated amperage.

b. Test setup with regulator installed. Install the regulator in the generator as directed. Connect the generator as shown in D, Foldout 2. The 0-to 100-ampere ammeter measures load current and the 0-to 50-volt voltmeter measures generator output voltage.

Note. -The ignition switch must be closed at all times during tests. This switch completes the field coil circuit.

c. Heat run test. Operate the generator under the conditions given in C, Foldout 2. Adjust the generator output voltage to 28 volts by removing the pipe plug (A, 24, Foldout 1) and rotating the potentiometer adjusting screw. Operate for 1 hour. Check that temperature rise does not exceed 280° F.

Note. - Perform this test at room temperature of 80° F.

d. Speed load test. Immediately after the heat. run test, operate the generator at the speeds indicated in table C, Foldout 2. Generator output must be at or above the indicated output.

e. Overspeed test. Disconnect the generator from the electrical circuit. Then operate the generator at the speed and for the time interval specified in table C, Foldout 2. Listen for any unusual noise that might indicate mechanical failure.

20. SUMMARY. In this lesson the overhaul of the 40/60-ampere AC generator was discussed. This included a description of the generator components and general tests that are performed on generators.

a. Rotor checks were described. The checks were the field winding current, sliprings, and ohmmeter checks for open and short circuits.

b. Stator checks were discussed. The differences between the Wye (Y) and Delta windings were covered.

c. Diode checks were also covered with respect to their connections to the stator winding.

d. The disassembly, inspection, testing, and repair was then discussed in detail.

Note. - Review the exercise instructions in lesson 1.

EXERCISE

16. The voltage output adjustment is found beneath the

- a. cover plate on the front housing.
- b. cover plate on the rear housing.
- c. pipe plug on the front housing.

17. The rectifying diodes, sliprings, and brushes are exposed when the

- a. stator is removed.
- b. drive end housing is removed.
- c. rear end housing is removed.

18. To check the generator output, the

- a. voltmeter is connected in series.
- b. ammeter is connected in parallel.
- c. ammeter is connected in series.

19. Which statement is true?

- a. Voltmeters offer very high resistance
- b. Ammeters offer very high resistance
- c. Voltmeters offer very low resistance

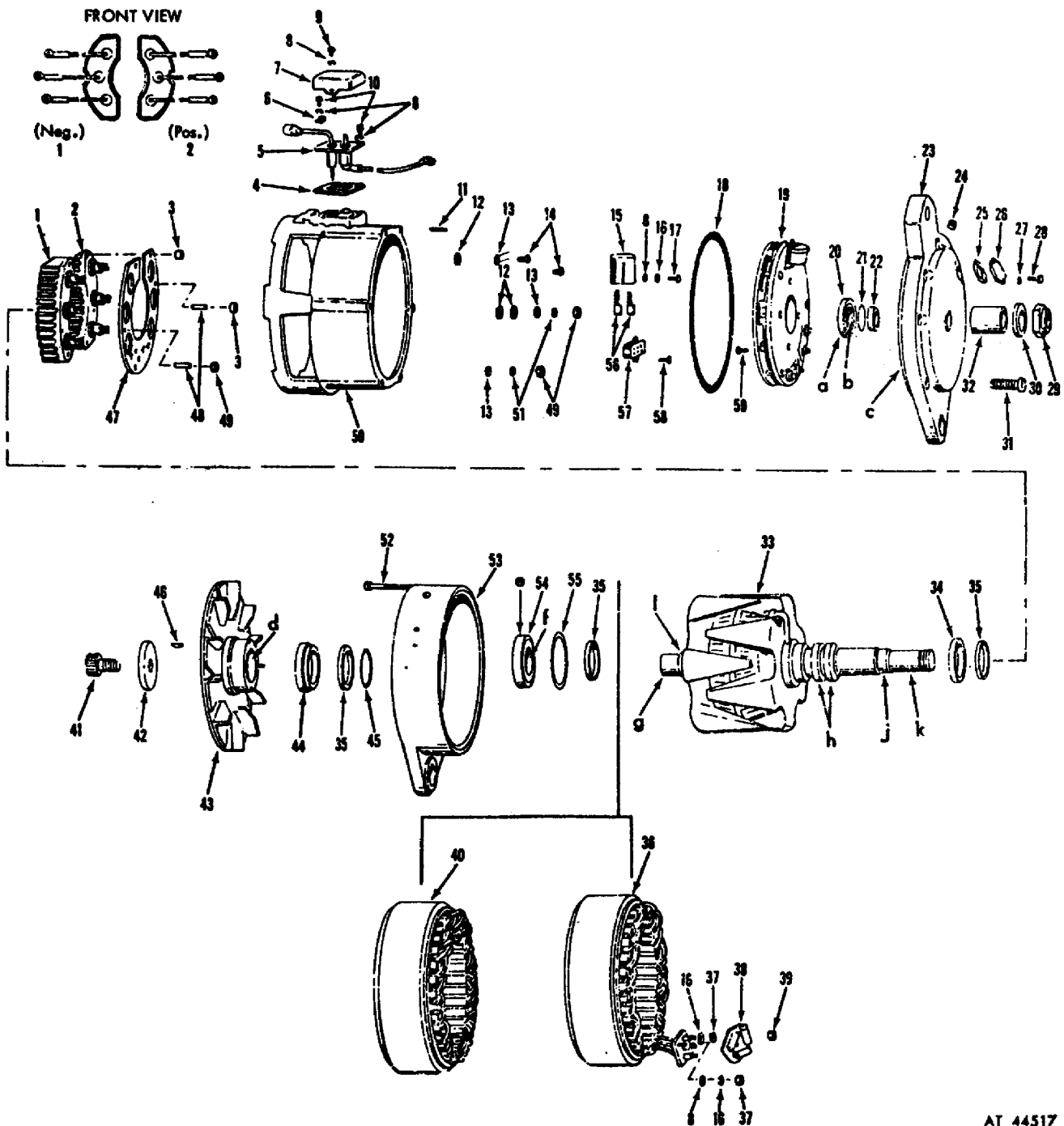
20. When testing the generator output, the variable load is connected in

- a. series with the battery.
- b. series with the voltmeter.
- c. parallel with the battery.

21. With an ohmmeter connected between a slipring and the rotor shaft, a low resistance reading indicates

- a. a shorted field winding.
- b. a grounded field winding.
- c. an open field winding.

22. With an ohmmeter connected between the sliprings on the rotor, a high resistance reading indicates
- a. an open field winding.
 - b. a shorted field winding.
 - c. a grounded field winding.
23. It is not practical to check the stator windings
- a. with the diode rectifiers disconnected.
 - b. for shorts due to low resistance.
 - c. for opens due to high resistance.
24. Which is easily determined?
- a. Shorted delta winding
 - b. Shorted Y (wye) winding
 - c. Open Y (wye) winding
25. What forward and reverse ohmmeter readings indicate a serviceable diode?
- a. Both readings are above 300 ohms
 - b. Both readings are below 300 ohms
 - c. One very low and one very high reading
26. To disassemble the drive end bearing
- a. the regulator does not need to be removed.
 - b. apply force to inner race to avoid damage.
 - c. apply force to outer race to avoid damage.
27. When installing the rotor, a special tool is inserted into the intermediate housing to prevent damage to the
- a. sliprings.
 - b. intermediate seal.
 - c. diode heat sinks.
28. Sliprings may be polished with very fine
- a. steel wool.
 - b. emery cloth.
 - c. sandpaper.
29. After polishing the sliprings, they and the rotor should be cleaned
- a. with compressed air.
 - b. by soaking in solvent.
 - c. with soft lint-free cloth.
30. If a brush spring tension is 10 ounces, what is the spring length?
- a. 1/2 inch
 - b. 1 inch
 - c. 1-1/2 inches



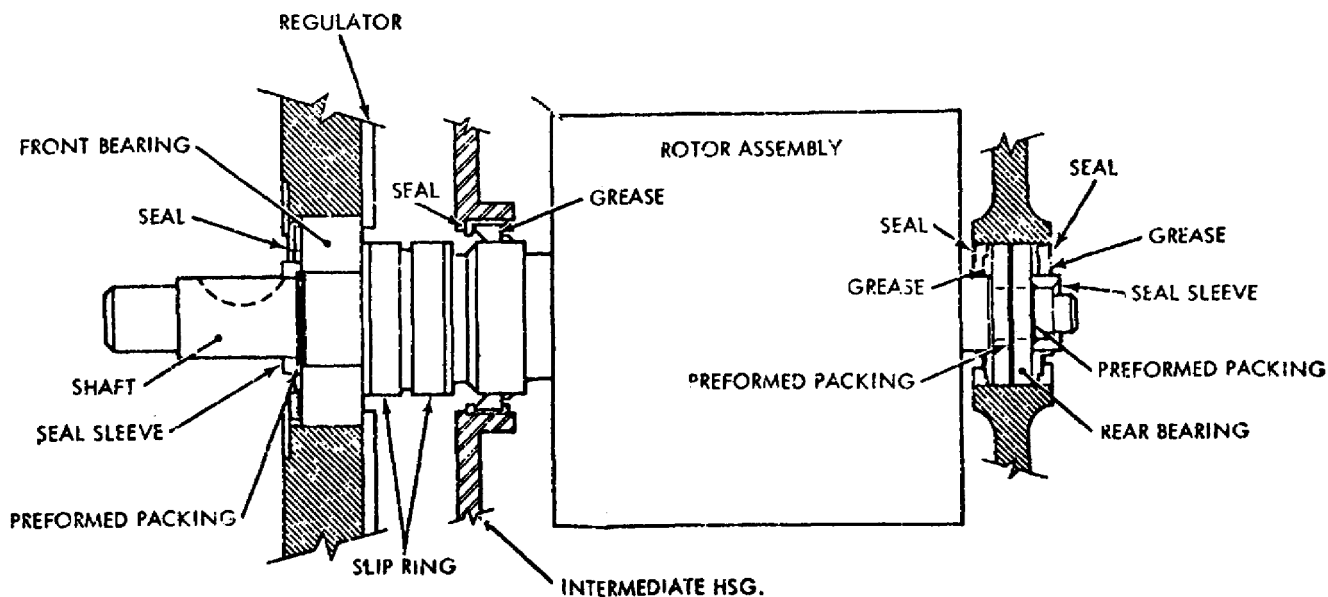
AT 44517

Figure A. Model 3002AC (Group 2) generator-exploded view.

Foldout 1.

- 1 Negative rectifier assembly
- 2 Positive rectifier assembly
- 3 Insulator mount bushing
- 4 Capacitor gasket
- 5 Capacitor and lead assembly
- 6 Lead assembly clamp
- 7 Capacitor cover
- 8 Lockwasher
- 9 Capacitor cover screw
- 10 Lead assembly screw
- 11 Intermediate housing pin
- 12 Insulator washer
- 13 Insulator guard washer
- 14 Insulator screw
- 15 Brush holder
- 16 Lockwasher
- 17 Brush holder screw
- 18 Voltage regulator preformed packing
- 19 Voltage regulator
- 20 Drive end bearing
- 21 Drive end preformed packing
- 22 Drive end spacer
- 23 Drive end housing
- 24 Drive end housing pipe plug
- 25 Drive end housing cover gasket
- 26 Drive end housing cover plate
- 27 Cover plate lockwasher
- 28 Cover plate screw
- 29 Rotor shaft nut
- 30 Rotor shaft guard washer

- 31 Drive end housing screw
- 32 Rotor shaft spacer
- 33 Rotor assembly
- 34 Rotor shaft seal
- 35 Rotor shaft lip seal
- 36 Stator and terminal assembly
- 37 Terminal board nut
- 38 Capacitor panel assembly
- 39 Capacitor panel assembly nut
- 40 Stator assembly -
- 41 Hub screw
- 42 Hub washer
- 43 Fan and hub assembly
- 44 Hub seal sleeve
- 45 End housing outer preformed packing
- 46 Hub key
- 47 Rectifier insulator mount
- 48 Rectifier stud
- 49 Rectifier nut
- 50 Intermediate housing assembly
- 51 Insulator lockwasher
- 52 End housing screw
- 53 End housing
- 54 End housing bearing
- 55 End housing bore preformed packing
- 56 Brush
- 57 Connector socket
- 58 Connector socket screw
- 59 Voltage regulator screw



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Figure B. Rotor shaft location of seals and preformed packings for model 3002AC generator.

Foldout 1. (continued)

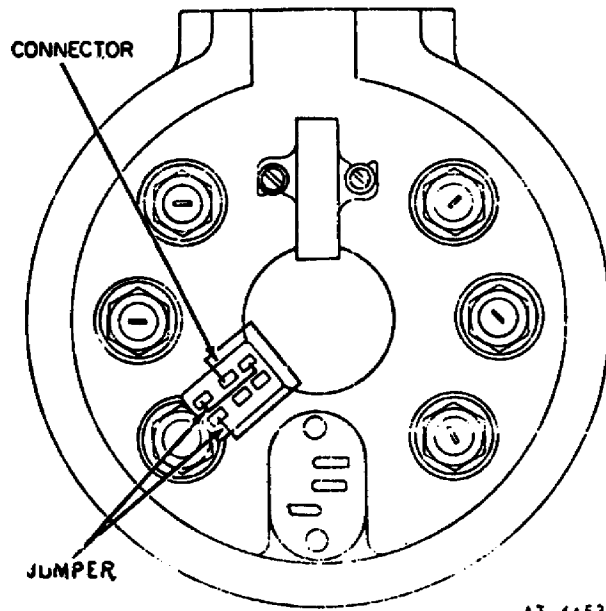


Figure A. Jumpers installed in connector of model 3002AC generator--typical.

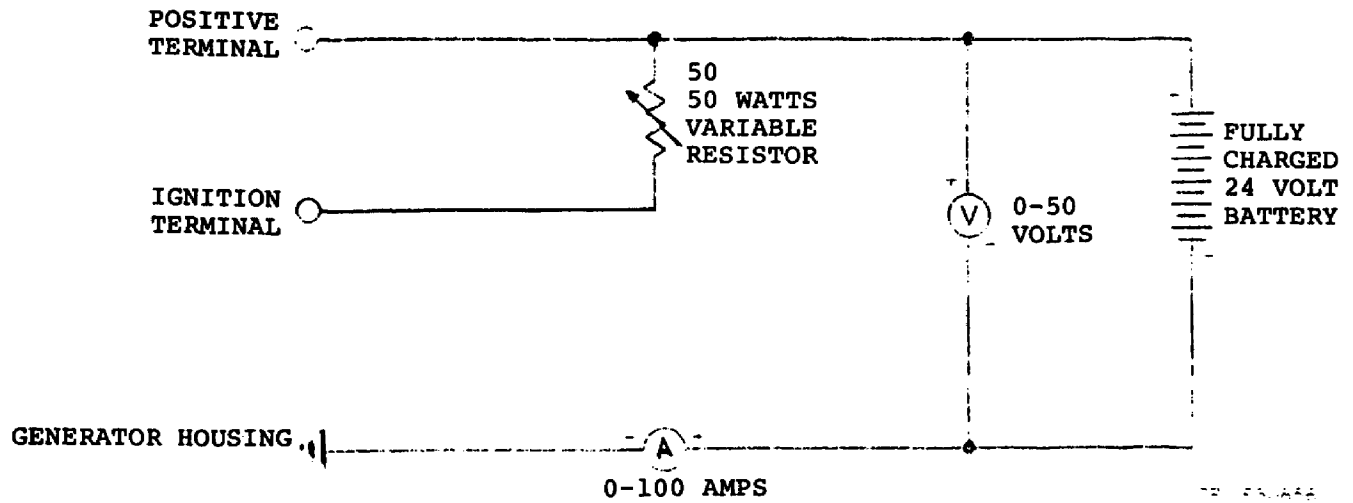


Figure B. Model 3002AC generator regulator removed test circuit--typical.

Foldout 2.

Regulator removed test			Speed load test		
Speed (rpm)	Amperage	Voltage	Speed (rpm)	Amperage	Voltage
1,500-1,800	55-60	28-30	2,000	58	28
Heat run test			Overspeed test		
Speed (rpm)	Amperage	Time	Speed (rpm)	Time	
2,000	58	1 hr	8,000	10 min	

Figure C. Models 3002AC and 3002AD generator test data.

TM 9-2920-225-34

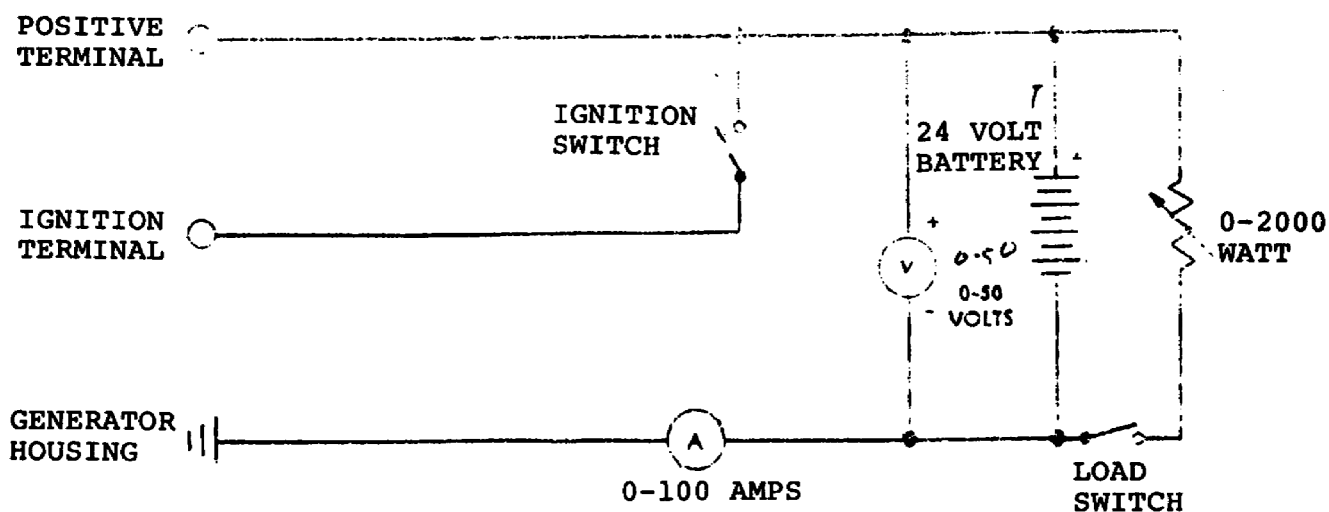


Figure D. Model 3002AC generator regulated test circuit--typical.

Foldout 2. (continued)

C O R R E S P O N D E N C E C O U R S E
o f t h e
U S A R M Y O R D N A N C E
C E N T E R A N D S C H O O L



LESSON ASSIGNMENT

Ordnance Subcourse No 010..... Electrical System Component Repair

Lesson 3..... Operation of 500-Ampere Starter
Generator Test Stand

Credit Hours..... Two

Lesson Objective..... After studying this lesson you will be
able to:

1. Describe the function of each test stand metering system.
2. State the purpose of each test stand control.
3. Describe the function of the varidrive.
4. Explain the test stand preoperational checks.
5. Describe the construction, chemical composition, use, and care of lead-acid batteries.

Text..... Attached Memorandum

Materials Required..... Answer sheet and response list

Suggestions..... None

ATTACHED MEMORANDUM

1. INTRODUCTION.

a. The test stand (fig 1) is an electrically operated device. Batteries of the lead-acid type are one source of electrical energy for the test stand. They are stored on the battery platform shown in figure 2. Different combinations of batteries may be used to produce the required DC outputs (fig 3). AC power for test stand operation must be available from an external source. Three-phase, 220/440 volt, 60-hertz (cycle) power is required.

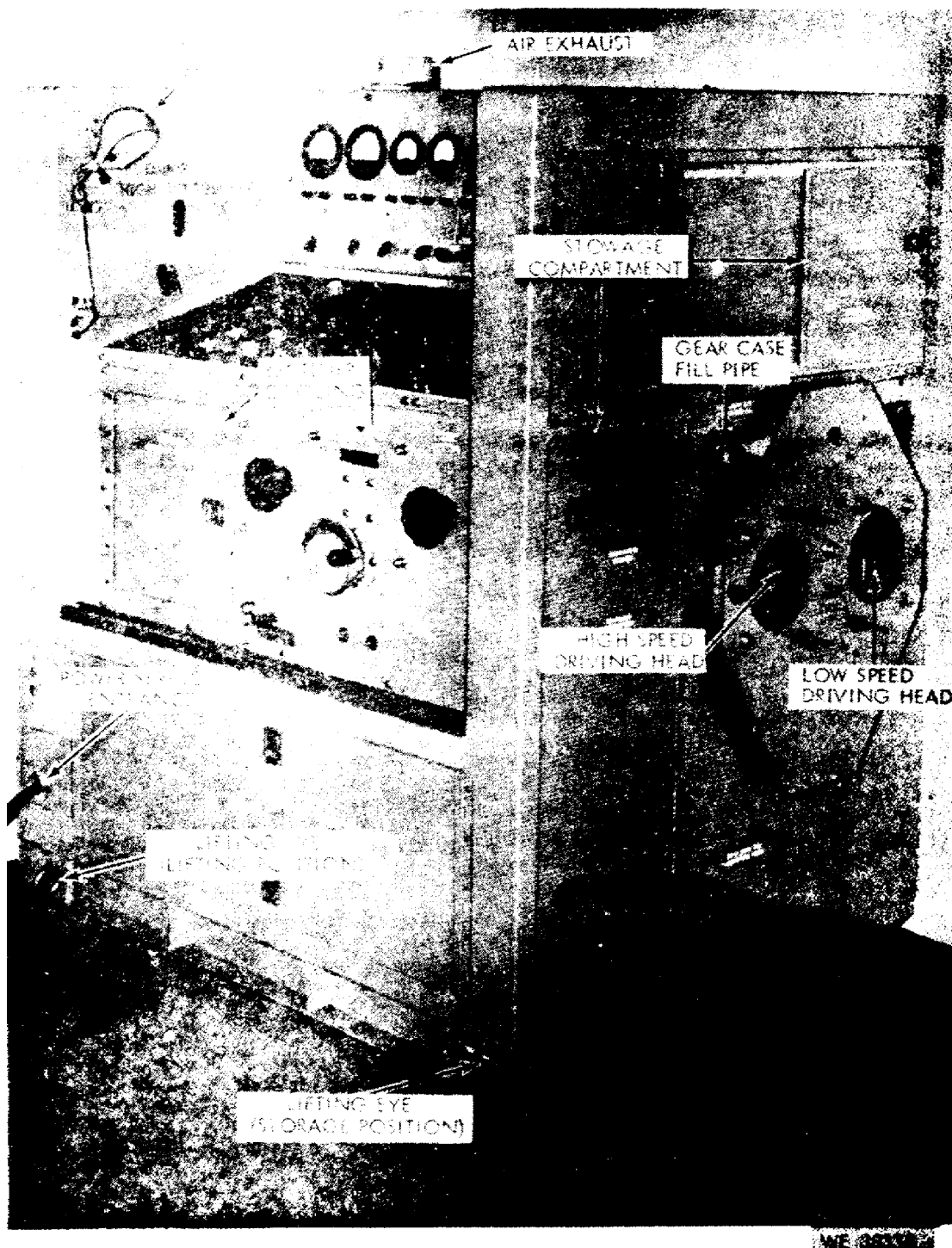


Figure 1. Test stand.

b. Consult the tabulated data (fig 4) paying particular attention to the testing range information. The test stand contains the necessary equipment to perform a wide variety of tests. Its many circuits can be utilized to test direct-drive generators, pulley driven generators, generator. control boxes, AC/DC systems, and starters.

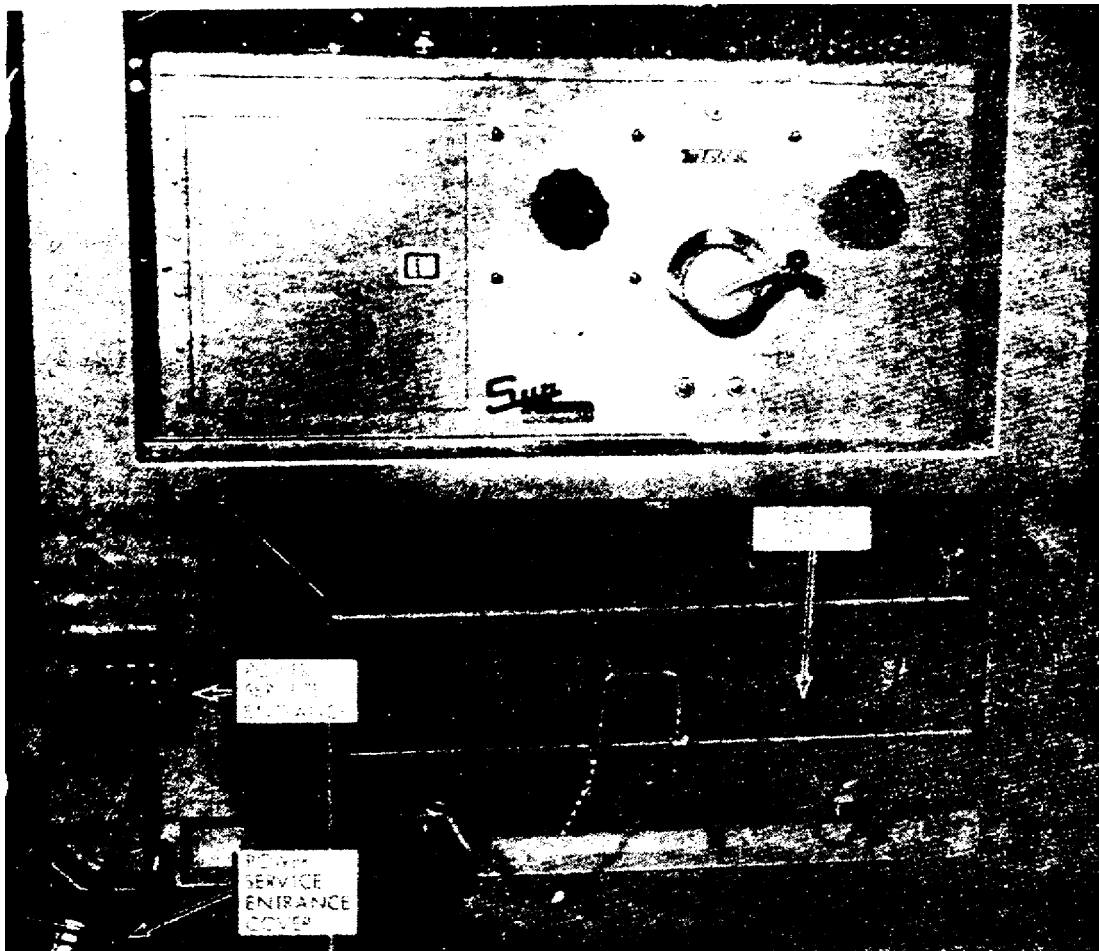


Figure 2. Test stand - front.

2. TEST STAND MONITORING METERS.

a. There are seven independent monitoring circuits on the test stand (fig 5). Each of these has one meter movement, one or more selector switches, and either a calibrating jack or a set of calibration binding posts. The calibration inputs are provided so that the test stand's measuring circuits can be easily compared with certified standards of known accuracy. Periodic calibration will detect errors in the monitor circuits. Discrepancies must be corrected before resuming tests with the test stand.

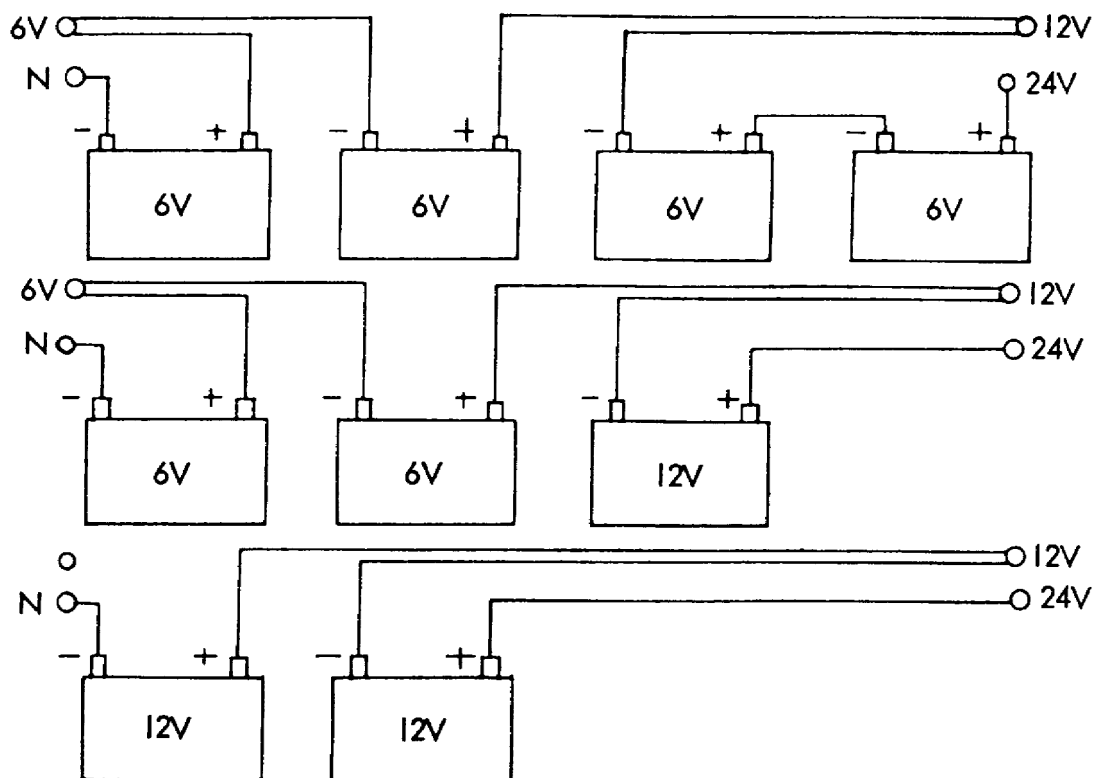


Figure 3. Battery wiring diagram. 6-, 12, and 24-volt combination.

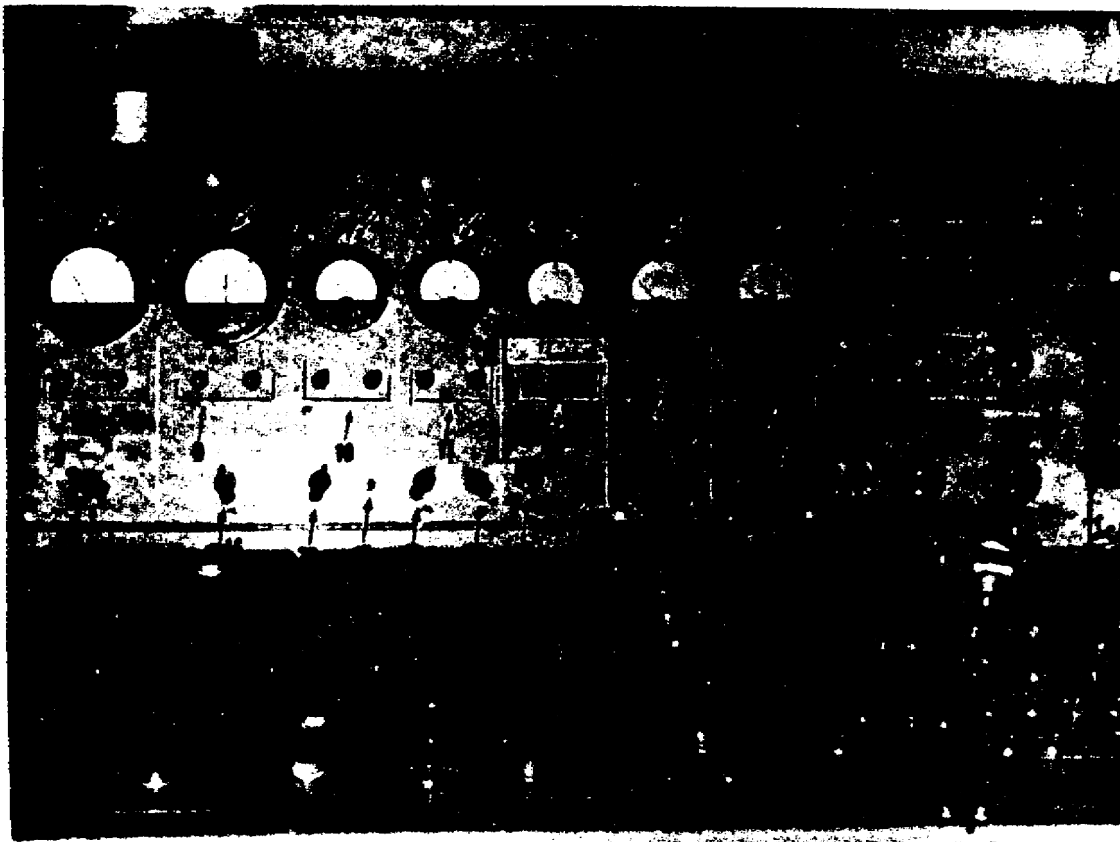
b. The load and starter DC ammeter (fig 5), in conjunction with its five position selector switch, is able to monitor DC currents up to 1,000A. Ranges of 0-50A, 0-150A, 0-200A, 0-500A, and 0-1,000A can be set up using the range selector in conjunction with the two scales on the meter face. Operators must be trained to read the correct scale and to select the range which will give the best resolution. When making tests the meter range should be selected so that the meter indication is well up scale. Trying to measure 40 amperes on the 0-1,000A range would be incorrect unless there is an overriding safety factor. Normally, 40 amperes should be read on the 0-50A scale. This monitoring system is used to perform measurements when the test stand circuits are connected to make various tests on starters (cranking motors).

c. When testing DC generators and AC alternators it is necessary to measure field current accurately. Located next to the load and starter DC ammeter is the monitoring system used to make these measurements (fig 5). The field and battery charger DC ammeter is a two-scale meter. Zero on both scales is located in the center and the meter may deflect in either direction from that point. Deflection right or left of center depends upon how the monitoring system is connected in the overall test circuit. The two scales are 5-0-5 and 15-0-15. The field and battery selector switch is a five-position switch. There is an OFF position and three field current measuring positions which set up the meter to read 5, 15, or 30 amperes at full scale. The fifth position, "battery charging," sets the monitoring system to measure 30A full scale.

<i>a. Test Stand</i>	
Manufacturer	Sun Electric Corp.
Model	AGT-9
Testing Range	
Amperes, dc	50-500
Voltage, dc	10-50
Amperes, ac	100-500
Voltage, ac	25-50
<i>b. Variable Assembly</i>	
Manufacturer	U.S. Electrical Motors Inc
Horsepower	22-1/2
(intermittent)	35
Voltage	220 / 440
Frequency	60 cycle
Speed (motor)	1800 rpm
Phase	3
Amps In-rush current (440 volts)	190
Amps In-rush current (220 volts)	380
Temperature rise	40 C
Frame	54-326U-51Y
Type	VEUHVGSdT
Class	B
Gear ratio	
(high speed head)	2.62:1
(low speed head)	1.12:1
High speed head	1830 to 11000 rpm
Low speed head	800 to 4800 rpm
<i>c. Blower Motor</i>	
Manufacturer	Marathon Electric
Model	6F4817D756AE
Horsepower	1 / 2
Voltage	230
Phase	1
Amps	3.75
Temperature Rise	40 C
Frequency	60-C
Speed	1725 rpm
<i>d. Dimensions and Weights</i>	
Length	66-3 / 4
Width	44
Height	65
Weight (without equipment)	2780 lbs
Cubage (packed for shipment)	210.4 cu ft
Weight (packed for shipment)	3000 lbs

Figure 4. Tabulated data.

d. A millivolt meter (fig 5) is used to measure the DC voltage differential between generator volts and battery volts. The millivolt meter momentary-on switch connects the meter and range selector into the circuit to be monitored when held in the ON position. Deflection to the left of zero indicates higher generator voltage. Deflection to the right of zero indicates higher battery voltage. The meter reads 0-900mV or 0-9V depending on the selector switch setting.



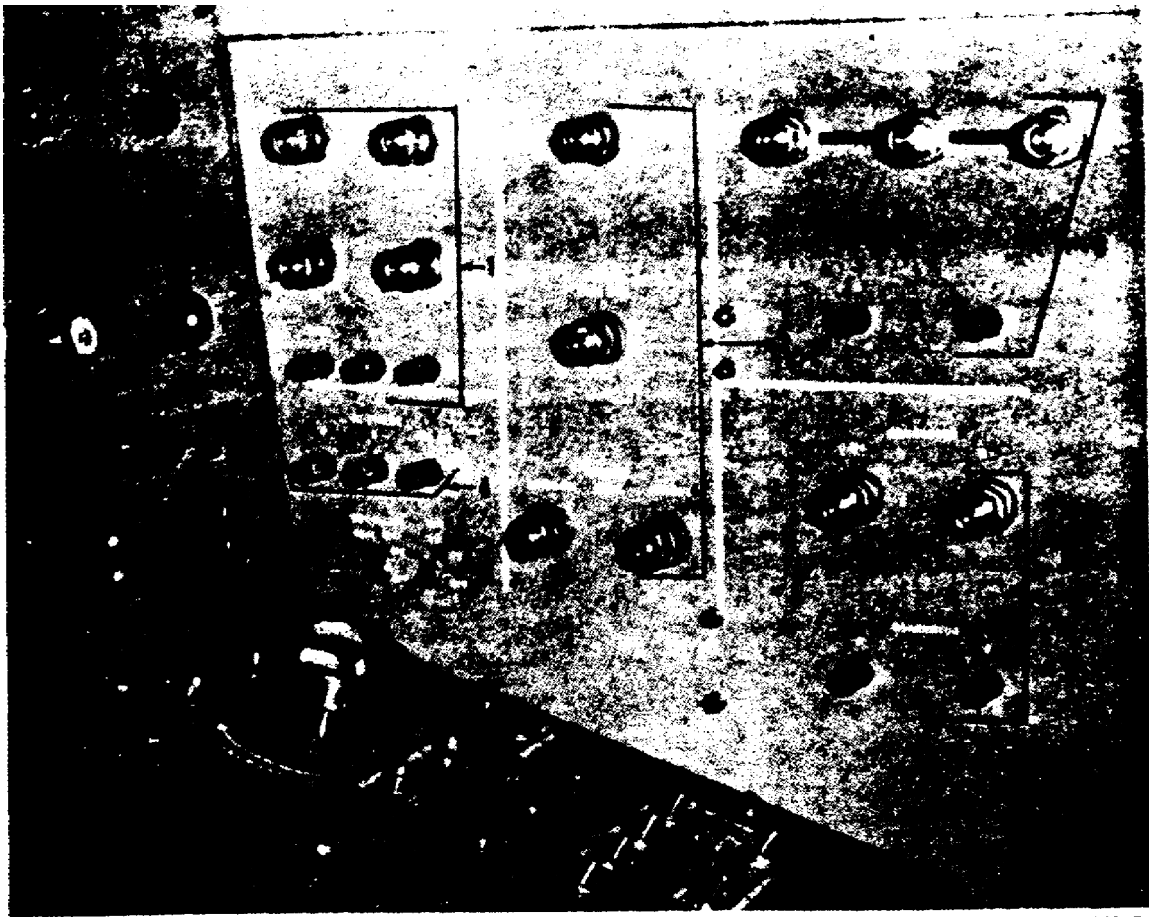
WT 38345

- | | | | |
|---|--|--|--|
| 1. Load and starter dc ammeter. | 9. DC ammeter field and battery charger calibrating binding posts. | 14. AC voltmeter calibrating binding posts. | 21. Tachometer pulley calibration control. |
| 2. Field and battery charger dc ammeter. | 10. Millivolt meter calibrating binding posts. | 15. DC ammeter load and starter selector. | 22. Tachometer circuit selector. |
| 3. Millivolt meter. | 11. DC voltmeter calibrating binding posts. | 16. DC ammeter field and battery charger selector. | 23. AC ammeter range selector. |
| 4. DC voltmeter. | 12. Tachometer calibrating binding posts. | 17. Millivolt meter range selector. | 24. AC ammeter phase selector. |
| 5. Tachometer. | 13. AC ammeter calibrating jack. | 18. Millivolt meter momentary-on switch. | 25. AC voltmeter range selector. |
| 6. AC ammeter. | | 19. DC voltmeter range selector. | 26. AC voltmeter circuit selector. |
| 7. AC voltmeter. | | 20. DC voltmeter circuit selector. | |
| 8. DC ammeter load and starter calibrating binding posts. | | | |

Figure 5. Control panel - upper.

e. The DC voltmeter, DC voltmeter range selector, and DC voltmeter circuit selector perform a wide variety of voltage monitoring functions (fig 5). The two scale meter reads out 0-10, 0-20, and 0-50 volts, dependent on the positioning of the range selector. Circuit selection is controlled by the circuit selector switch which has four positions.

(1) The "RECT GEN" position connects the metering circuit to +G and G generator binding posts (fig 6) when testing DC systems. When testing AC/DC systems the metering circuits are connected to the -D and +G rectifier input output binding posts in the rectifier cooling compartment.



WF 38347

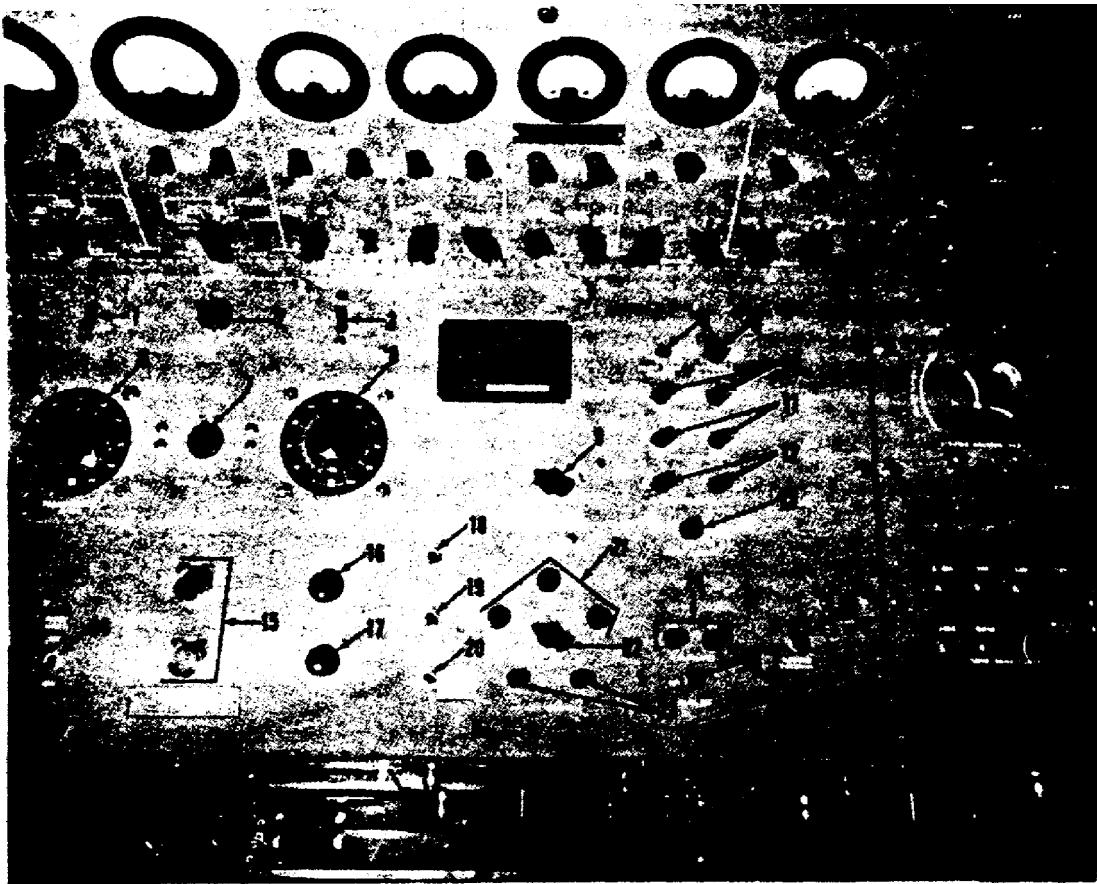
- | | | |
|---|-----------------------------|---|
| 1. Regulator terminals and binding posts. | 3. Alternator terminals. | 6. Ignition switch. |
| 2. Starter terminals. | 4. AC system binding posts. | 7. Generator terminals and binding posts. |
| | 5. Coil equalizer switch. | |

Figure 6. Binding post side panel.

(2) The "BAT" position connects the metering circuit to the battery circuits in the test stand. This permits the voltage condition of the batteries to be checked on the DC voltmeter.

(3) The "EXT" position permits the voltmeter to measure DC voltage from sources outside the test stand circuitry. In this position the metering circuit is connected to the positive and negative DC voltmeter binding posts.

(4) In the "VAR DC SUPPLY" position the metering circuit is connected to the negative and positive DC power supply binding posts (10, fig 7). Variable DC voltage supplied by the test stand to a DC system under test can be monitored with the switch in this position.



WE 36346

- | | | | |
|------------------------------------|---|--|--------------------------------------|
| 1. Power supply switch. | 8. Battery charge control. | 12. DC voltmeter remote meter testing binding posts. | 18. External field switch. |
| 2. Battery charge indicator lamp. | 9. Regulator load resistor selector. | 13. Relay closure lamp. | 19. Field common switch. |
| 3. Battery charge switch. | 10. DC power supply remote meter testing binding posts. | 14. Work light switch. | 20. Field current switch. |
| 4. Relay lamp switch. | 11. Millivolt meter remote meter testing binding posts. | 15. Start-Stop button. | 21. Battery voltage indicator lamps. |
| 5. Regulator resistor fuse holder. | | 16. Drive ON indicating lamp. | 22. Battery selector. |
| 6. Power supply control. | | 17. Power ON indicating lamp. | 23. Battery terminals. |
| 7. Charge timer. | | | 24. Pile flutter. |
| | | | 25. Head set phone jack. |
| | | | 26. Ground polarity switch. |

Figure 7. Control panel - center.

f. The tachometer, tachometer pulley calibration control, and tachometer circuit selector (fig 5) are used to measure revolutions per minute (RPM) during the testing of direct driven generators, pulley driven generators, and alternators. The 0-12,000 RPM scale is read when using the high speed driving head. When using the low speed driving head, the 0-5,000 RPM scale is used. The tachometer circuit selector switch is a two-position switch. It can be set for "Direct Drive" or "Cal Pulley." When testing direct driven generators or alternators, the tachometer pulley calibration control is set in the counterclockwise position and speed (RPM) is read directly from the meter scale. Adjustment of the tachometer pulley calibration control is determined by formula when the unit being tested is pulley driven.

g. An AC ampere monitoring system is used to measure the AC ampere output of AC/DC systems. The AC ammeter, in conjunction with its range selector switch, allows measurement of AC currents on two ranges: 0-100AC ampere and 0-400AC ampere (fig 5). The AC ammeter phase selector switch in this monitoring system is used to detect the phase balance of the system being tested. This is done by moving the switch from A to B to C while observing the ammeter reading. When the meter readings remain approximately the same, a balanced phase condition exists in the unit being tested.

h. The AC voltmeter, AC voltmeter range selector, and AC voltmeter phase selector are used to determine voltage and phase conditions in AC/DC systems under test. There are two voltage ranges: 0-25AC volts and 0-50AC volts. The circuit selector has four positions: OFF, T1-T2, T1-T3, and T2-T3. A balanced phase condition can be detected by observing the meter indication as the switch is rotated. Voltage differential of more than 1 volt between any two settings indicates unbalanced phase conditions. When not in use, the AC voltmeter circuit selector should be set to the OFF position.

3. FRONT CONTROL PANEL.

a. Figure 8 gives a good view of the rectifier cooling chamber and shows the front panel controls. The field current control is in the OFF position when rotated fully counterclockwise. When rotated clockwise this rheostat varies the field current through units under test.

b. The load current control is a rotary type rheostat. Use with the 0-25 switch. Its OFF position is fully counterclockwise. The load to the unit under test is varied by rotating the load current control clockwise.

c. The speed of a unit under test is controlled by the drive speed control. The high and low speed drive heads are driven by the varidrive. The drive speed control, when rotated counterclockwise, increases the speed of the varidrive and, therefore, the unit under test. When stopping the varidrive always reduce the speed to at least one-quarter. Never move the drive speed control in either direction when the varidrive is not in operation.

4. CENTER CONTROL PANEL (FIG 7).

a. Variable DC power is controlled by the power supply switch and the power supply control. The power supply switch is an ON-OFF circuit breaker type toggle switch. The "power on" indicator lamp illuminates with the switch in the ON position. The power supply control is a rheostat. The OFF position is fully counterclockwise. Clockwise rotation varies the supply output from 0-32VDC.

b. The relay lamp switch selects the proper circuit for the relay closure indicator lamp. It is a three-position toggle switch (12V-OFF-24V).

c. Overload protection for the regulator load resistor is provided by a fuse, which is held under the screw cap of the regulator resistor fuse holder.

d. Battery charging time is set by the charge timer. The timer is divided in 1 minute increments and can be set for a maximum of 120 minutes. When lit, the battery charge lamp indicates that the battery charger controls are in the circuit.

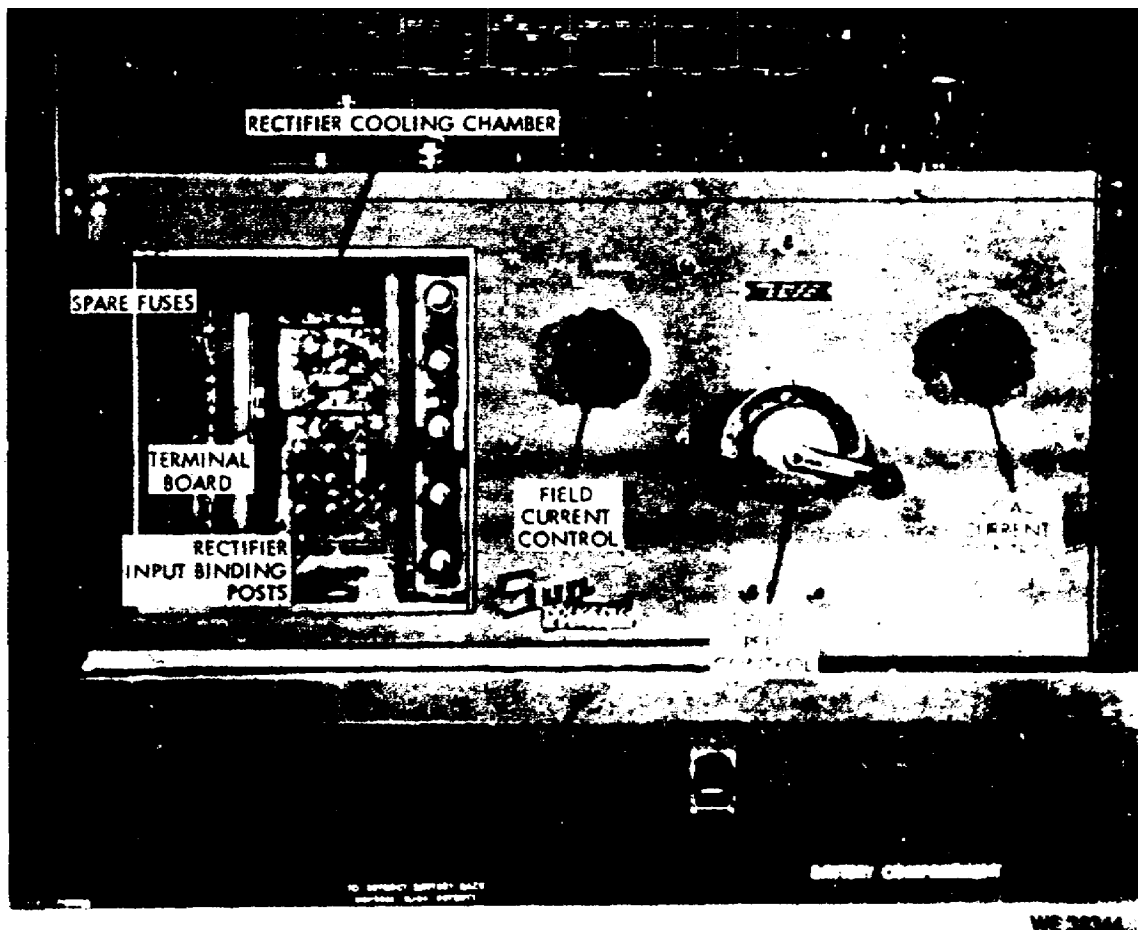


Figure 8. Rectifier cooling chamber and front control panel.

e. Proper resistance for the regulator test circuit is set with the regulator load resistor selector. Four positions of the selector (fig 7) choose resistance values of $1/4$, $1-1/2$, $2-1/4$, and 7 ohms. The fifth position is OFF.

f. There are three pairs of remote meter testing binding posts. Connection to the 0-32VDC variable power supply is provided at the DC power supply remote meter testing posts. Connection to the millivolt meter is provided at the millivolt meter remote meter testing binding posts. The DC voltmeter remote meter testing binding posts provide for external testing and comparison using the DC voltmeter.

g. Illumination for the control panel is provided by a work light. The two-position work light switch provides ON-OFF control of this light.

h. The varidrive unit is controlled by the start-stop buttons. The buttons control a magnetic switch supplying power to the varidrive unit. The "drive on" indicator lamp illuminates when the varidrive unit is operating.

i. There are three two-position field switches. The external field switch controls the external voltage to the unit being tested. Proper grounding of the generator (under test) field circuit is determined by the setting of the field common switch. The field circuit switch closes the field circuit of the unit under test. The "Manual" position is used when no regulator is connected in the circuit. With a regulator in the circuit, the switch is set to the "Regulator" position.

j. The battery terminals are used for external testing and comparison of battery voltage. The four-position (OFF, 6V, 12V, 24V) battery selector connects the proper battery circuit for testing. Respective battery indicator lamps illuminate as the 6V, 12V, and 24V circuits are selected.

k. The headset phone Jack and pile flutter binding posts are used when audio testing. The pile flutter circuits are used when checking the carbon pile of generator (alternator) regulators.

l. The ground polarity switch is used to set the proper ground polarity within the test stand. Most generators and regulators tested will require the switch to be set to the minus (-) ground position. Positive (+) grounded systems are rare.

5. CONTROL BOX RECEPTACLES AND VOLTAGE ADJUSTER (FIG 9).

a. Cables are furnished to connect various types of control boxes to the test stand. There are four receptacles for connecting 150-ampere control boxes. When testing 400-ampere control boxes appropriate cables connect the unit under test to two receptacles on the test stand.

b. The voltage adjuster is used to increase or decrease the generator output voltage when testing 400-ampere control box receptacles. The voltage adjuster is a rheostat type control.

6. STARTER AND LOAD CONTROLS.

a. The starter test switch is a two-position ON-OFF switch which applies power to the starter voltage adjuster. The starter voltage adjuster is a rheostat type control used to adjust the voltage to the starter under test.

b. The master load switch is a two-position, ON-OFF, toggle switch. Fixed loads of 25A, 50A, 100A, and 200A can be selected by the ON-OFF, load bank toggle switches. There is also a switch to select the variable 0-25A load. Predetermined loads are selected with the load bank switches and placed in the unit (under test) circuit with the master load switch.

7. RIGHT SIDE PANEL (FIG 6).

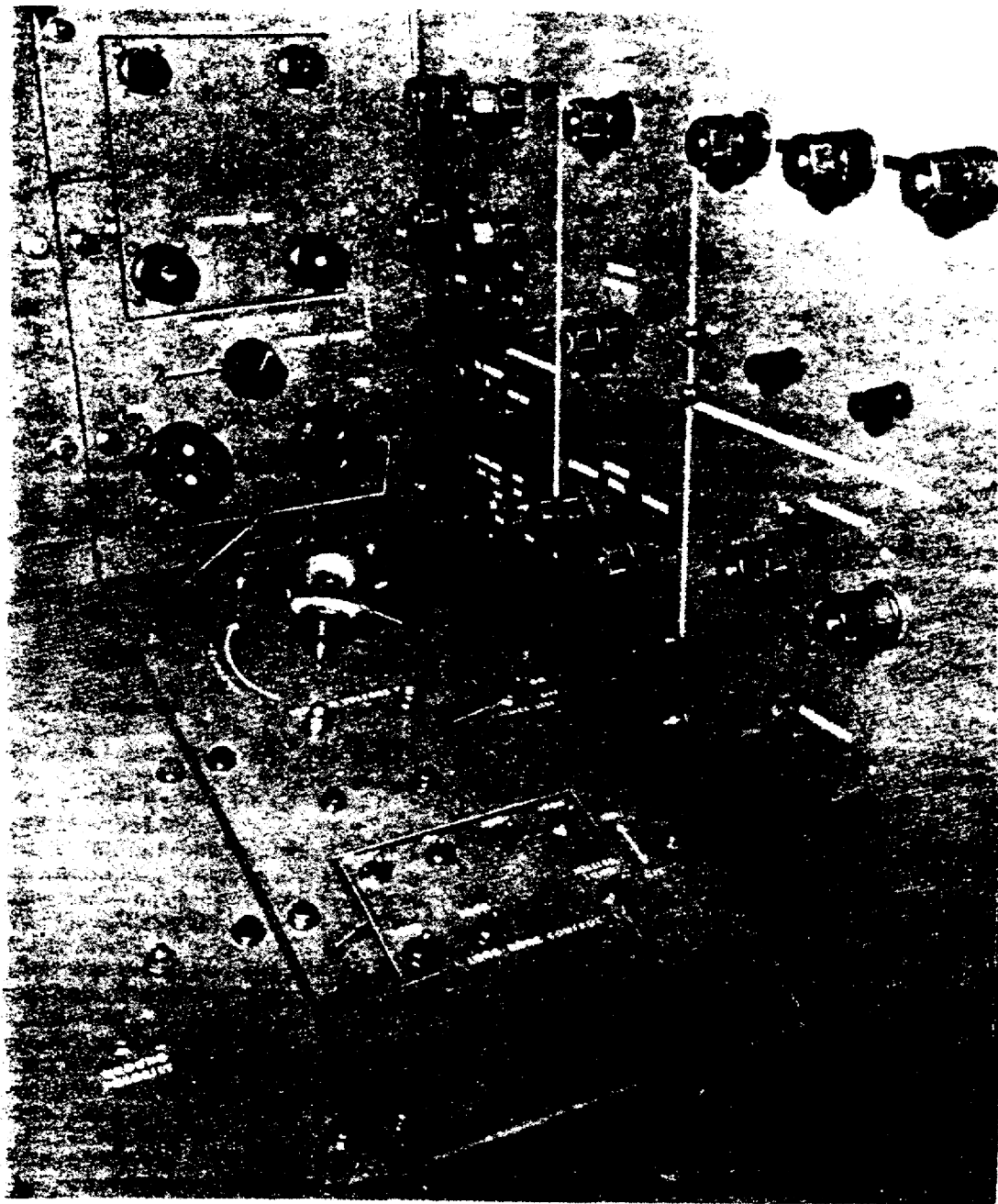
a. Four terminals and three binding posts are used to connect the regulator under test to the test stand. The four terminals are designated B+, B-, G+, and G-. The binding posts are designated GND, D, and F-B.

b. Starter units are tested by utilizing the four starter terminals on the test stand. The terminals are designated STARTER INPUT, STARTER FREE RUN, STARTER STALL COMMON, and TORQUE.

c. Alternators are connected to the test stand using three terminals and two binding posts. The binding posts are designated D and E. The terminals are labeled ALTERNATOR T1, T2, and T3.

d. D, E, and IGN are the AC system binding post designations. These posts are used during the testing of alternators (generators) on the test stand.

e. The coil equalizer switch and ignition switch are located below the AC system binding posts. The coil equalizer switch is an OFF-MOMENTARY-ON toggle switch used to check alternator dropoff voltage when testing 28V, 100A, or 400A AC/DC systems and 150A or 400A generator control boxes. The ignition switch is used in conjunction with the control box of some units under test. It is a two-position toggle switch.



WE 36354

1. 150-ampere generator
control box receptacles.
2. Voltage adjuster.

3. 400-ampere generator
control box receptacles.
4. Starter voltage adjuster.

5. Starter test switch.
6. Load bank switches.
7. Master load switch.

Figure 9. Control box receptacles, starter test controls, and load bank switches.

f. G+ and G- are the designation of the two generator terminals. The generator binding posts are labeled D and F. These connectors are used for connecting 150A or 300A generators to the stand.

8. LEFT SIDE PANEL (FIG 10 AND 11).

a. The high voltage compartment is behind the left side panel. When the panel is opened a push-contact, release breaker, interlock switch automatically cuts off power to the test stand. There are, however, dangerous electrical potentials in the high voltage compartment. Turn OFF the main breaker switch when the compartment door is open.

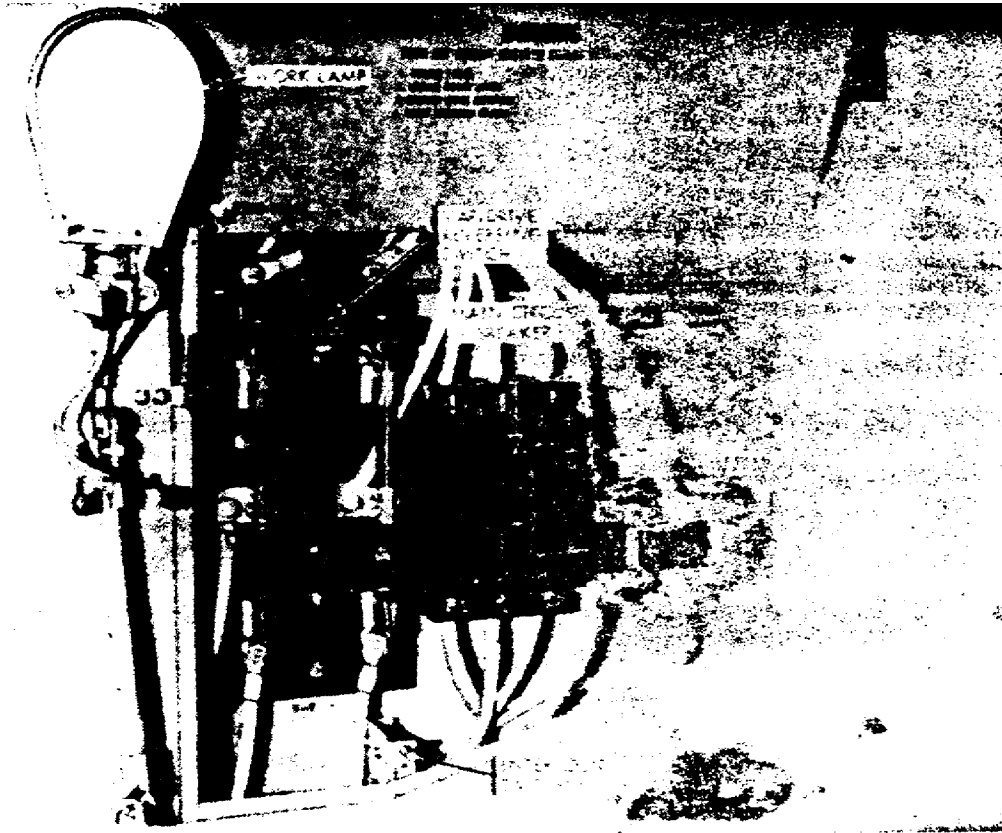


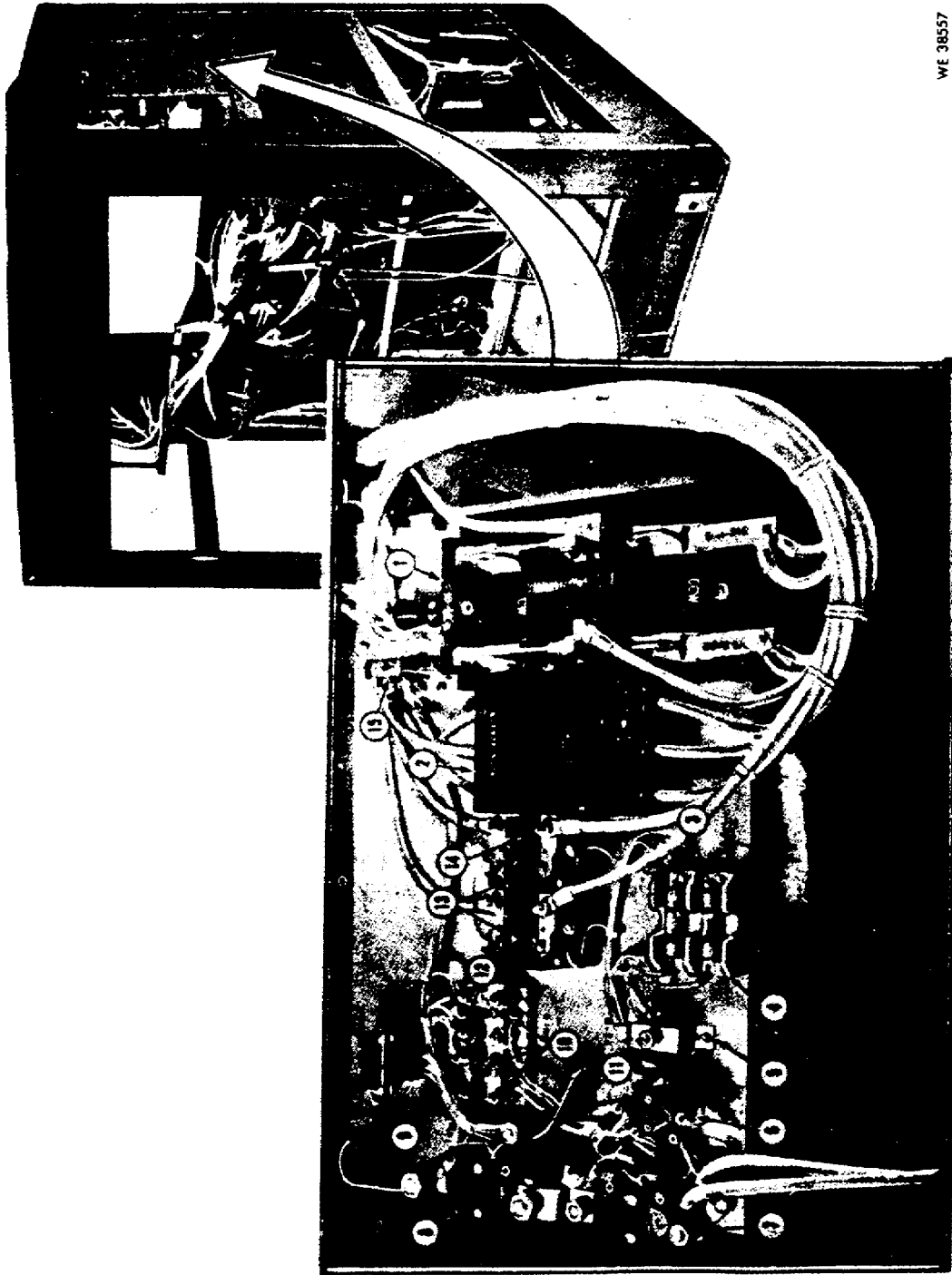
Figure 10. High voltage compartment.

b. The main breaker switch extends through the high voltage compartment door. This two-position switch is the master control for the test stand.

c. Protection for the blower motor is provided by two in-line 10A, 250-volt fuses. These fuses are located in fuse holders in the high voltage compartment.

d. The varidrive reversing switch is used to reverse the direction of varidrive rotation. It is a two-blade knife switch. The main breaker switch should be turned OFF when changing the varidrive reversing switch.

e. The test stand is wired for 220-volt operation when shipped from the factory. Overload relay heater elements W-158 are installed for 220-volt operation. If the test stand is rewired for 440-volt operation, W-151 elements must be installed. The overload relay heaters provide thermal overload protection for the test stand.



WE 38557

Figure 11. Electrical components panel.

9. REAR VIEW - MAJOR ASSEMBLIES.

a. Figure 12 shows the transformer panel assembly (3), load bank and blower motor assembly (1), and varidrive assembly (2). Part of the wiring which interconnects the various components of the test stand can also be seen in this view. Rear cover panels enclose the rear of the test stand after these major components are installed.

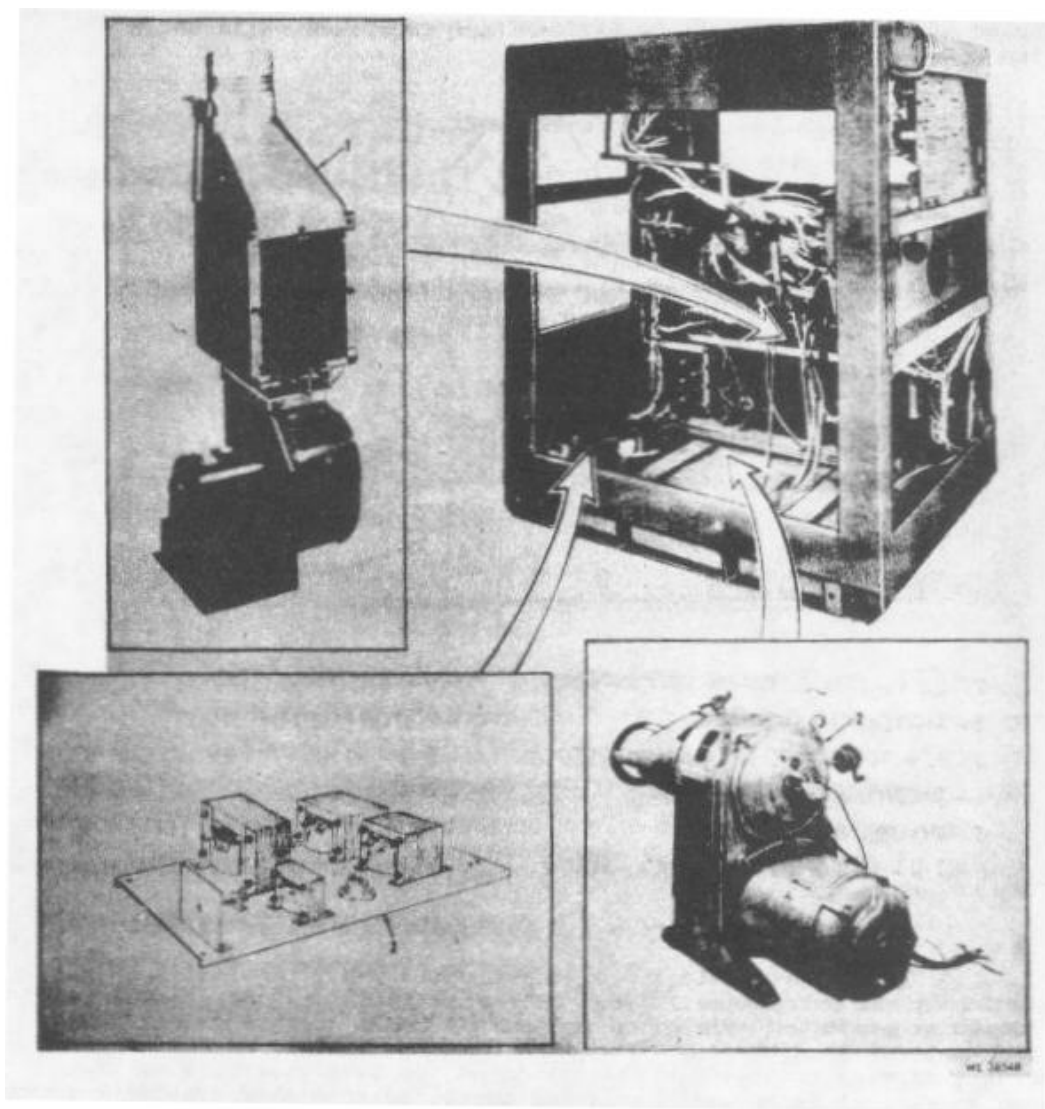


Figure 12. AGT 9 test stand--partially exploded view.

b. The varidrive assembly (fig 13) is shock-mounted to prevent control panel vibration. A speed transmission and motor are embodied in this self-contained unit. The front panel drive speed control allows the unit's RPM to be varied over a wide range. Rotating the control counterclockwise causes the moveable lower varidisc hub, mounted on the rotor (motor) shaft, to slide toward its companion varidisc. The added tension on the V-belt causes the moveable varidisc on the driven shaft to retract against the spring. This simultaneous action causes the V-belt to assume a larger diameter on the lower varidisc and a smaller diameter on the upper varidisc. The speed of the driven shaft is therefore increased while motor speed remains constant.

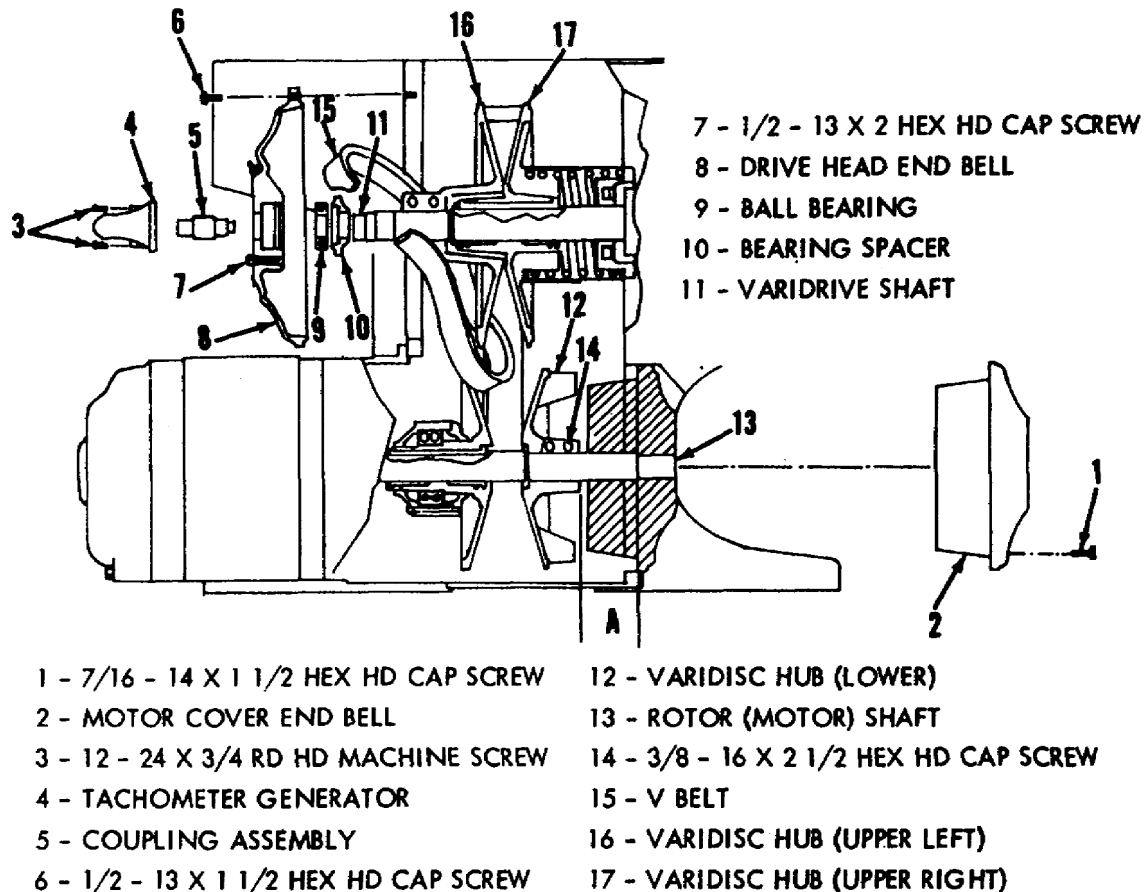


Figure 13. Varidrive and tachometer generator assembly.

c. We have previously discussed the tachometer indicator meter mounted on the meter panel. That indicator is electrically connected to the tachometer generator mounted on the end of the varidrive shaft. When the varidrive speed is increased the direct current output of the generator increases, causing an up-scale deflection on the tachometer. When the tachometer circuit is properly adjusted the speed of either driving head can be read directly from the meter.

d. The electrical wiring diagram (fig 14) is included at this point so that you can familiarize yourself with the location of all the components we have discussed in this lesson. Locate the items discussed but do not study the diagram extensively at this time. Selected circuits will be discussed in following lessons.

ELECTRICAL WORK

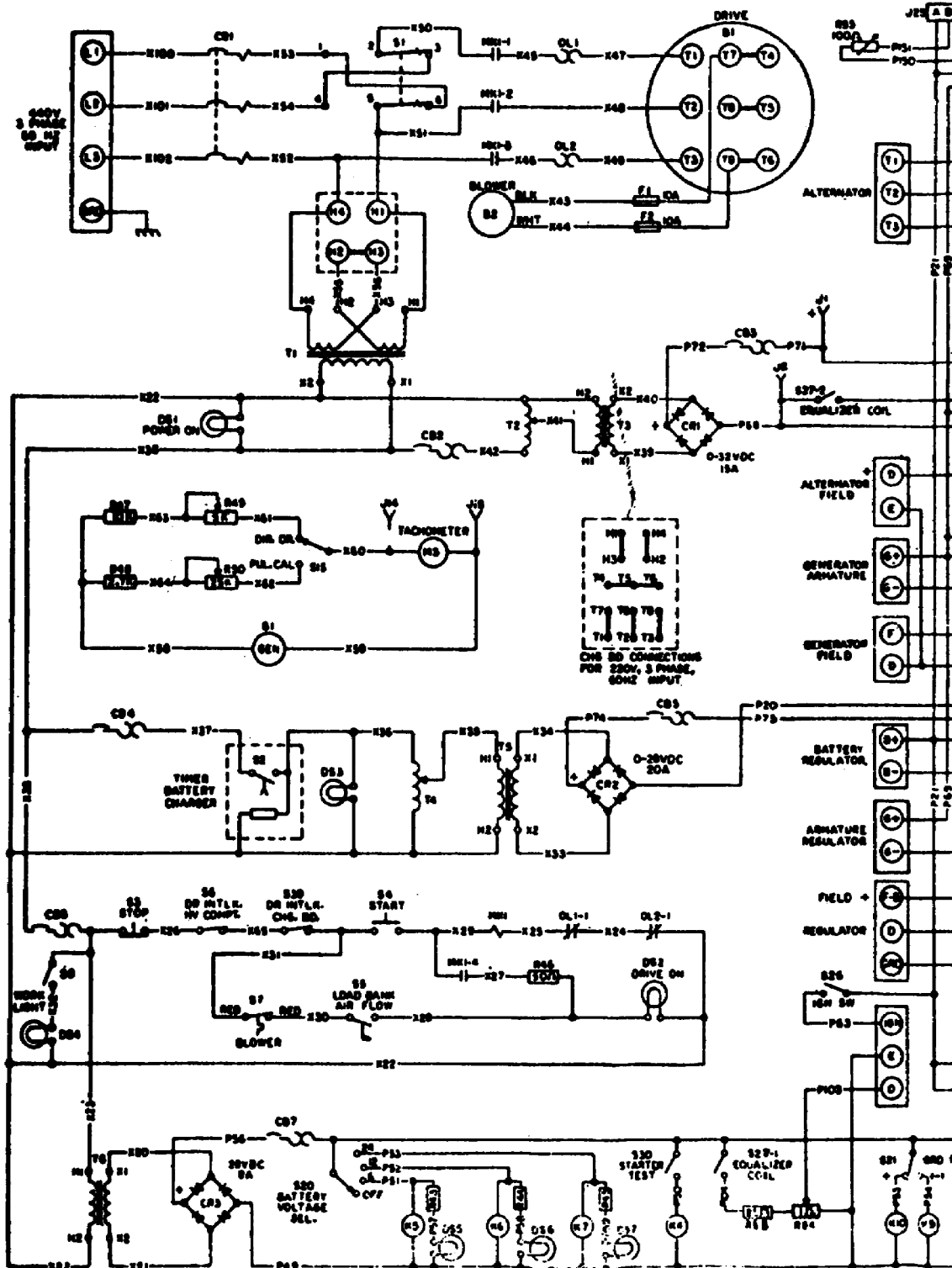


Figure 14.

OS 010, 3-P17 (continued)

10. PREOPERATIONAL CHECKS.

a. Before the start of any generator, alternator, or starter test, the controls of the test stand must be set to specific positions. This action prevents damage to the test stand circuitry. It also prevents damage to the unit under test. Each test procedure must begin with the controls positioned as indicated in figure 15. Fill in the figure and key number information by reviewing figures 1 through 11.

b. Each of the seven meters must be checked for static charges and adjusted for a proper zero. The zeros are adjusted with the adjustment screws located in the lower center of the meter lens. Static charges can be built up on the lens of the meters. Accuracy is affected if a static charge exists. To check for the presence of a static charge, move a hand rapidly across the front of the meter. The hand should be as close to the lens as possible but should not touch it. If a charge is present, the meter pointer will follow the hand for a short distance. If this occurs, the lens must be cleaned and recoated with antistatic and cleaning compound.

c. The battery condition must be checked each time the test stand is placed in operation. In nearly all cases, early battery failure can be traced to a lack of preventive maintenance. When the batteries are used during tests they are subjected to heavy current loads. Improper care will cause them to deteriorate rapidly.

d. The battery condition is checked after the control position and meter condition have been checked. Proceed as follows:

- (1) Place the battery charge switch ON.
- (2) Note the DC voltmeter range selector is set at 50V.
- (3) Turn DC voltmeter circuit selector to BAT.
- (4) Rotate battery selector to 6V (DC voltmeter should read 6+ volts).
- (5) Rotate battery selector to 12V (DC voltmeter should read 12+ volts).
- (6) Rotate battery selection to 24V (DC voltmeter should read 24+ volts).
- (7) Return battery selector to OFF.
- (8) Return DC voltmeter circuit selector to RECT/GEN.
- (9) Return battery charge switch to OFF.

Note. - If voltage readings are not adequate, the batteries must be charged. Additional information on the lead-acid battery is presented later in this lesson.

e. The varidrive assembly should be checked under no-load conditions each time the test stand is operated. Proceed as follows:

- (1) Place the circuit breaker switch to ON.

Control	Illustration		Position
	Fig. no.	Key no.	
D.C. ammeter load and starter selector			500A
D.C. ammeter field and battery charger selector			15A
Millivolt meter range selector			9V
D.C. voltmeter range selector			50V
D.C. voltmeter circuit selector			RECT / GEN
Tachometer pulley calibration control			Counterclockwise
Tachometer circuit selector			Direct drive
A.C. ammeter range selector			400A
A.C. ammeter phase selector			Any
A.C. voltmeter range selector			50V
A.C. voltmeter circuit selector			Any
Power supply switch			Off
Battery charger switch			Off
Relay lamp switch			24V
Power supply control			Counterclockwise
Charge timer			Off
Battery charger control			Counterclockwise
Regulator load resistor selector			Off
External field switch			Off
Field common switch			GND (-)
Field circuit switch			Any
Battery selector			Off
Ground polarity switch			GND (-)
Field current control			Counterclockwise
Drive speed control			Clockwise
Load current control			Counterclockwise
Coil equalizer switch			Off
Ignition switch			Off
Starter voltage adjust			Counterclockwise
Starter test switch			Off
Load bank switches			Off (All
Master load switch			Off

Note. - Bus bars should be installed between the B+ and G+ regulator terminals and between the B and G regulator terminals. These bus bars are removed only when specific test procedures dictate their removal.

Figure 15. Position of the controls on control panel prior to operation of the test stand.

(2) Depress the START button.

(a) The button must be held long enough for the varidrive assembly to come up to speed. When operational speed is achieved, the interlock of the magnetic motor starter will hold the starting contacts closed.

(b) Never hold the START button closed for more than 30 seconds. If the varidrive assembly does not come up to speed (but continues running) within this time, the system is defective.

(3) Rotate the drive speed control so that the varidrive is operated over its entire speed range.

(4) Check the direction of rotation. This information will be required when tests are begun. By making this determination now, necessary starting and stopping of the varidrive can be avoided.

(5) Set the varidrive for 2,000 RPM as indicated on the tachometer (0-5,000 RPM scale).

(6) Check the speed of the high or low speed driving head using either a hand tachometer or stroboscopes of known accuracy. The tachometer circuit selector remains in the DIRECT DRIVE position during this check. The tachometer must agree with the hand tachometer or stroboscopes.

(7) Set the drive speed control clockwise (reducing variable drive speed).

(8) Depress the STOP button.

(9) Place the circuit breaker switch to OFF.

f. The preceding checks must be made each time the test stand is operated. Once these checks are completed the operator can begin the testing procedure required by a specific item of equipment. The mounting of units under test and the specific tests required will be discussed in later lessons.

11. LEAD-ACID BATTERIES (GENERAL CONSTRUCTION).

a. Storage batteries of the lead-acid type are called wet-cell batteries. The chemical action between two unlike conductors and an electrolyte produces electrical energy. Stiff lead alloy is used to construct the grid network of both positive and negative plates. This grid network gives the plates strength. The active material is applied to the grids in paste form and allowed to dry. Brown lead peroxide is applied to the positive plates and grey spongy lead to the negative plates. Plates are combined into positive and negative groups by welding lugs on the top corner of each plate to a lead plate strap. The plate strap on each group has a terminal post which serves as an outside electrical connection.

b. An element is formed by putting positive and negative plate groups together. Then separators of wood, rubber, or glass are inserted between positive and negative plates to prevent them from touching. The separators have many small holes so that the electrolyte can pass through them. When an element is immersed in electrolyte, it becomes a cell. The voltage of a fully charged cell of this type is about 2.1 volts.

c. The electrolyte is a mixture of sulfuric acid and pure water. The electrolyte of a fully charged cell contains about 38 percent sulfuric acid by weight (27 percent by volume). The condition of a cell can be checked by measuring the specific gravity of the electrolyte. Fully charged cells have a specific gravity of 1.280 at 80° F. This figure states that the electrolyte is 1.280 times heavier than pure water.

d. Several cells are connected in series to form batteries larger than 2 volts. Three cells are required for 6-volt batteries and six cells for 12-volt batteries. The cell terminals are connected by welding them to connector straps. Cells are placed in a one-piece container that is divided into compartments. Each compartment is the container for one cell. Figure 16 shows a cutaway view of a single cell. The element rests on raised ribs. The area between the ribs serves as sediment space. During use, the active material on the plates gradually sheds and falls into the sediment space. The container is constructed of insulating material which is resistant to acid corrosion and mechanical shock.

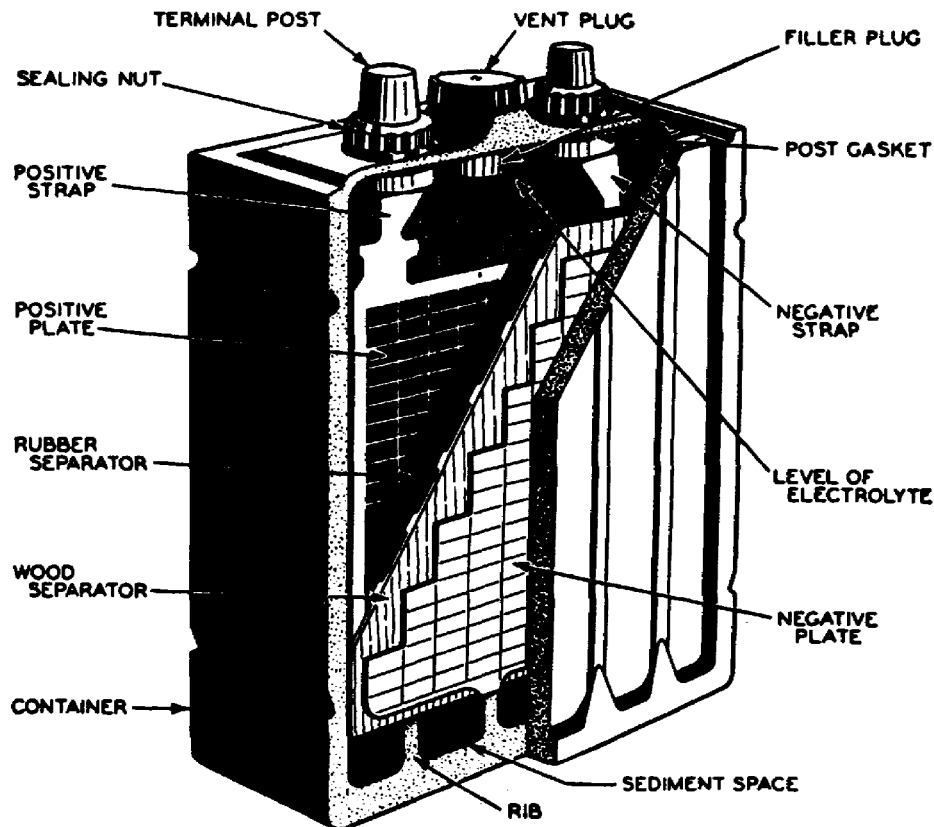


Figure 16. Cutaway view of single cell.

e. The top of each cell is fitted with a cell cover made from the same material as the container. Some batteries have cell covers made so that straps used to connect the cell terminals are exposed. On others, the connecting straps are covered and only two terminal posts are exposed. Regardless of the type of cover used, each cell cover is fitted with a vent plug which may be removed. to inspect the cell or to add water. To seal the battery after the cell cover is installed, the space between the edges of the cell covers and the container is filled with an acid-resistant battery sealing compound. Some form of seal is also used where the terminal post extends through the cover. The terminal posts are the output connections of the battery. The terminals are tapered and the positive terminal is slightly larger than the negative terminal (fig 17).

12. LEAD-ACID BATTERIES (CHEMICAL ACTION).

a. When a load such as a lamp is connected to the battery, electrons flow through the lamp from the negative plates to the positive plates. At this time, the battery is said to be discharging. Several chemical changes take place inside the battery during the discharge (fig 18). As the current flows, atoms of the sulfuric acid leave the electrolyte and enter the battery plates. This decreases the amount of acid that is in the electrolyte making the mixture weaker. As you may recall, atoms from all elements are different and the nature of all materials is determined by the atoms they contain. Therefore, the atoms of sulfuric acid mixing with the battery plates will change the nature of the plates. The spongy lead of the negative plates turns into lead sulphate; the lead peroxide of the positive plates also turns into lead sulphate.

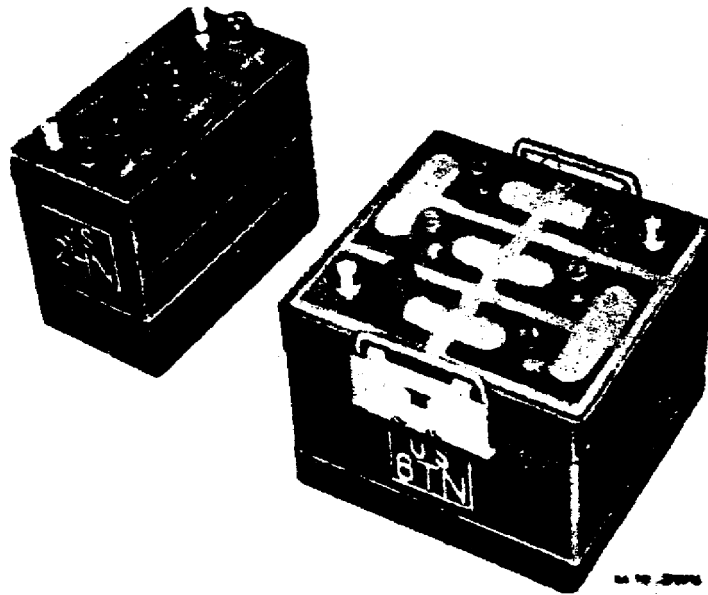


Figure 17. Batteries.

b. If the lamp is left connected to the battery, current flow continues and the electrolyte will get weaker and weaker until it is almost all water. At the same time, the negative and positive plates will be gradually turning into lead sulphate. Finally, the battery reaches a point where it will no longer supply enough voltage to cause the current flow and the lamp will stop glowing. The battery is then said to be discharged.

c. The chemical reaction in the battery can be reversed and a discharged battery returned to a charged state. This is done by supplying direct current from an external power source, such as a DC generator, and running it through the battery opposite the direction it travels when the battery is discharging. This causes the atoms from the acid to return to the electrolyte making the electrolyte stronger. As the acid atoms leave the battery plates they change back to their original nature--spongy lead and lead peroxide (fig 19).

d. As a battery is charged some of the water in the electrolyte is broken down and passed off in the form of gas. If charging is continued after the battery is fully charged, the amount of gas given off is increased and the battery overheats. This is called overcharging and can damage the battery. The gas given off by a battery during the charging process is explosive and can be easily ignited by a spark.

e. Repeated charging and discharging slowly wear out the battery. It causes the lead peroxide to fall off the positive plates into the sediment space in the bottom of the container. It is possible for the sediment to build up high enough to cause a short circuit between the negative and positive plates, but normally the cell will be worn out before the sediment reaches the short circuit stage.

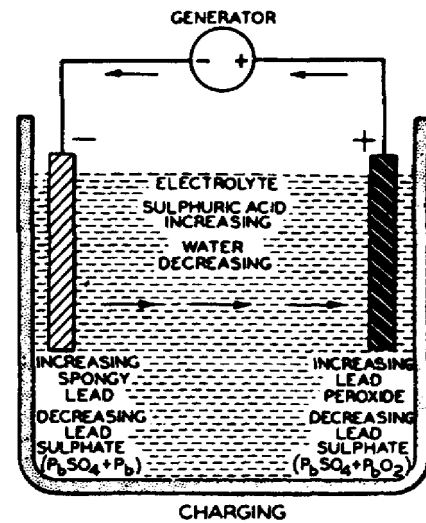
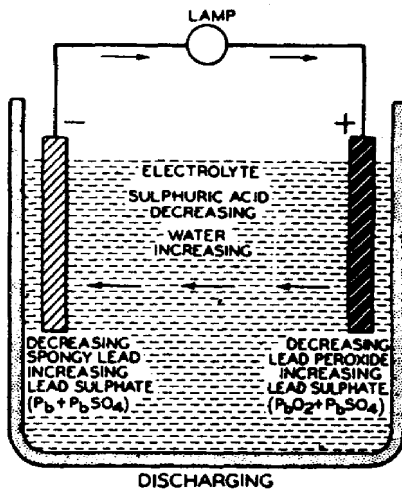
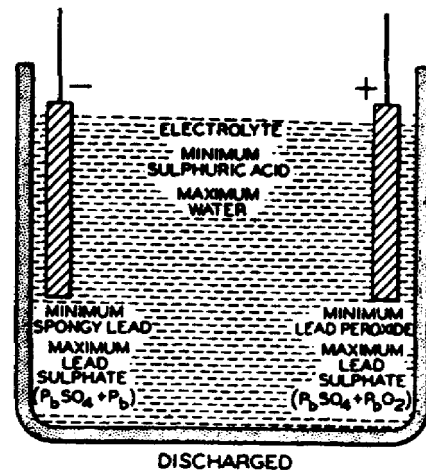
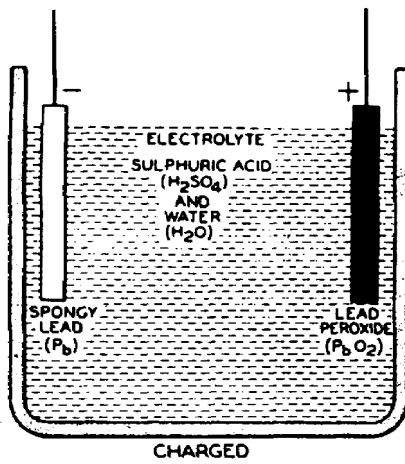


Figure 18. Battery discharge.

Figure 19. Battery charge.

13. BATTERY TESTING.

a. Since the amount of sulfuric acid in the electrolyte decreases as the battery discharges, the specific gravity of the battery also decreases as the battery's state of charge decreases. By using a testing hydrometer (fig 20) to measure the gravity of the electrolyte, the battery's state of charge can be determined.

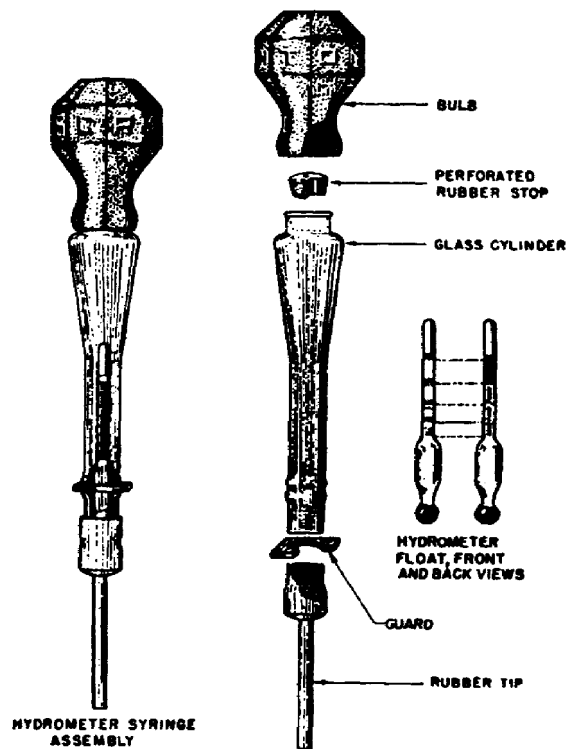


Figure 20. Hydrometer.

b. The hydrometer has a glass cylinder containing a glass float. A rubber inlet tip is fitted to the bottom of the cylinder and a rubber bulb at the top. A scale on the neck of the float has numbers ranging from 1.100 to 1.300. The scales may also be marked off in zones that are identified as full charge, half charge, and discharged, or good, fair, poor, and dead. The level of the hydrometer float in a liquid indicates the specific gravity of the liquid.

c. To test the gravity of a battery cell squeeze the hydrometer bulb and insert the inlet tip into the electrolyte of a battery cell (fig 21). Hold the hydrometer in a vertical position and release the bulb to draw in Just enough electrolyte so the float moves freely. To avoid wrong readings, the float should not touch the sides or the top and bottom end of the cylinder. Hold the hydrometer so the surface of the liquid is level with your eyes, then read the mark on the scale at this level. Always put the electrolyte back into the cell to prevent weakening the mixture. Test all cells in the battery in the same manner.

d. The hydrometer should be kept clean by flushing it out once in a while with soapy water so the parts will not stick together. Inspect the hydrometer often for cracks. The float is hollow and if it develops a leak the hydrometer will no longer give the right readings.

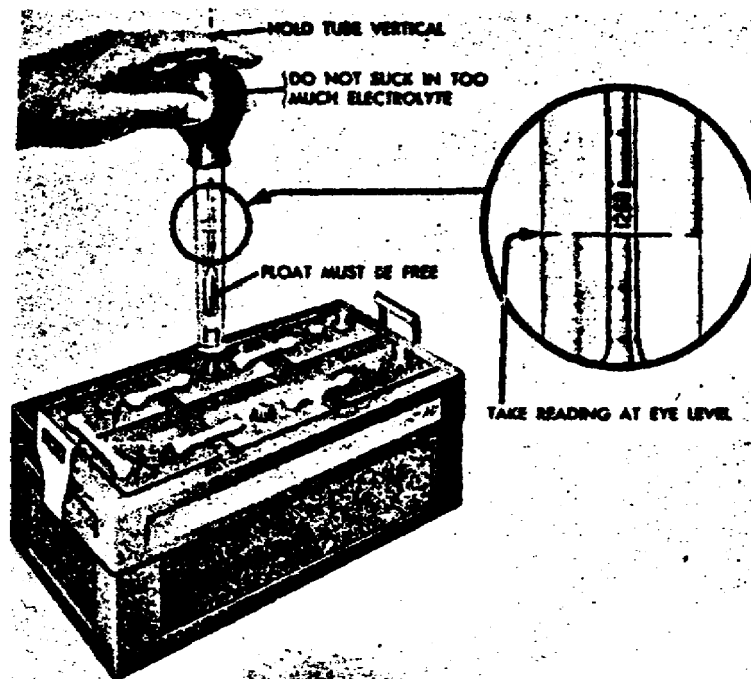


Figure 21. Testing the specific gravity of a battery.

e. The gravity of the battery is affected by temperature. When heated, the electrolyte expands so it occupies more space. When the temperature drops, the electrolyte contracts and takes up less space. In view of this, warm electrolyte will weigh less than the same volume of cool electrolyte, so warm electrolyte has a lower specific gravity than cold electrolyte. Electrolyte that has been mixed for normal use will test 1.280 at 80° F. This is the temperature of the electrolyte and not the surrounding air. At ordinary temperatures it is not necessary to consider any variations when testing the gravity of a battery. However, any large variation above or below 80° is very important when deciding the true state of battery charge.

f. In order to correct for temperature changes, test both the gravity and temperature of the electrolyte. Some hydrometers have a built-in thermometer so you can do both at the same time. For each 10° of temperature variation from 80°, change the gravity reading 4 points (fig 22). Add points to gravity readings when the electrolyte is above 80°; take points away when the temperature is below 80°.

g. The electrolyte should be at the correct level in the cell when it is tested. Water in the electrolyte evaporates, the acid does not. If the water has evaporated enough so the electrolyte level is low, the mixture will be strong and the gravity reading will be high. On the other hand, if the battery has been overfilled with water the electrolyte will be weakened and the reading will be low. When water is added, it will tend to remain at the top of the cell so a hydrometer reading taken immediately after adding water would not be right. If water has to be added before taking a reading, the battery should be charged for 1 to 2 hours to mix the electrolyte before the hydrometer is used. This may be done by connecting the battery to a battery charger. Gravity readings will not tell the true state of the electrolyte if taken just after a battery has been discharged at a high rate. The acid has been used up next to the plates but the electrolyte near the top of the plates is still strong. The hydrometer will read a higher state of charge than that which actually exists. The electrolyte will mix so a true reading can be obtained if the battery is allowed to stand unused for several hours or if it is charged for 1 to 2 hours.

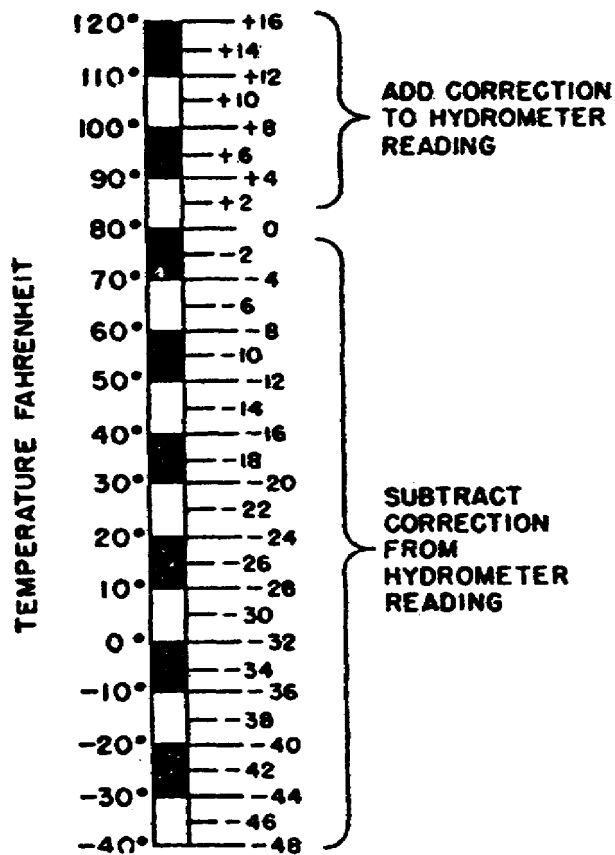


Figure 22. Correction chart.

14. BATTERY RATINGS.

a. The amount of water a can will hold may be measured in pints, quarts, or gallons. Battery capacity is measured in ampere-hours which are the number of amperes the battery will deliver multiplied by the number of hours the battery will deliver it. For example, suppose a battery will deliver 5 amperes for 20 hours, then 5 amperes multiplied by 20 hours equals 100 ampere-hours. If the ampere-hour rating is based on nothing more, the rating would change if the rate of discharge is changed. Suppose that we increase the load on the battery from 5 to 10 amperes. The battery would then produce the 10 amperes for a period less than 10 hours, so its rating would figure to be less than 100 ampere-hours. As you can see, some form of standard procedures must be used to rate the ampere-hours before the ratings will mean the same in all tests.

b. The capacity of batteries is rated by a standard procedure called the 20-hour rating. This rating gives the number of ampere-hours the battery will deliver if it is discharged at a uniform rate for 20 hours, at a temperature of 80°, and with a battery voltage of 1.75 volts per cell at the end of the 20-hour period.

c. Through use and age the capacity of a battery decreases. This is due to some of the active material dropping off the plates and the buildup of a hard coating of sulphate on the plates. Because of this, testing the gravity of the battery with a hydrometer may not always reveal the true conditions of the battery. The electrolyte may be strong enough, but the battery capacity may be reduced to a point where the available current supply is too small. This condition can be detected by making a high-rate discharge test of the battery.

(1) Do not perform a high-rate discharge test when the specific gravity of the electrolyte is 1.225 or less, or if the variation of specific gravity between cells is more than 25 points. After charging, the battery should be allowed to set for several hours before making a high-rate discharge test.

(2) High-rate discharge testers are available for testing batteries, but the test instruments vary a great deal. Always perform a high-rate discharge test according to instructions that are with the test instrument. In use, the test instrument draws a high current from the battery and the battery voltage is read on a voltmeter during the discharge. The correct amount of voltage will vary depending on the test instrument used.

d. In order to increase voltage, the batteries are connected in series. Recall that in a series circuit the current has only one path to follow; therefore, the same current will flow through all batteries when they are connected in series. A series connection of two batteries is made by connecting the negative terminal post of one battery to the positive terminal post of another battery. Batteries connected in series should have the same ampere-hour rating. A voltage source equal to the sum of both batteries is then available at the two remaining terminal posts. The ampere-hour rating of batteries connected in series is the same as the smallest battery by itself (fig 23).

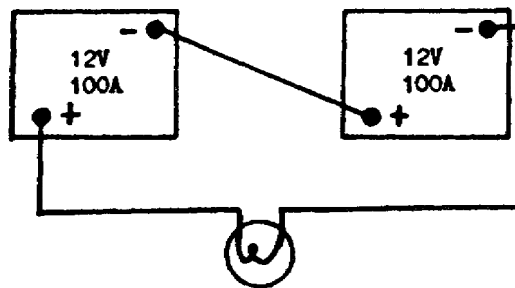


Figure 23. 24-volt, 100-ampere-hour supply.

e. In order to increase the ampere-hour rating, the batteries are connected in parallel. In a parallel circuit the current has more than one path to follow. Batteries connected in parallel must have the same voltage rating. To connect two batteries in this manner, the positive terminal posts of both batteries are connected together and then the negative terminals of the batteries are connected. Each battery will now furnish half the current flowing in the load so their ampere-hour ratings will be added together, but the voltage will be the same as one battery alone (fig 24).

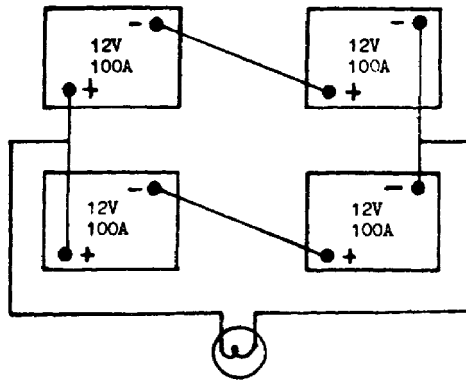


Figure 24. 12-volt, 200-ampere-hour supply.

f. Batteries are connected in series-parallel to increase both the voltage and ampere-hour rating. To demonstrate how to make use of the series-parallel connection let's say that we require a 24-volt, 200-ampere-hour power source. We will use four 12-volt, 100-ampere-hour batteries. The batteries are first set apart into groups of two. In each group the batteries are connected in series so they will provide 24 volts and 100-ampere-hours per group. Then, the two groups are connected in parallel to increase the capacity rating to 200 ampere-hours (fig 25).

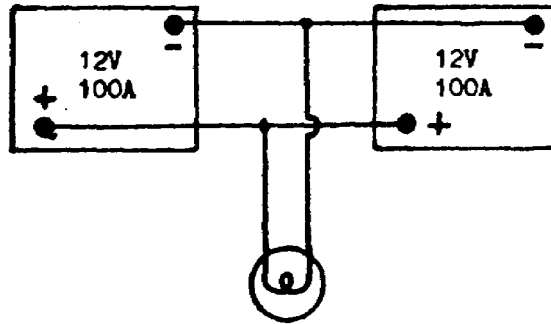


Figure 25. 24-volt, 200-ampere-hour supply.

15. CHARGING METHODS.

a. Any time the gravity of a battery drops below 1.225 it is best to recharge it with a battery charger under controlled conditions. The two principal ways of charging are constant current and constant potential (voltage). The method used will depend on the equipment and facilities available. Constant current charging is usually done only at installations where a regular battery shop is set up. Several batteries are generally connected in series when charging by the constant current method. When connecting the batteries their combined voltage should never be higher than the charging voltage. Allow 2.5 volts per cell when adding up the battery voltage. All batteries in the same series should be in about the same condition. Batteries being charged by the constant current method must be checked often, particularly in the final stages, to prevent overcharging.

b. Battery chargers supplied for use in the field are the constant potential type. A charger usually consists of a DC generator powered by a gasoline engine. They are made with 7-1/2-and 15-volt outputs or with a 15-and a 28-volt output.

(1) When using the battery charger to charge one 12-volt battery, connect its 15-volt output or load terminals to the battery terminals. Connections must be positive to positive and negative to negative. If more than one battery is to be charged from the 15-volt output they must be connected in parallel. If you connect the batteries in series their voltage will be higher than the charging voltage and the charger could not force current through the batteries. Care must be taken when charging batteries in parallel. The current demand on the charger may be excessive if the batteries are extremely weak.

(2) To charge 12-volt batteries from the 28-volt output of a charger, connect two batteries in series, then connect them to the 28-volt terminals. To charge more than two batteries they must be connected in series-parallel. The batteries in each series group should be in about the same condition.

(3) When a battery is first placed on a constant potential charging system its voltage is much lower than the charging voltage, so a high current will flow. As the battery is charged its voltage increases, but the charging voltage remains constant. This causes the current to decrease as the battery is charged and in the end will taper off to a very slow rate. Less attention is required near the end, but care must be taken to prevent overheating the battery at first. The constant potential battery chargers are generally equipped with a variable resistor so the operator has some control over the charging rate.

16. CHARGING PROCEDURES.

a. Batteries should only be charged in the open air or a well ventilated room due to the gases they expel. Before attempting to charge a battery give it a thorough cleaning and inspection. Don't waste your time on batteries that are cracked or damaged in any way that will make them unserviceable. Place good batteries on a board or wooden rack; never place them on top of each other or on the ground or a concrete floor.

b. Check and record the specific gravity of each cell of all the batteries to be charged. Add water to bring the electrolyte to the proper level. Arrange and connect the batteries for charging. All batteries connected in one series group should have about the same specific gravity readings. Make sure all the vent plugs are secure and the vents not plugged, then begin the charge.

c. Watch closely for overheating or excessive gassing for the first few minutes of charge. If either occurs, reduce the charging rate. For best results the battery electrolyte should not exceed 1100 F. The battery should gas very little when it is first placed on charge, but steady gassing later on when the battery nears full charge is normal.

d. Check the specific gravity of the battery often while it is being charged. Just how often will depend on the rate of charge. Check the gravity hourly when the batteries near full charge. You may reduce the time between checks if the charge rate is decreased. Add water to replace any lost during the charge. A battery is fully charged when three successive hydrometer readings show no further rise in specific gravity.

e. When the battery is charged removed it from the charger and clean its top to remove any acid. Inspect the battery once again for any cracks that may have opened due to the charging process. Screw the vent plugs tightly in place. If the battery has handles and the paint on them is worn, apply a coat of acid-resistant black paint.

17. PLACING BATTERIES IN SERVICE.

a. New batteries that you receive will probably be charged and dry. If they are, you will have to fill them with electrolyte in preparing them for service. Instructions are generally received with new batteries on how to prepare them for service and should always be followed. In general, the following instructions apply:

b. Remove and destroy the sealing devices from the vent holes of the vent plugs. Remove the vent plugs and fill each cell with electrolyte to the proper level. The temperature of the battery and electrolyte must be at least 60°. Let the battery stand for 30 minutes after filling to allow the plates and separators to become soaked, then check the specific gravity of each cell. The electrolyte level must be correct.

c. The battery is now ready for use unless one or more of the following conditions exist:

(1) The specific gravity of any cell is below 1.250 after the 30-minute stand.

(2) The battery will not be used for 12 hours after filling.

(3) The battery is going into service in temperatures below zero.

d. If any of the above conditions exist, the battery must be charged. If you have the time and equipment it is always best to charge the battery, regardless of condition, to insure longer service life. After charging, the specific gravity should be at or very near 1.280.

e. At the time the battery is prepared for service it must have a service date stamped on it. This is so that its age can be determined at a later date. Stamp the date with 1/8-inch or 3/16-inch metal stamps (fig 26). The date will consist of the letter S followed by the month and year. For example, if the battery was prepared in January 1970, the date will be S-1-70.

18. SUMMARY. This lesson has introduced you to the 500-ampere starter generator test stand. You should now be familiar with all of the controls and indicating devices; realize that the test stand batteries must be kept in top condition to meet the demands which are made on them when performing tests; and have a general knowledge of the types of tests which can be made with the test stand. Your basic understanding of the test stand will assist you in learning the specific testing procedures discussed in following lessons.

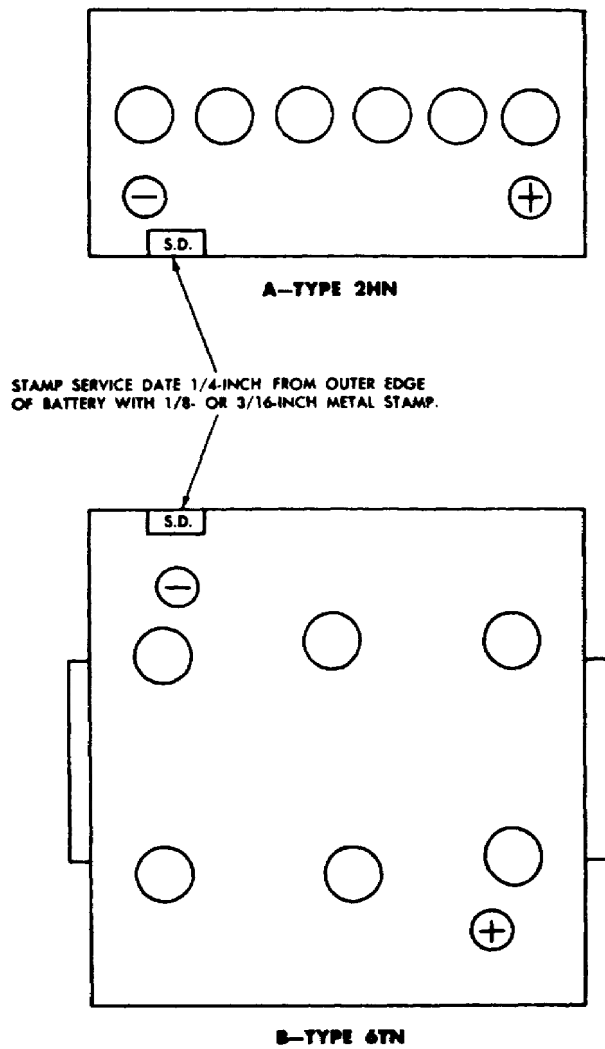


Figure 26. Service date.

EXERCISE

Note. - Refer to the lesson exercise instructions given in lesson 1.

31. Three-phase, 220/440-volt, 60-hertz power is supplied to the test stand from an external source. Where, on the test stand, is the service entrance for this power located?
 - a. Rear
 - b. Front
 - c. Right side
32. There are four 6-volt batteries being used in a particular test stand. How should they be interconnected?
 - a. Series
 - b. Parallel
 - c. Series-parallel
33. What is the running speed (RPM) of the varidrive motor?
 - a. 800
 - b. 1,800
 - c. 2,800
34. RECT GEN, BAT, EXT, and VAR DC SUPPLY are the four positions of the circuit selector switch of which meter?
 - a. Load and starter DC ammeter
 - b. Field and battery charger DC ammeter
 - c. DC voltmeter
35. Which are the two positions of the tachometer circuit selector switch?
 - a. 0-5,000 RPM; 0-12,000 RPM
 - b. DIRECT DRIVE; CAL PULLEY
 - c. HIGH SPEED HEAD; LOW SPEED HEAD
36. Which meter circuit selector switch should be set to the OFF position when the meter is not in use?
 - a. AC ammeter
 - b. AC voltmeter
 - c. DC voltmeter
37. You are checking the specific gravity of a battery with a hydrometer. The electrolyte temperature is 850 F. What should the hydrometer reading be if the battery is fully charged?
 - a. 1.278
 - b. 1.289
 - c. 1.282
38. Each test stand meter has an associated set of calibrating binding posts or a calibrating Jack. How are these posts/Jacks used?
 - a. To compare the test stands measuring circuits with certified standards of known accuracy
 - b. To calibrate meters associated with generators, alternators, control boxes, and AC/DC systems under test
 - c. To self-check the monitoring systems during preoperational checks using the 0-32 VDC power supply as a source

39. What are the positions of the relay lamp switch?
- a. ON-OFF
 - b. 6V-12V-24V
 - c. 12V-OFF-24V
40. The MANUAL position of the field circuit switch is used when
- a. testing a generator with no regulator in the circuit.
 - b. making an alternator rectifier short circuit check.
 - c. adjusting the starter torque field winding phase screw.
41. Which unit is being tested when the headset phone Jack and pile flutter binding posts are used?
- a. Starter
 - b. Generator
 - c. Regulator
42. The coil equalizer switch is an OFF-MOMENTARY-ON toggle switch located below the AC system binding posts. This switch is used when
- a. torque testing starters.
 - b. checking alternator drop-off voltage.
 - c. adjusting AC/DC system phase.
43. Which action occurs when the drive speed control is rotated counter-clockwise?
- a. Lower varidisc hub slides away from its companion varidisc
 - b. V-belt assumes a larger diameter on upper and lower varidisks
 - c. Moveable varidisc on drive shaft retracts against spring
44. Where on the electrical wiring diagram are the tachometer, generator, and associated circuits located?
- a. Center section
 - b. Left of center
 - c. Right of center
45. Controls must be in specific positions prior to operating the test stand. Which control is set to the correct preoperational position?
- a. DC ammeter load and starter selector.....50A
 - b. DC ammeter field and battery charger selector.....150A
 - c. Millivolt meter range selector.....9V

C O R R E S P O N D E N C E C O U R S E
o f t h e
U S A R M Y O R D N A N C E
C E N T E R A N D S C H O O L



LESSON ASSIGNMENT

Ordnance Subcourse No 010.....Electrical System Component Repair

Lesson 4.....Testing and Adjusting AC Generators
and Regulators

Credit hours.....Four

Lesson Objective.....After studying this lesson you will
be able to:

1. Explain the requirements necessary in preparation for a test including the preparation of the varidrive assembly.
2. Explain generator test stand procedures and precautions to be observed during such tests.
3. Explain procedures required to operate the test stand for testing of the 100-ampere regulator.

Text.....Attached Memorandum

Material Required.....Response list and answer sheet

Suggestions.....None

ATTACHED MEMORANDUM

1. INTRODUCTION. During the previous lessons the 40/60-ampere AC generator and 500-ampere test stand have been discussed; therefore, you should be familiar with the construction and operation of these items. Also, you should know what is to be tested on the 40/60-ampere AC charging system.

a. In this lesson you will apply the knowledge previously gained. Specifically, you will be shown how to operate the test stand, to test the necessary components of the 40/60-ampere AC generator, and to test the 100-ampere DC regulator.

b. Retention of this knowledge will enhance your abilities as a maintenance supervisor. It will enable you to properly instruct and assist your maintenance personnel in locating and eliminating defective and/or inoperable components from the 40/60-and the 100-ampere AC charging systems.

2. PREPARATION. In preparing for a testing operation certain basic items require operational maintenance. Among these are the mechanical zero of meters, positioning of controls, tachometer calibration, and a check of the storage batteries.

a. Before operating the test stand, the mechanical zero of the panel meters should be verified. The seven operating panel meters are shown in foldout 5. The zero adjustment is located below the lens in the center part of the meter. The meters are zeroed by turning the adjustment screw. Clockwise rotation will swing the pointer to the right--counterclockwise to the left.

b. The tachometer and battery need to be checked at periodic intervals. These checks were discussed in the previous lesson and will not be covered here.

c. To preclude damage to the system being tested and the test stand, the switches and controls need to be preset before doing any tests. Table 1 lists the controls and their positions. To prevent damage, it is important to preset the controls to the positioning indicated prior to operating the test stand.

Table 1. Presenting controls keyed to foldout 5.

Control	Key	Position
D.C. ammeter load and starter selector	1	500A
D.C. ammeter field and battery charger selector	2	15A
Millivolt meter range selector	3	9V
D.C. voltmeter range selector	5	50V
D.C. voltmeter circuit selector	6	RECT/GEN
Tachometer pulley calibration control	7	Counterclockwise
Tachometer circuit selector	8	Direct drive
A.C. ammeter range selector	9	400A
A.C. ammeter phase selector	10	Any
A.C. voltmeter range selector	11	50V
A.C. voltmeter circuit selector	12	Any
Power supply switch	A	Off
Battery charger switch	B	Off
Relay lamp switch	21	24V
Power supply control	C	Counterclockwise
Charge timer	D	Off
Battery charger control	E	Counterclockwise
Regulator load resistor selector	25	Off
External field switch	29	Off
Field common switch	30	GND (-)
Field circuit switch	36	Any
Battery selector	31	Off
Ground polarity switch	33	GND (-)
Field current control	41	Counterclockwise
Drive speed control	42	Clockwise
Load current control	43	Counterclockwise
Coil equalizer switch	19	Off
Ignition switch	F	Off
Starter voltage adjust	24	Counterclockwise
Starter test switch	27	Off
Load bank switches	34	Off (all)
Master load switch	39	Off

3. VARIDRIVE PREPARATION. Before starting any tests the varidrive assembly should be operated over the entire range. This provides a functional check to determine operational status.

a. Protruding through the high voltage panel there is a main circuit breaker switch that makes three-phase power available to the whole test stand. This panel can be seen in figure 1 next to the work lamp. Also, behind this panel is the varidrive reversing switch, which is a large dual knife switch to the left of the main circuit breaker. These components can be seen in figure 2.

b. To make power available to the varidrive place the circuit breaker to the ON position. This is indicated by the illumination of the "Power On" lamp. The high voltage compartment door must be tightly closed or the interlock switch (fig 2) will be open. If the interlock is open, it will prevent the varidrive assembly from operating.

c. To start the varidrive, depress the START button (28, foldout 5) on the control panel. The button must be held down until the blower motor comes up to speed. This will happen in just a few seconds. Once air is flowing through the load bank and the rectifier compartment, the flow sensing switch (S5) will close. Then the magnetic motor starter, which is a large relay, will lock itself up through a 50-ohm resistor at reduced current and remain energized. This will keep the three-phase power applied to the varidrive through the contacts of the magnetic motor starter.

(1) If for some reason there is no airflow for cooling, the varidrive unit will not remain in operation, indicating a malfunction.

(2) Holding the START button closed in excess of 30 seconds will cause the magnetic motor starter to overheat and damage the starter coil.

CAUTION: REPEATED USE OF THE MAGNETIC MOTOR STARTER AT FREQUENT SHORT INTERVALS MAY DAMAGE THE STARTER COIL AND CONTACTS BY OVERHEATING.

(3) Once the varidrive assembly has started, operate it over the entire range of 1,830 to 11,000 RPM by turning the drive speed control (42, foldout 5) clockwise and then counterclockwise.

d. To reverse the direction of rotation, the varidrive must be completely stopped.

WARNING: HIGH VOLTAGE EXISTS IN THE HIGH VOLTAGE COMPARTMENT. BEFORE OPENING THE COMPARTMENT DOOR, PLACE THE MAIN CIRCUIT BREAKER IN THE OFF POSITION.

(1) Depress the STOP button to stop the varidrive assembly.

(2) Snap the main circuit breaker to the OFF position.

(3) Place the varidrive reversing switch (fig 2) into the opposite position.

4. TESTING CONSIDERATIONS. In preparing the 500-ampere test stand for operation, one must consider the unit under test (UUT) and its installation on the test stand. The UUT's are generators, alternators, regulators, rectifiers, and starters. Our concern here is with generators, alternators, and regulators.

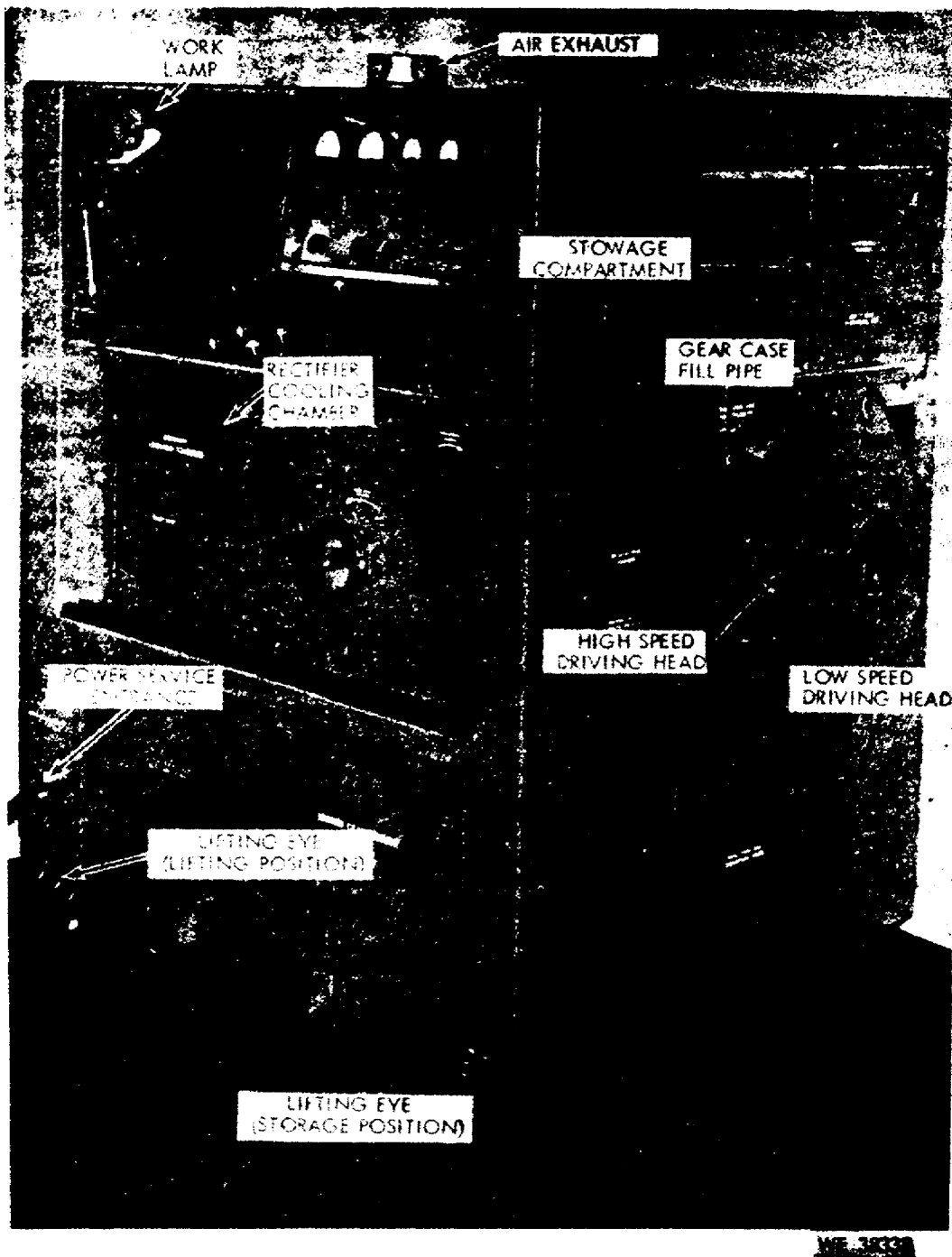


Figure 1. Test stand.

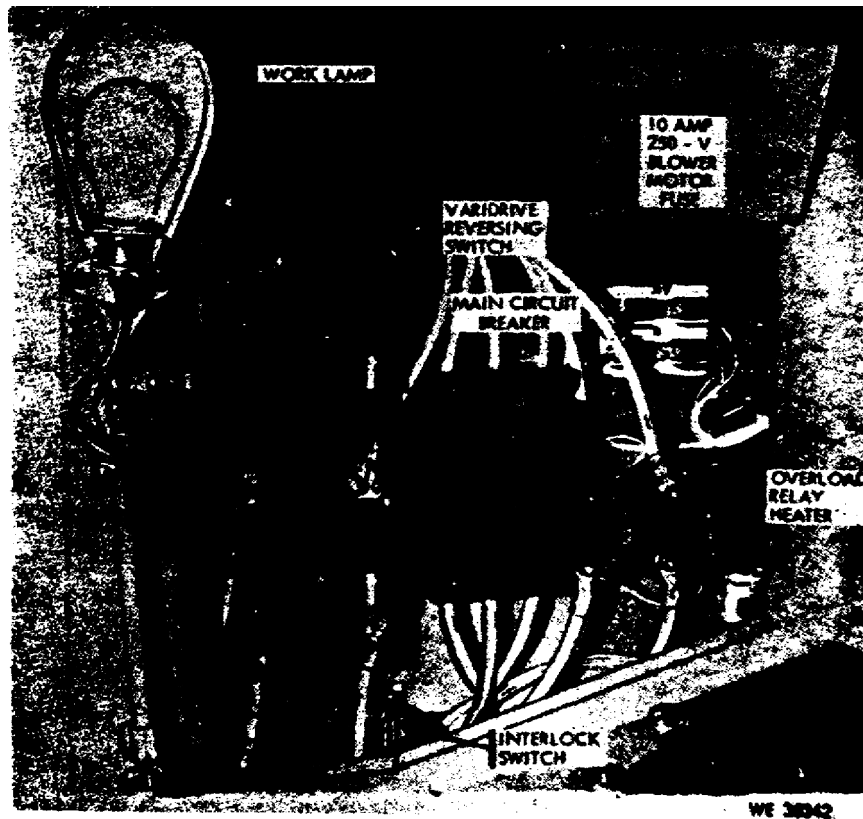


Figure 2. High voltage compartment.

a. 40/60-ampere AC generator (fig 3). The testing principles of the 40/60-ampere AC charging system were covered in lessons 1 and 2. Tests included were with and without the internal regulator. These required special test circuits to connect externally to the generator. The circuit components consisted of measuring meters, resistors, switches, and batteries. Once these components were connected in the configuration required for the particular test, then an external motor or engine was connected to operate the generator at the various speeds of rotation (RPM) to perform the test. As you learned in lesson 3, the 500-ampere test stand has these components for the external test circuits and a motor system, which turns the generator to the required speeds, all enclosed in a single unit. Thus, all that is further required is the installation of the generator on the stand for the tests.

b. 100-ampere generator (alternator). Even though the 100-ampere generator (fig 4) has not been discussed in detail, it functions basically in the same manner as the 40/60 system. The differences between them are as follows.

(1) The 40/60-ampere system has an AC generator, rectifier, and regulator all contained in a single unit.

(2) The 100-ampere system consists of three individual components which are connected together by electrical cables. These individual components are the AC generator, separate rectifier component, and separate regulator component.



Figure 4. 100-ampere generator.

(3) The engine generator, a 28-volt, three-phase, alternating current unit, has a rated output of 100 amperes and obtains full output at 2,000 generator RPM. The generator is self-cooled and utilizes a swivel-type mounting bracket. Bearings support the rotor shaft which is belt driven from the drive end of the shaft by a pulley.

c. 500-ampere test stand. The test stand (fig 1) has been designed so many different types of systems relating to vehicles can be tested. Once you learn the basic operation and functioning of the stand components many testing applications should become apparent. One of the first things to do in preparing for operation is to mount the generator or alternator to the test stand.

(1) Accessories. Foldout 1 shows the accessories used with the 500-ampere test stand. During operational conditions part of these accessories are usually fastened to the test stand. The rest are stored in the provided storage compartments. The accessories that remain more or less permanent are the mounting brackets and pivot arm. Each of these accessories is identified in foldout 2.

(a) The permanently mounted accessories are shown in figure 5. Also shown are the access ports to the driving heads. One is for low speed and the other is for high speed. The low speed head operates between 800 to 4,800 RPM, while the high speed head is from 1,830 to 11,000 RPM.

(b) The pivot arm (6) allows the selection of either driving head. It is held in place by three hexagon studs (7). If the rated RPM of the UUT is below 3,300, mount it on the low speed head. If the RPM is above 3,300, mount it on the high speed head. For most cases of generator or alternator unit under test (UUT), the low speed head will generally suffice for testing.

(c) The pivot arm (6) is pulled outward along the pivot shaft (5) far enough to clear the hexagon studs (7). The pivot arm can now be swung into position with either of the driving heads.

(d) When the three stud holes in the pivot arm are aligned with the three hexagon studs, the pivot arm is pushed inward allowing the studs to protrude through the holes in the pivot arm. The pivot arm is then secured to the test stand with three hexagon nuts when the mounting flange adapter is put in place. Nine other hexagon nuts secure the mounting flange adapter to the pivot arm.

(2) Direct driven. Figure 6 shows the direct driven mounting of a generator or alternator. The driving head shaft is connected to the generator by a coupling shaft. These two shafts are keyed together with a square piece of metal called a machine key. There are setscrews that secure the machine key and the coupling shaft to the driving head.

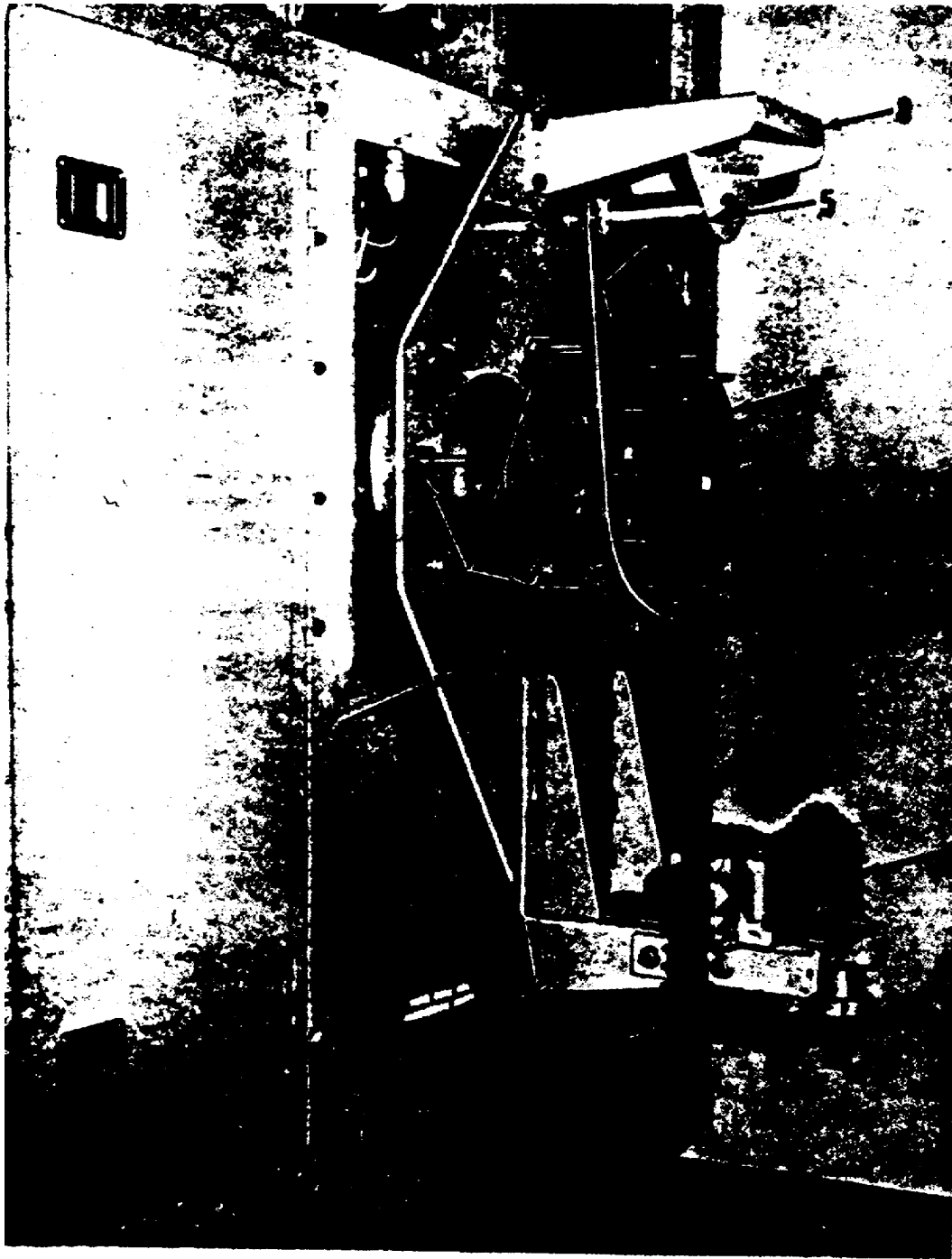
(a) The shaft coupling (2) is made to fit a generator or alternator with a large splined shaft. If the generator shaft is smaller, then a spline adapter (3) is used. This spline adapter mounts between the coupling shaft and generator.

(b) The direct driven generator (9) is mounted over the middle row of studs on the mounting flange adapter (8) by sliding the splined shaft of the generator into the spline adapter (3). The generator can be secured to the mounting flange adapter (8) with six hexagon nuts.

(3) Pulley driven. Figure 7 shows the pulley driven mounting of a generator. Here a pulley is connected to the driving head, so the proper size of pulley must be selected to match the generator pulley (foldout 1).

(a) Mounting. Once the pulley (29 or 30) has been selected, it must be mounted upon the pulley output shaft assembly (33). The pulley is held by a brass washer (24) and a retaining ring (23). Before the pulley can be mounted upon the shaft, the machine key (26) is inserted and then the pulley is installed. The key locks the pulley to the shaft.

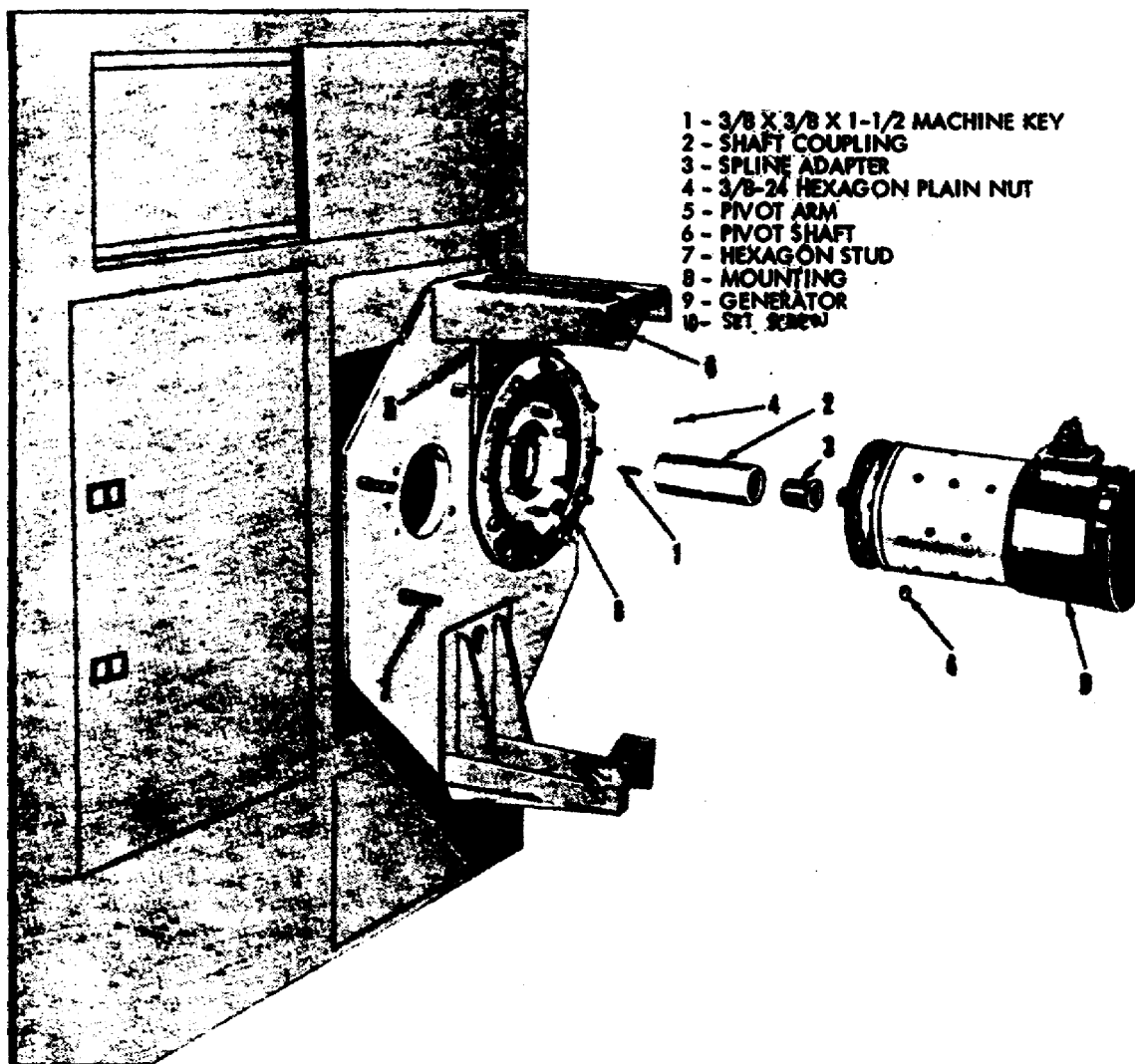
1. The machine key (25) is inserted into the driving head end of the pulley shaft. The pulley shaft is then slid on the driving head by aligning the keyways. The pulley shaft will slide over the middle row of studs on the mounting flange adapter. It is secured to the mounting flange adapter with six hexagon nuts.



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- | | |
|-------------------------------|------------------|
| 1. Mounting bracket | 5. Pivot shaft |
| 2. Mounting plate | 6. Pivot arm |
| 3. Mounting bracket extension | 7. Hexagon studs |
| 4. Cradle assembly | 8. Pivot bracket |

Figure 5. Installation of generator, alternator, and starter mounting bracket and pivot arm.



WE 38352

Figure 6. Mounting direct driven generator or alternator.

2. The pulley driven generator is mounted in the cradle assembly (4, fig 5). This cradle assembly is a chain vise.

CAUTION: When installing an alternator or generator in the chain vise, be sure to avoid clamping over nameplates and raised or protruding surfaces. Do not clamp over the soft shell sections of the devices under test that are not supported by stator or flange iron. Use the mounting angle (20, foldout 1) or mounting channel (21, foldout 1) as support to prevent crushing the thin sheet steel shell.

3. Mount the generator and secure with the chain vise. Loosen the four hexagon nuts under the chain vise and slide the unit as required to aline the pulleys (fig 5).

4. Loosen the four nuts that fasten the mounting bracket (1) to the mounting plate (2). Adjust the pulley driven unit under -tent to the required height to allow installation of the V-belts, being certain that the proper size of V-belts matches the pulley.

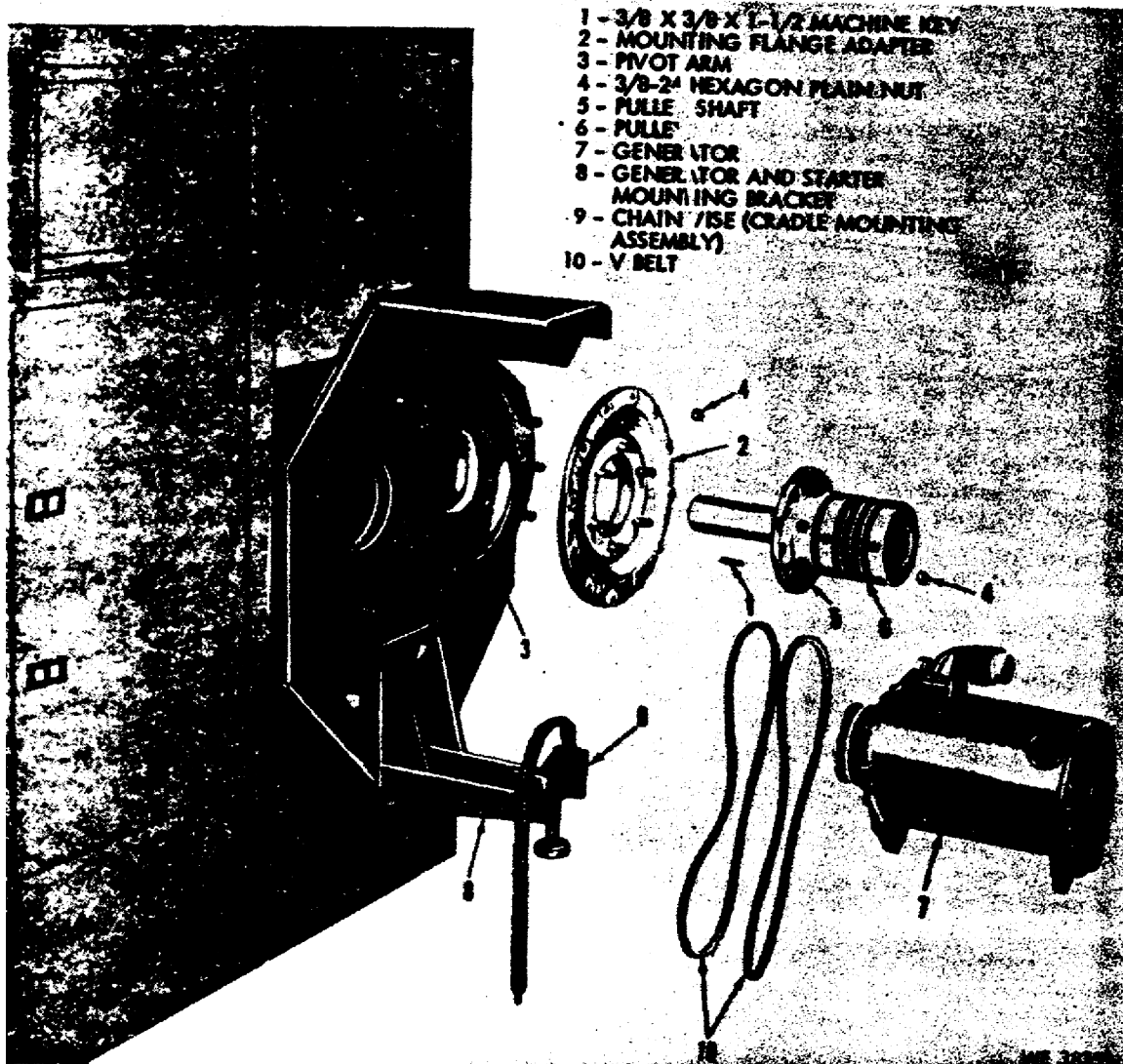


Figure 7. Mounting pulley driven generator or alternator.

5. Adjust the mounting bracket to obtain proper tension on the V-belts and tighten the four hexagon nuts to secure the mounting bracket.

6. If further alinement of the pulleys is required, slide the chain vise on the bracket as needed. Tighten the hexagon nut under the chain vise to secure the vise in place.

(b) Pulley calibration. During the testing of pulley driven units it is necessary to know the rate of rotation (RPM). Pulley size varies from unit to unit. Calibration of the tachometer circuitry to the pulley is required. The tachometer has a two-position selector switch which allows selection of either DIRECT DRIVE or CAL PULLEY. The CAL PULLEY position is calibrated with the calibration control just to the left of the selector switch. To perform the pulley calibration proceed as follows:

1. Referring to foldout 5, turn the tachometer pulley calibration control (7) to its counterclockwise position and the selector switch (8) to the DIRECT DRIVE position.

2. Start the varidrive assembly and preset the RPM of the driving pulley. This is done by increasing the drive speed control (42) so that tachometer RPM is indicating at a reference point on the meter face.

Example: If the UUT is mounted on the low speed head, select a reference point on the lower scale in the vicinity of 2,000 RPM. If mounted on the high speed head, select a point on the upper scale in the vicinity of 6,000 RPM.

3. Determine the speed of rotation (RPM) of the pulley on the UUT by using the following equation:

$$\text{UUT pulley RPM} = (\text{Test stand RPM} \times 4) \div D$$

Where D = diameter of UUT's pulley

Example:

Test stand RPM = 2,000 RPM, as indicated on the tachometer.

D = 3 inches = diameter of UUT's pulley.

$$\text{UUT pulley RPM} = (2,000 \times 4) \div 3$$

$$= 8,000 \div 3$$

$$= \frac{8,000}{3}$$

$$\text{UUT pulley RPM} = 2,666$$

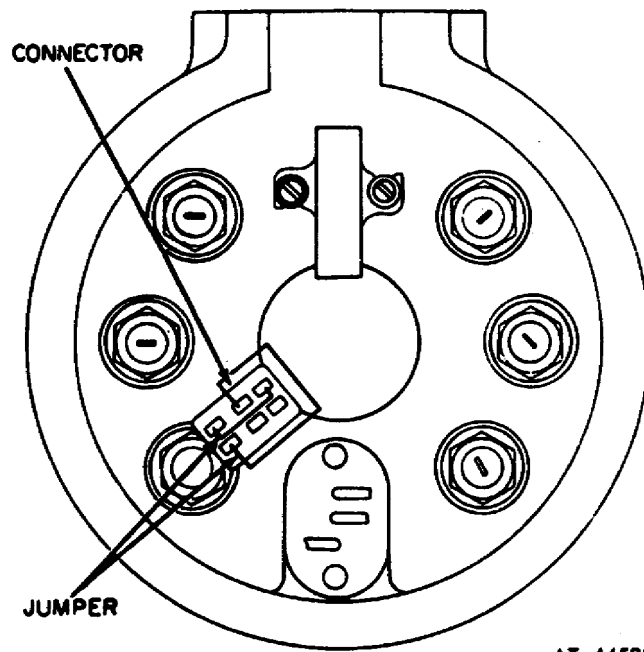
4. To calibrate the tachometer for the RPM indicated in the example, simply turn the selector switch (8) to the CAL PULLEY position.

5. Turn the calibration control (7) clockwise until the scale on the tachometer reads 2,666 RPM.

6. Now, during testing, the drive speed control (42) can be adjusted and the tachometer will indicate the true RPM of the pulley driven unit under test.

5. TESTING 60-AMPERE SYSTEM. As we said before, testing of the 60-ampere system is with or without the voltage regulator. The first test to perform is the test without the regulator. If this test does not perform properly, then disassemble the generator and test to find malfunctioning components of either the stator, rotor, or rectifying diodes.

a. Regulator removed. The regulator must be removed from the generator to perform this test. Also, the internal connector, which connects to the regulator, has open circuits. These circuits must be jumped so operation of the field circuit in the rotor may be controlled from the test stand. Figure 8 shows the connector and jumper wires which are connected between terminals 1 and 5 and also 2 and 3.



AT 44532

Figure 8. Installation of jumper wires.

(1) Once the jumper wires are in place, the rectifier assembly is grounded and the ignition terminal is directly connected to the field circuit. Figure 9 shows what is happening schematically.

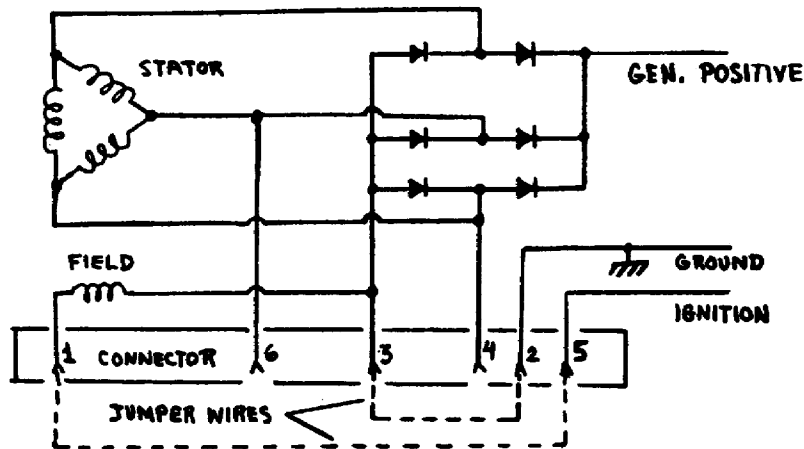


Figure 9. Schematic operation.

(2) After installing the drive end housing on the generator it may be connected to the test stand (B, foldout 6).

(a) Connect cables from generator positive (A, foldout 6) to test stand G+ and from generator ground (frame) to G-.

(b) Connect cable from generator ignition (A, foldout 6) to the F terminal.

(c) Install the links between G+ and B+ connectors and also between G-and B-of the regulator section. This straps the batteries and loads to the generator.

(3) Before starting the varidrive, place the test stand switches and selectors in the following positions:

(a) Place the DC ammeter load and starter selector (1) in the 150A position.

(b) Set the DC ammeter field and battery charger selector (2) in the 5A position.

(c) Set the DC voltmeter range selector (5) in the 50V position.

(d) Set the DC voltmeter range selector (6) in the RECT/GEN position.

(e) Set the field circuit switch (36) in the MANUAL position.

(f) All load switches (34) to the OFF position.

(g) Verify that the ground polarity switch (33) is in the negative (-) position.

(h) Verify that the field current control (41) is counterclockwise.

(i) Verify that the battery selector (31) is OFF.

(4) Testing procedure. Start the varidrive by actuating the start button (28) and turning the drive speed control (42) counterclockwise until the direct drive pulley is operating at 2,000 RPM, so the tachometer "CAL PULLEY" position can be calibrated.

(a) Once the generator pulley has been calibrated, the generator pulley is to be adjusted to between 1,500 and 1,800 RPM.

CAUTION: TO PREVENT DAMAGE TO THE INTERNAL RECTIFIER, THE VOLTAGE MUST NOT EXCEED 32 VOLTS. INCREASING THE LOAD CURRENT CAUSES THE VOLTAGE TO DECREASE; DECREASING THE LOAD CURRENT CAUSES THE VOLTAGE TO INCREASE. SO IF THE VOLTAGE WAS SET TO 28 VOLTS AND THE LOAD CURRENT WAS DECREASED, THE VOLTAGE COULD EXCEED 32 VOLTS, PROVIDING THE FIELD CURRENT ISN'T TOUCHED.

(b) Place the battery selector to the 24V position.

(c) Turn the MASTER LOAD switch (39) to the ON position.

(d) Adjust the field current control (41) for a 28-volt reading on the DC voltmeter; the field current should not exceed 1 ampere.

(e) Gradually apply a 60-ampere load while maintaining 28 volts.

1. Turn the 0-25A LOAD switch (34) to the ON position and adjust the LOAD CURRENT CONTROL (43) for 60 amperes on the LOAD meter while maintaining 28 volts on the DC voltmeter.

2. If 60 amperes cannot be obtained with the 0-25A LOAD, decrease the field current control (41) to a safe level; then back off the LOAD CURRENT CONTROL (43) to its minimum position (counterclockwise), while making certain the DC voltmeter does not exceed 28 volts.

3. Turn the 25A LOAD switch (34) to the ON position; the DC voltmeter reading should now decrease.

4. Bring the DC voltmeter reading back to 28 volts by adjusting the field current control (41).

5. Increase the load current reading by adjusting the LOAD CURRENT CONTROL (43) to 60 amperes. If not possible, repeat step (2); then turn the 25A switch OFF and the 50A switch ON and continue with step (4).

(f) If test reading cannot be obtained, the generator is unserviceable and must be repaired.

(g) This completes the test. Turn the field current control (41) fully counterclockwise (CCW).

1. Turn LOAD CURRENT CONTROL (43) CCW.

2. Remove all loads (34).

3. Decrease drive speed control (42) CW to OFF.

4. Depress stop button (35).

5. Remove all cables and leads.

(h) Remove generator from test stand and install the regulator assembly for further testing.

(i) Return all controls to positions indicated in table 1.

(5) Indications from the test stand can locate the trouble area. For example, if the rotor field is open, there will be no voltage or current indicated on any of the meters, except when the internal battery is selected.

(a) An open rotor stops all alternator functions; so, when low voltage and no current are observed, the most logical circuit to check would be the rotor. It could be an open field coil or sliprings.

(b) If, during the test, field current is indicated on meter 2 of foldout 6 and low load current on meter 1, or output voltage on the DC voltmeter, the stator winding or the rectifiers would be the most logical points to check.

(c) When trouble occurs one should first expect an operator fault, such as a switch in the wrong position. In testing without a regulator, if the field current switch (36) is in the REGULATOR position, you will have all the symptoms of an open rotor field winding.

1. If the battery voltage selector (31) is in the wrong position, bad indications will result. So doublecheck this switch.

2. Another switch that may give you trouble is the 0-25A load switch (34). Procedures will require the adjustment of the LOAD CURRENT CONTROL (43) to increase the load current. If the 0-25A load switch is OFF, the LOAD CURRENT CONTROL will not vary the current in the load.

b. With regulator. Once the regulator has been properly installed it may be connected to the test stand.

(1) Hookup. Connect the cables and leads to the generator as shown in foldout 6.

(2) Switch positions. Before starting the varidrive, place the test stand switches and selectors in the following positions:

- (a) Place the DC ammeter selector (1) in the 150A position.
- (b) Place the DC ammeter selector (2) in the 5A position.
- (c) Place the DC voltmeter selector (5) in the 50V position.
- (d) Place the DC voltmeter selector (6) in the RECT GEN position.
- (e) Set field circuit switch (36) in the REGULATOR position.
- (f) All load switches (34) in their OFF positions.
- (g) Set the ground polarity switch (33) in the negative (-) position.
- (h) Set ignition switch (IGN) in the OFF position.
- (i) Set battery selector (31) in the OFF position.

(3) Testing procedure. Start the varidrive by actuating the start button (28) and turning the drive speed control (42) counterclockwise (CCW) until the generator pulley is operating at 2,000 RPM.

- (a) Turn the field current control (41) fully clockwise (CW).
- (b) Turn the battery selector (31) to the 24V position.
- (c) Set the ignition switch (IGN) to the ON position. If the LOAD DC ammeter reads above 10 amperes, snap ON the 25A and 0-25A switches (34) of the load bank.
- (d) Turn ON the master load switch (39).
- (e) The DC voltmeter should indicate 28 volts.
 - 1. If 28 volts are not indicated, remove the drive end housing pipe plug and adjust the variable resistor on the regulator for 28 volts.
 - 2. If the regulator will not adjust, then stop tests and replace the regulator.
- (f) Apply the load and increase the load current slowly to 60 amperes by adjusting the load current control (41).
 - 1. DC voltmeter should indicate 28 volts.
 - 2. DC ammeter field current (2) should not read over 1 ampere.

(g) If the tests are not conclusive, then submit the faulty unit for adjustment or repair.

(4) Test stand shutdown. To be certain not to damage the rectifier, the output voltage must not exceed 32 volts. Turning the field current control (41) fully CCW will decrease the output voltage and load current at the same time, thereby preventing damage to the rectifier. When shutting down the test stand, turning the field rheostat to reduce the field current to zero is the best practice.

- (a) Turn the drive speed control (42) fully clockwise (CW).
- (b) Stop the varidrive by actuating the stop button (35).
- (c) Return all switches to the positions indicated in table 1.
- (d) Remove all cables and leads.
- (e) Remove the generator from test stand.

6. THE 100-AMPERE SYSTEM. Shown in figure 10 is the 100-ampere alternator kit which is used to convert lower amperage in vehicles to the 100-ampere capability.

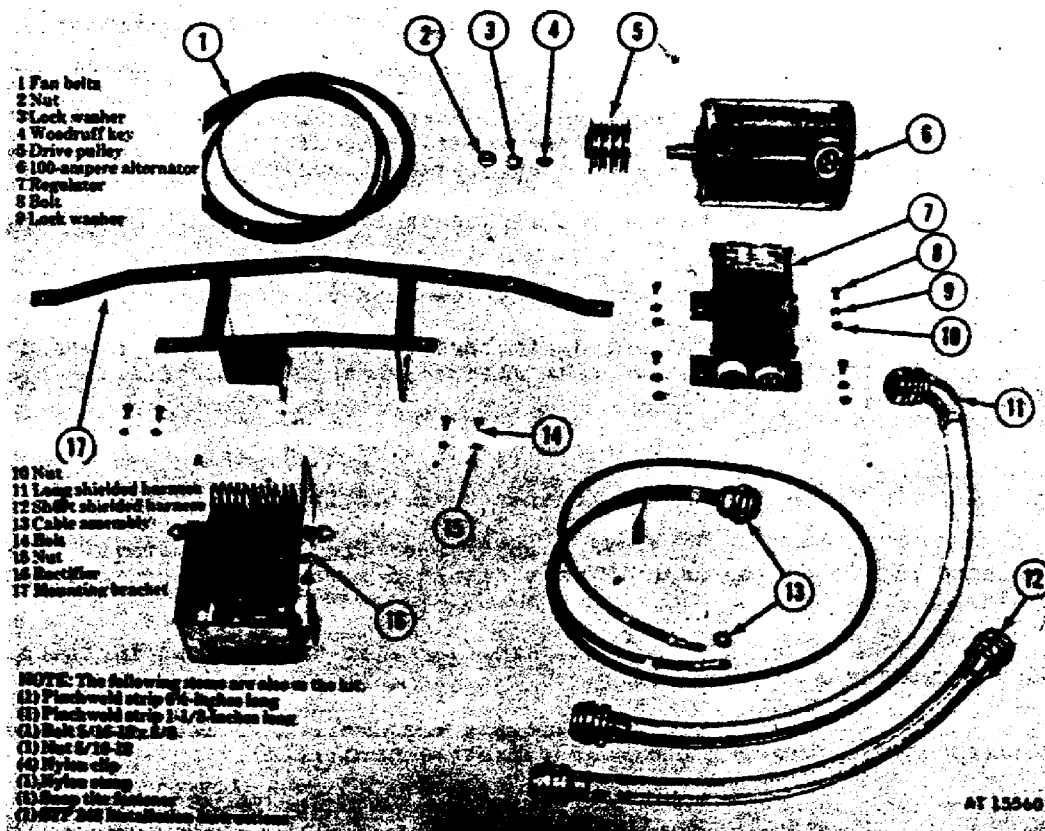


Figure 10. 100-ampere system.

a. 100-ampere. The 100-ampere alternator (6) is an engine driven generator, with three functional parts: rotor, stator, and brushes. It provides a three-phase AC current output whose amplitude is controlled by the current in the field winding of the rotor.

b. Rectifier. The rectifier is a separate unit (16). It is a selenium rectifier that changes the three-phase AC current to direct current and is connected to the alternator and regulator by cables.

c. Regulator. The regulator (7) senses the output voltage of the rectifier (16) and controls the alternator (6) output to the rectifier.

(1) The regulator is a solid-state voltage regulator designed for self-load limiting alternators. It is a direct replacement item for the older carbon pile regulator.

(2) It utilizes silicon transistors to switch the field current of the alternator ON and OFF. It also incorporates a load relay for disconnecting the charging system.

d. Testing the 100-ampere alternator. The alternator may be tested on the test stand without a voltage regulator. However, a rectifier is required so the DC output can be used to load the alternator. Foldout 7 shows the cable hookup; in particular, note the rectifier connection.

(1) Unlike the 60-ampere generator, the test stand is connected between the alternator and rectifier. This being the case, each phase of the alternator can be monitored and checked.

(2) The AC voltmeter checks the voltage between the phases and the AC ammeter checks the current in each phase.

(3) The AC voltage between the phases should be equal.

(4) The AC ammeter should indicate 100 amperes as the 100-ampere load is applied to the output of the rectifier.

(5) The DC ammeter monitoring the field current should not indicate less than 9 or greater than 12 amperes.

7. TESTING THE 100-AMPERE REGULATOR. In testing the regulator, the alternator, rectifier, and regulator are operationally connected. It is necessary that the alternator and rectifier be known to be operational. In other words, in order to verify the regulator, the alternator and rectifier have to functionally meet their specifications. Connection of the three components is shown in foldout 8.

a. The alternator is mounted to the test stand and its pulley calibrated as previously discussed. Make certain that all the controls are positioned according to table 1.

b. Take notice that the bus bar links between B+ and G+ and B- and G- have been removed. This is very important.

c. The rectifier is mounted in the cooling chamber where the blower circulates air. There is an interlock switch that actuates when the chamber door is closed, so be certain the cooling chamber door is closed or the stand will not function.

d. The regulator is mounted in a special bracket which is connected to the mounting base located in front of the rectifier cooling chamber.

e. Before continuing with the tests, position the field current control (41) maximum clockwise and the DC ammeter selector (1) to the 150-ampere range.

f. The line switch (LOAD RELAY) test is as follows:

(1) Temporarily move the regulator lead from the ignition switch to terminal J1 on the DC power supply.

(2) Place the DC voltmeter selector switch to V or DC-supply.

(3) Turn the DC power supply control fully CCW.

(4) Place DC power supply switch to the ON position.

(5) Turn the test stand main power switch ON.

(6) While observing the DC voltmeter, turn the DC power supply control slowly clockwise and listen for a "click" from the regulator. The "click" indicates the closing of the relay.

(7) The relay should close between 15 and 20 volts. If the relay does not close within these limits, the regulator is considered to be unserviceable.

(8) To discontinue the test, turn the DC power supply fully CCW.

(a) Turn DC power supply switch OFF.

(b) Turn DC voltmeter selector (1) to the RECT/GEN position.

(c) Return the ignition lead to the ignition terminal.

g. The voltage regulation test is as follows:

Note. - Read and study the outlined procedures very carefully before proceeding with the actual tests and adjustments.

CAUTION: During the testing, do not allow the generator voltage to exceed 32 volts as this could damage the rectifier, and, unless specifically stated, the battery must be connected in the circuit at all times.

(1) Start the test stand. Turn battery selector and ignition switches to the ON positions; increase the test stand speed to 2,000 RPM while observing voltmeter.

CAUTION: Be sure the voltage does not exceed 32 volts at any time during testing. If the voltage does exceed 32 volts, attempt to obtain a low voltage of less than 32 volts by using the voltage adjustment on the regulator.

(2) If a stable voltage of 27.5 to 28.5 volts cannot be obtained, the regulator is unserviceable and should be discarded as directed by the appropriate technical publication. If the voltage is obtained, proceed to the next step.

(3) Turn the master load (load disconnect) switch to the ON position.

(4) While observing the voltmeter reading, place 25-, 50-,

75-, and 100-ampere loads on the system.

Note. - The voltage should remain between 27.5 and 28.5 volts. If it does not, the regulator is unserviceable and should be discarded.

(5) If the regulator performs as stated, it is considered serviceable and can be prepared for issue to a user.

(6) Discontinuing the test.

- (a) Turn all rheostats fully counterclockwise.
- (b) Turn all loads off.
- (c) Reduce the test stand speed to 1,000 RPM.
- (d) Stop the test stand main drive motor.
- (e) Turn all remaining switches to the OFF position.
- (f) Remove all leads and store in proper compartments.

8. SUMMARY. In this lesson we have discussed in detail the testing of the 60-ampere generator and the 100-ampere regulator with the 500-ampere test stand. In preparation, the test stand meters were electrically zeroed, the switches and controls were preset, and the varidrive operated throughout its range.

a. Direct driven and pulley driven generators can be tested on the stand. The speed of the generator determines what driving head is used. Normally, the low speed driving head will suffice for most generators.

b. The pulley driven generator requires the use of the CAL PULLEY position of the tachometer selector. You were shown how to calibrate the tachometer in this position so that the proper pulley speed is visually indicated.

c. Detailed tests were discussed and now you should understand that alternators can be tested without regulators. Also, if an alternator does not have an internal rectifier, one must be included in the alternator test to properly load it.

d. The regulator tests included a relay pull-in test and its function to regulate the output voltage to specified limits. Understanding the principles presented here will greatly aid you and improve your abilities with the use of the 500-ampere test stand. Successful completion of the exercise questions will verify your understanding and reinforce the material presented.

Note. - Refer to the exercise instructions presented in lesson 1.

EXERCISE

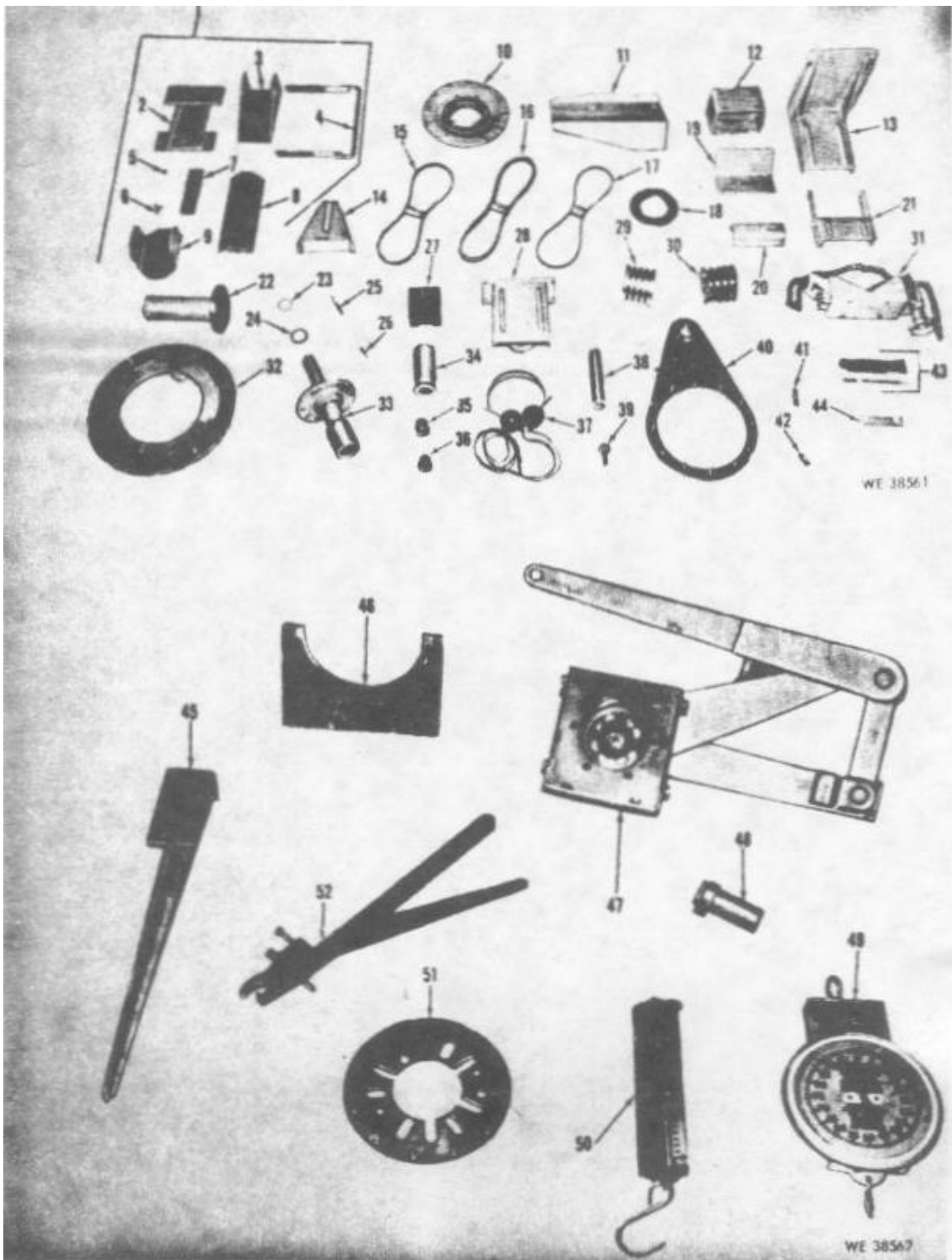
46. What is done first when preparing the 500-ampere test stand for operation?

- a. Calibrate the CAL PULLEY
- b. Check the battery voltages
- c. Mechanically zero the meters

47. The meter's mechanical zero adjustment is located
- above the lens to the right.
 - below the lens in the middle.
 - below the lens to the right.
48. In preparation of the 500-ampere test stand, what is done to preclude damage to the system?
- Calibrate the tachometer
 - Operate the varidrive assembly
 - Preset the switches and controls
49. The lamp is LIT and the START button is actuated but the varidrive does not start. Which is a possible trouble?
- Main circuit breaker is OFF
 - High voltage compartment door is open
 - No airflow in the rectifier compartment
50. The START button is actuated and the varidrive assembly starts, but as the START button is released the varidrive assembly stops. What is a possible trouble?
- Main circuit breaker is OFF
 - High voltage compartment door is open
 - No airflow in the rectifier compartment
51. What safety precaution should be observed when starting the varidrive assembly? Hold the START button closed
- more than 30 seconds.
 - less than 30 seconds.
 - more than 60 seconds.
52. What accessories are left mounted to the test stand after the completion of a test?
- Pivot arm and mounting brackets
 - Pulley and belts
 - Regulator mounting brackets
53. The mounting flange adapter connects between the
- cradle assembly and generator.
 - mounting plate and pivot arm.
 - pivot arm and generator.
54. A spline adapter is used when a direct driven generator is mounted. It adapts the coupling shaft to the
- generator.
 - mounting flange.
 - driving head.
55. The pulley output shaft assembly is used when a pulley driven generator is mounted. Its purpose is to couple between the
- coupling shaft and pulley.
 - driving head and pulley.
 - driving head and coupling shaft.

56. When mounting the generator in the chain vise, what precaution should be observed? Never clamp over the
- a. stator housing.
 - b. end bearing housing.
 - c. thin shell housing.
57. The tension on the pulley V-belts is adjusted by positioning the
- a. mounting bracket.
 - b. pivot bracket.
 - c. driving head.
58. If the diameter of the generator pulley is 4 inches, what is the RPM of the generator?
- a. Test stand RPM X 4
 - b. Test stand RPM $\div$ 4
 - c. Test stand RPM
59. If the diameter of the generator pulley is 3 inches and the test stand RPM is 6,000, what is the RPM of the generator under test?
- a. 8,000
 - b. 6,000
 - c. 4,500
60. The 2,666 RPM of the generator has been calculated. The next step to be performed is to adjust the
- a. drive speed control for 2,666 RPM.
 - b. CAL PULLEY position.
 - c. calibration control for 2,666 RPM.
61. When the 60-ampere system is tested without the regulator, why must the internal connections be Jumped with wires?
- a. To complete the stator circuit
 - b. To complete the rectifier circuit
 - c. To complete the field circuit
62. When a generator is operated without a regulator, what precaution should be observed if the DC voltmeter shows 28? The field current should be reduced first if the
- a. load is to be increased.
 - b. load is to be decreased.
 - c. RPM is to be decreased.
63. A generator is operated without a regulator. No voltage or current except that of the internal batteries is indicated. What is the most likely trouble area?
- a. Stator
 - b. Rectifier
 - c. Rotor
64. What may be damaged if the output voltage exceeds 32 volts in the 60-ampere system?
- a. Stator
 - b. Rectifier
 - c. Rotor

65. In the 60-ampere system, the field current should not exceed
- a. 1 ampere.
 - b. 2 amperes.
 - c. 3 amperes.
66. The 60-ampere system is tested with the regulator. If the load is increased, what should happen to the output voltage?
- a. Increase
 - b. Decrease
 - c. Remain constant
67. The 100-ampere alternator is a
- a. single-phase generator.
 - b. dual-phase generator.
 - c. three-phase generator.
68. The new regulator used with the 100-ampere system is a
- a. solid-state device.
 - b. carbon pile device.
 - c. electron tube device.
69. The LOAD RELAY test of the 100-ampere system is performed with the
- a. generator rotating at 2,000 RPM.
 - b. DC power supply.
 - c. load switches.
70. In the 100-ampere system, what is the proper field current?
- a. Less than 9 amperes
 - b. Greater than 12 amperes
 - c. Between 9 and 12 amperes

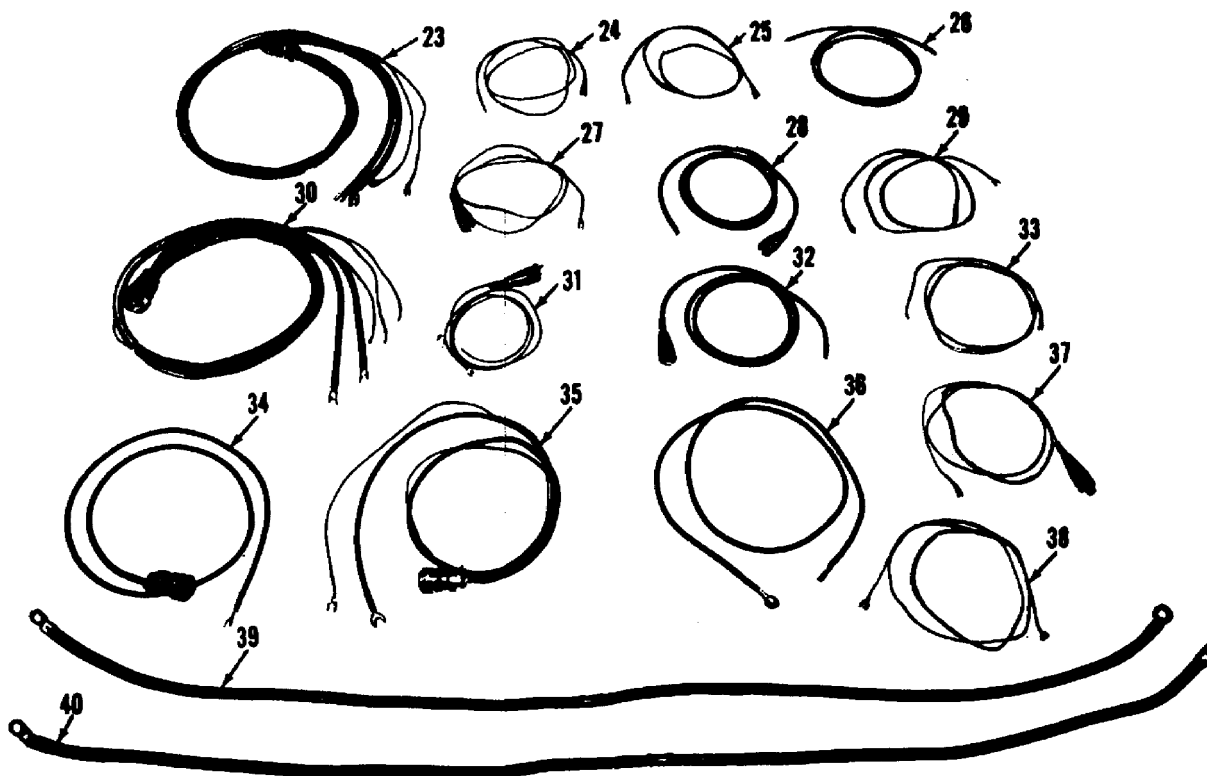
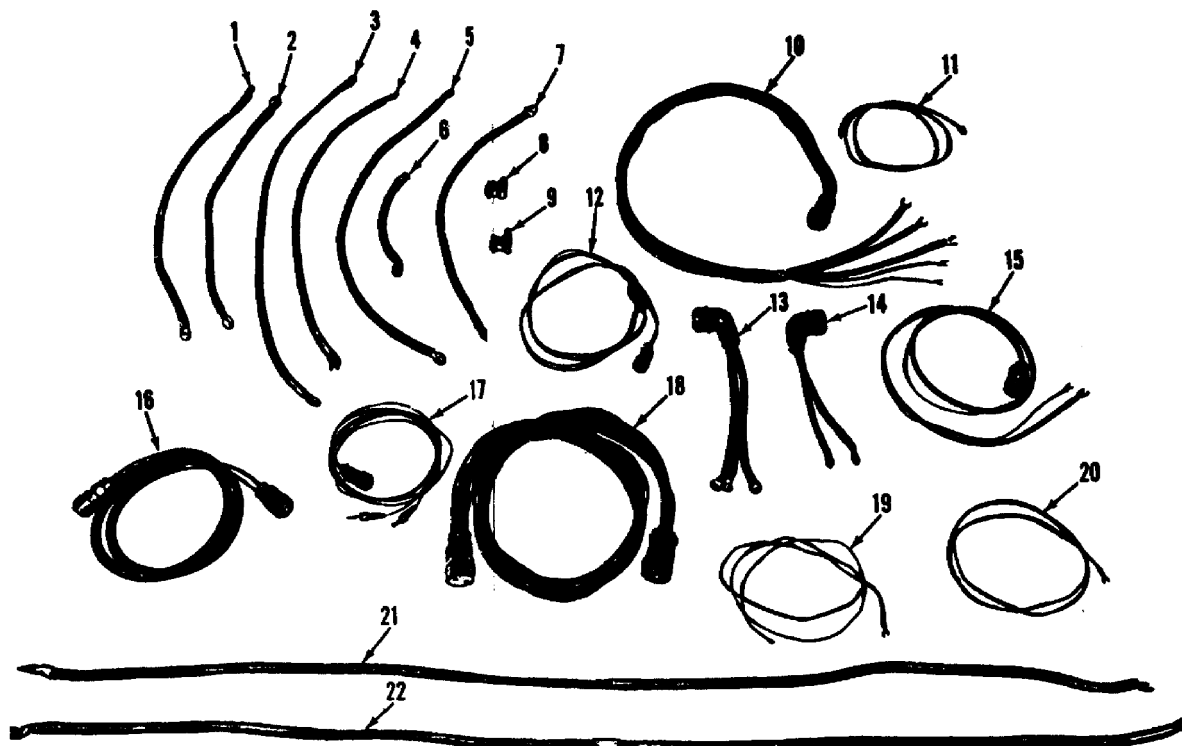


Foldout 1.

REPAIR PARTS

(1) SMR CODE	(2) FEDERAL STOCK NUMBER	(3) DESCRIPTION	(4) UNIT OF MEAS.	(5) QTY INC IN UNIT	(6) ILLUSTRATION
					(b) ITEM NO.
		ACCESSORY GROUP—Continued			
P-O	4910-254-6326	BATTERY BLOCK, HOLD-DOWN: C548-1820 (82386)	EA	4	27
P-O	4910-254-6336	BRACKET, PIVOT SUPPORT: C548-2149 (82386)	EA	1	28
P-O	3020-253-5879	PULLEY, GROOVE: C548-2162 (82386)	EA	1	29
P-O	3020-253-5878	PULLEY, GROOVE: C548-2161 (82386)	EA	1	30
P-O	4910-254-6322	CRADLE, MOUNTING: generator / alternator C548-2170 (82386)	EA	1	31
P-O	4910-254-6335	ADAPTER, FLANGE: C548-2242 (82386)	EA	1	32
P-O	4910-254-6341	PULLEY OUTPUT SHAFT ASSEMBLY: C548-2156 (82386)	EA	1	33
P-O	4910-253-5868	COUPLING, SHAFT: 3046-5001-01 (82386)	EA	1	34
P-O	4910-254-6340	ADAPTER, SPLINE: C548-2246 (82386)	EA	1	35
P-F	4910-786-4118	ADAPTER, SPLINE: 1/2 PD male to no. 8 PD female spine 140-008 (82386)	EA	1	36
P-O	5965-470-9521	HEADSET, ELECTRICAL: 70-06 (81812)	EA	1	37
P-O	4910-253-5877	SHAFT, PIVOT: C548-2148 (82386)	EA	1	38
P-O	5307-410-4935	STUD, SHOULDERED: C548-2155 (82386)	EA	6	39
P-O	4910-254-6324	ARM, PIVOT: C548-2147 (82386)	EA	1	40
P-C	5920-465-8906	FUSE: cartridge, 10 amp, ferrule type, 250 V 739-014 (82386)	EA	1	41
P-F	5920-783-7859	FUSE, CARTRIDGE: glass body 15 amp, 125 V, DC, normal instantaneous, ferrule type 414015 (75915)	EA	1	42
P-F	6680-834-5941	TACHOMETER, HAND: reed type 31627 (99664)	EA	1	43
P-O	4910-254-6320	LINK, BUS BAR: C548-5700 (82386)	EA	2	44
P-O	4910-254-6337	BAR, TORQUE ARM: C548-2195 (82386)	EA	1	45
P-O	4910-254-6333	SUPPORT, STARTER MOUNTING: C548-2199 (82386)	EA	1	46
P-O	4910-253-5876	LOCK, TORQUE ASSEMBLY: C548-2177 (82386)	EA	1	47
P-O	4910-253-5871	JAW, CLUTCH HOUSING ASSEMBLY: C548-2188 (82386)	EA	1	48
P-C	6670-440-0318	SCALE, SPRING: 0001-5006 (82386)	EA	1	49
P-C	6670-440-0317	SCALE, SPRING: 0001-5007 (82386)	EA	1	50
P-O	4910-254-6328	FLANGE, UNIVERSAL MOUNTING: C548-2198 (82386)	EA	1	51
X2-F	.....	TORQUE ARM CLAMP ASSEMBLY: pinion driven C548-2194 (82386)	EA	1	52

Foldout 2.

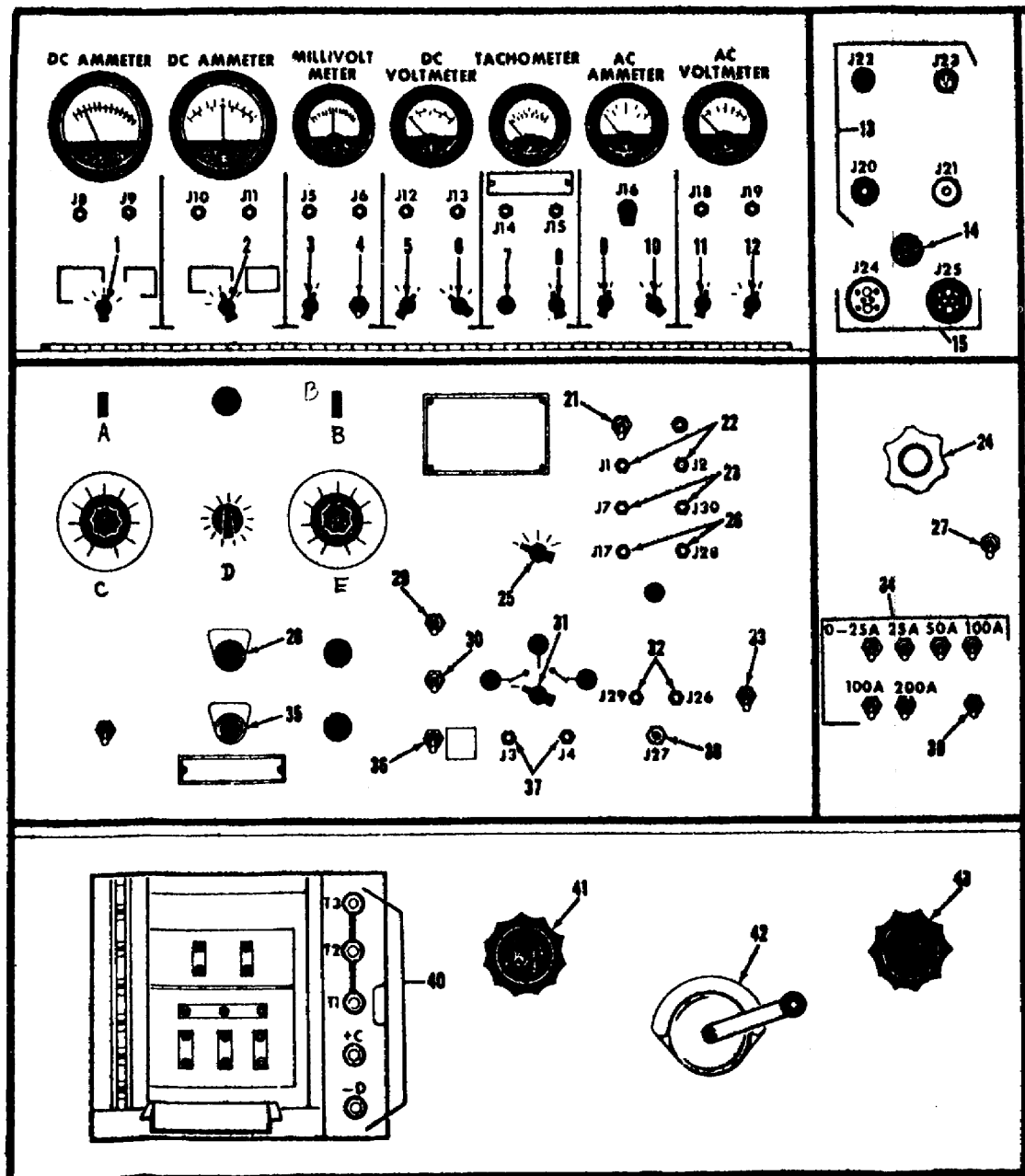


Foldout 3.

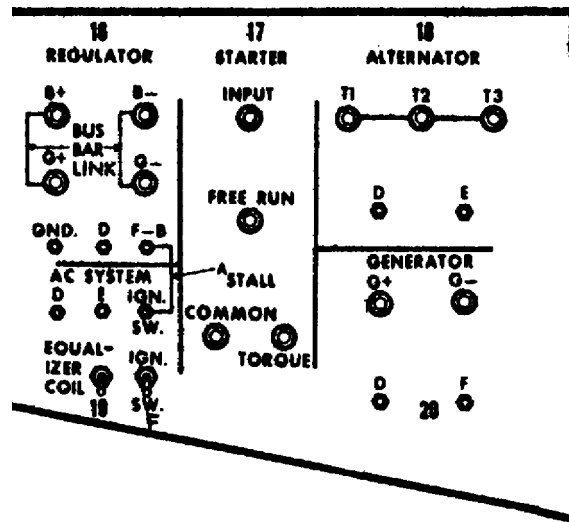
REPAIR PARTS

(1) SMR CODE	(2) FEDERAL STOCK NUMBER	(3) DESCRIPTION	(4) UNIT OF MEAS.	(5) QTY INC IN UNIT	(10) ILLUSTRATION (b) ITEM NO.
CABLE ASSEMBLY GROUP					
—Continued					
P-O	6625-491-0610	LEAD, TEST: w / lugs C548-4100-18 (82386)	EA	1	28
P-O	6625-489-8423	LEAD, TEST: w / lugs C548-4100-12 (82386)	EA	1	29
P-O	4910-254-6319	TEST LEAD, REGULATOR: C548-4115 (82386)	EA	1	30
P-O	6625-491-0584	LEAD, TEST: C548-4100-07 (82386)	EA	1	31
P-O	6625-496-8542	LEAD, TEST: w / lugs C548-4100-19 (82386)	EA	1	32
P-O	6625-491-0581	LEAD, TEST: w / lugs C548-4100-13 (82386)	EA	1	33
P-O	5995-134-6687	CABLE, SPECIAL PURPOSE, ELECTRICAL: C548-4106 (82386)	EA	1	34
P-O	5995-134-6675	CABLE, SPECIAL PURPOSE, ELECTRICAL: C548-4107 (82386)	EA	1	35
P-O	6625-489-8422	LEAD, TEST: C548-4100-14 (82386)	EA	1	36
P-O	6625-489-8421	LEAD, TEST: C548-4100-15 (82386)	EA	1	37
P-O	6625-491-0588	LEAD, TEST: w / lugs C548-4100-01 (82386)	EA	1	38
P-O	6625-491-0587	LEAD, TEST: w / lugs C548-4100-02 (82386)	EA	1	39
P-O	6625-491-0592	LEAD, TEST: w / lugs C548-4100-17 (82386)	EA	1	40

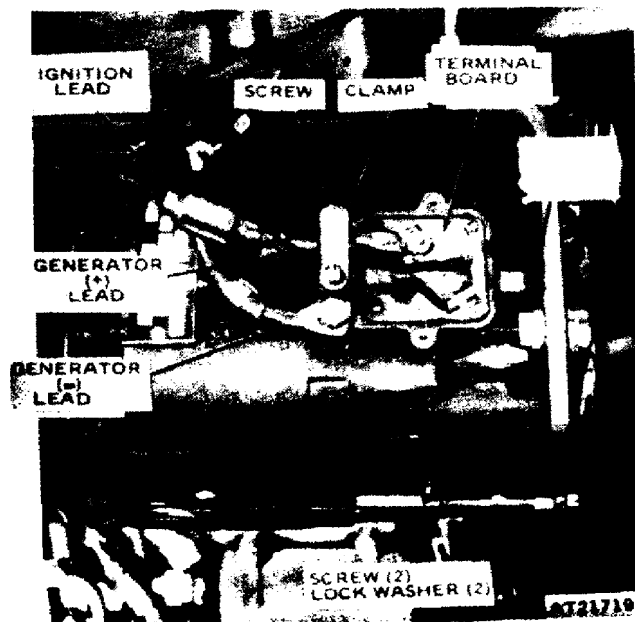
Foldout 4.



Foldout 5.

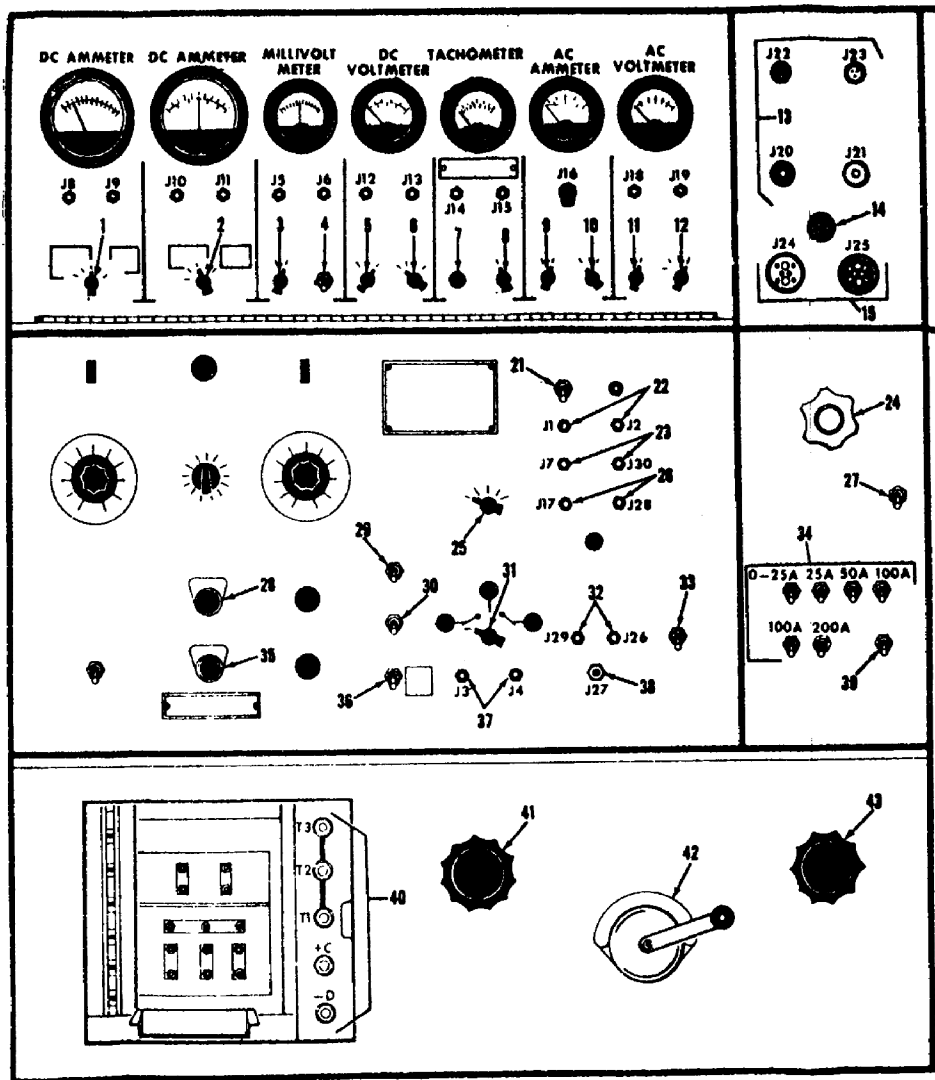


Foldout 5. (continued)



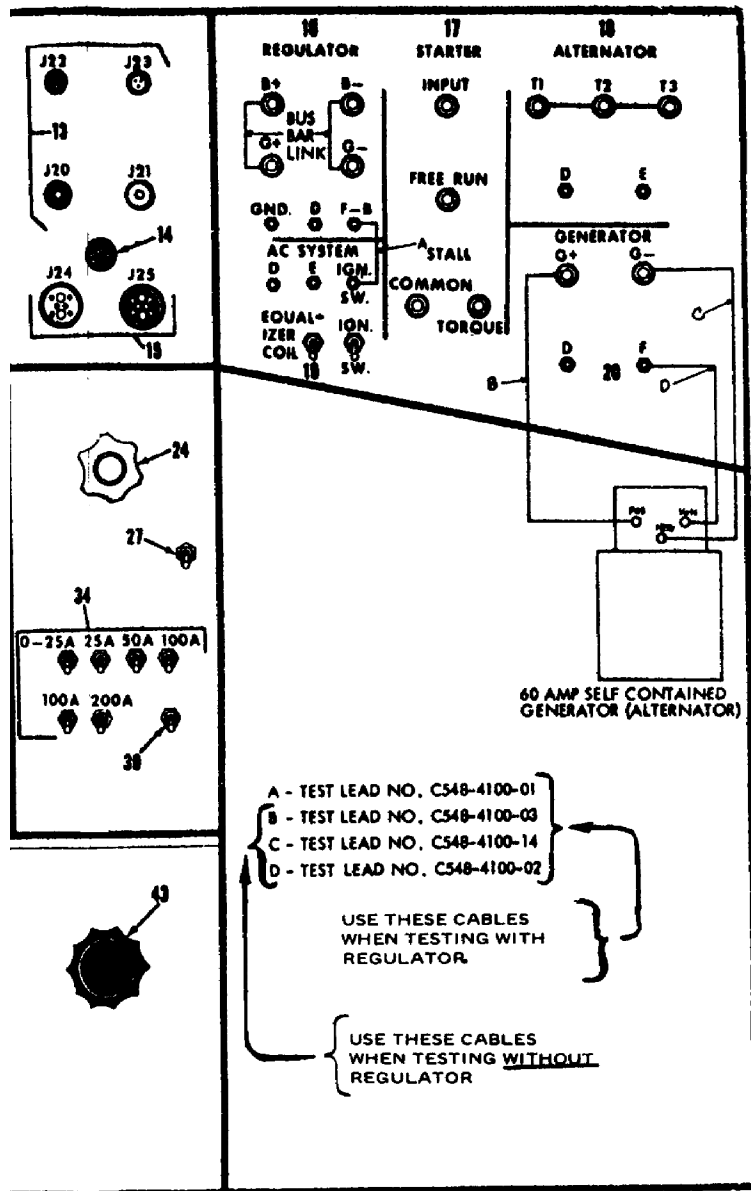
A

Foldout 6



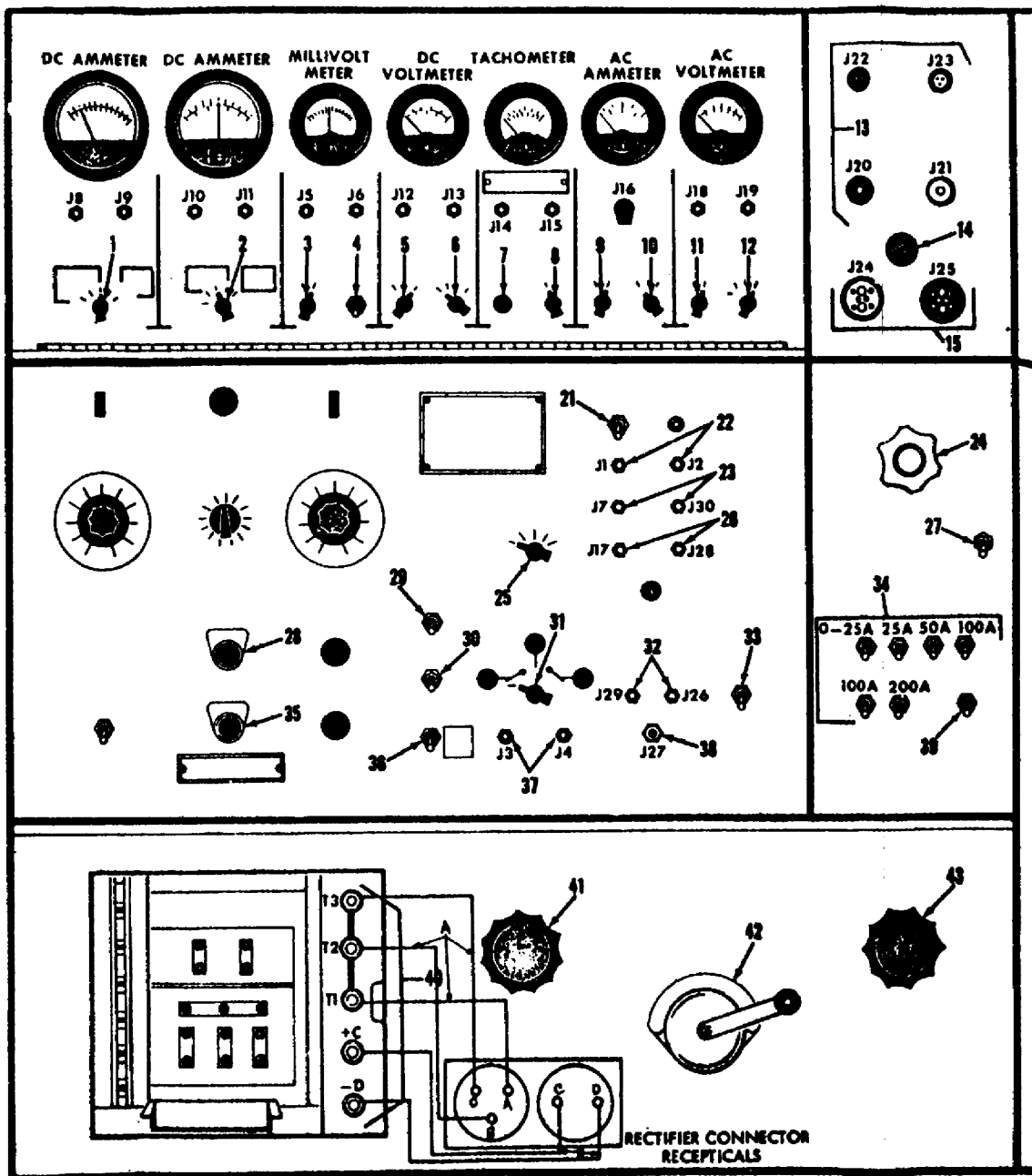
B

Foldout 6 (Continued)

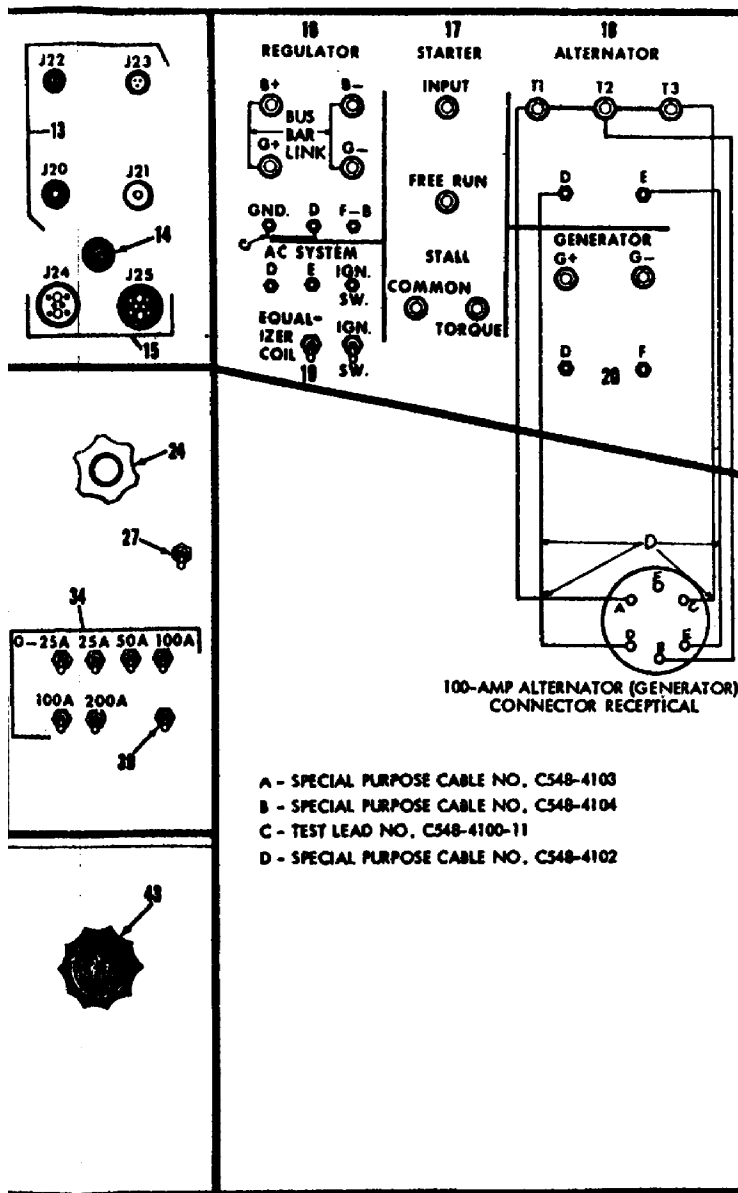


B

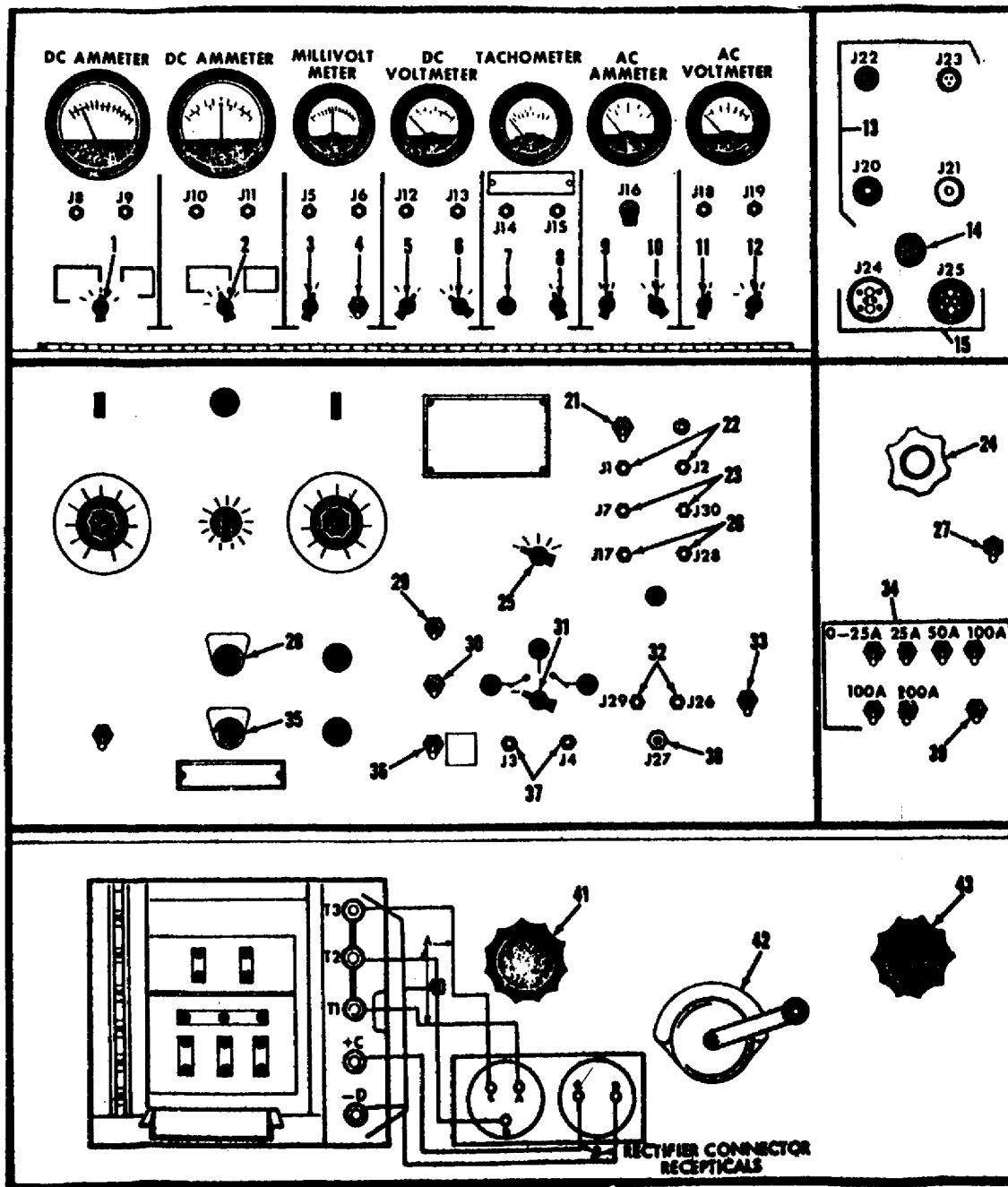
Foldout 6 (continued)



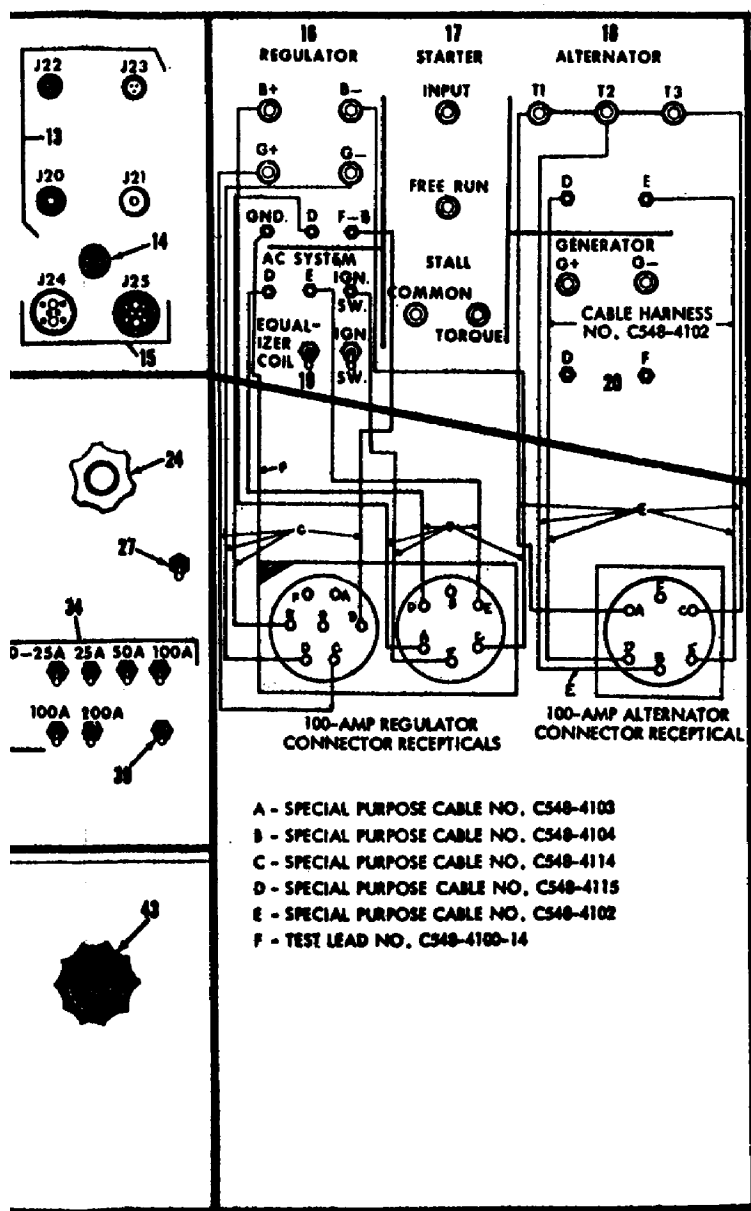
Foldout 7



Foldout 7 (continued)



Foldout 8



Foldout 8

C O R R E S P O N D E N C E C O U R S E
o f t h e
U S A R M Y O R D N A N C E
C E N T E R A N D S C H O O L



LESSON ASSIGNMENT

Ordnance Subcourse No 010..... Electrical System Component Repair

Lesson 5..... Testing and Adjusting DC Regulators

Credit Hours..... Two

Lesson Objective..... After studying this lesson you will be able to:

1. Describe the purpose and use of an automotive voltage regulator.
2. Explain the basic principles of regulator operation.
3. Describe bench testing procedures.
4. Explain test stand operational testing procedures.

Text..... Attached Memorandum

Materials Required..... Response list and answer sheet

Suggestions..... None

ATTACHED MEMORANDUM

1. REGULATORS. There are many different models of regulators, each designed to meet the requirements of a specific application of voltage and current. Although the external appearances of these regulators may vary considerably, the internal circuitry of each model remains basically the same. Since this lesson describes the basic internal circuit, it will apply equally to all models of regulators.

a. Generators need to be kept under control (regulated) to keep them from building up too much voltage and current. Without regulation, a generator will continue to increase its output as its speed increases. The faster the generator turns (fig 1), the higher the output voltage. If left unchecked, after a short time it will be producing so much voltage and current that it will overheat and burn up. An uncontrolled generator will not only damage itself, but also the battery, which it is charging, and other electrical equipment in the vehicle could be damaged.

b. The need for a regulator in the charging circuit is brought about by the fact that the generator voltage increases with the increase in generator speed. This is graphed in figure 2. Sufficient voltage must be developed at low speeds to charge the battery and operate electrical accessories.

The sole function of the regulator is to prevent high voltage by limiting the generator voltage to a safe preset value.



Figure 1. Charging circuit (pictorial).

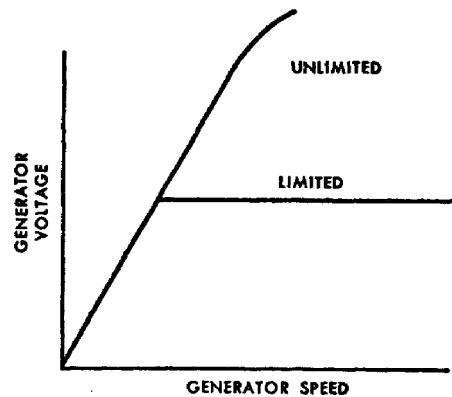


Figure 2. Speed vs voltage.

2. RELAY REGULATORS. There are several ways of regulating generator output, but the most common way is to regulate the field current. Figure 3 shows a typical generator where the field current is controlled by a variable field rheostat. The output voltage to the load could also be manually regulated by adjusting the variable field resistance. The controlling action would be as follows:

a. As the generator speed increases, we would observe an-increase in voltage on the voltmeter. Since we are manually regulating, we would turn the variable field resistance down, maintaining the proper voltage output on the voltmeter.

(1) As the generator speed decreases, we would have to increase the field current to maintain the proper output voltage.

(2) By adjusting the field resistance, we control the field current (I_F), which in turn controls the amount of magnetic flux to the stator, thereby inducing more or less current (I_L) into the stator windings. The rectified current (I_L) goes to the load developing more or less voltage across the load. Now observe the voltage change and regulate it with the field resistance.

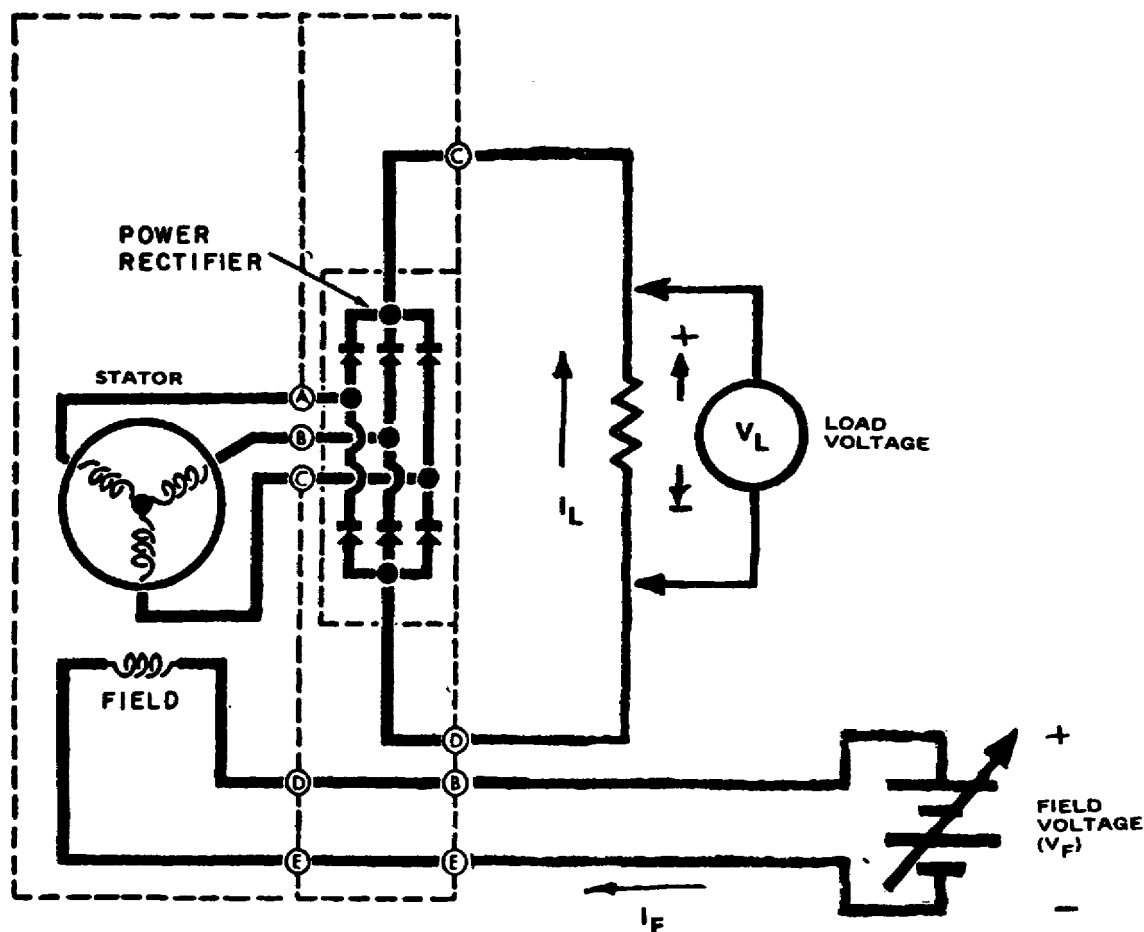


Figure 3. The generator.

b. Another scheme may be used to control the amount of magnetic flux in the field; this is shown in figure 4. Here the field winding is connected across the battery that is being charged. Notice that it is connected through a regulator switch.

(1) When the voltmeter indicates above normal, we open the switch and shut off the field current (I_F). This causes the magnetic flux to decrease, thereby decreasing the output of voltage.

(2) When the voltmeter indicates below normal, we close the switch and apply the field current (I_F). The current I_F produces an increasing magnetic flux increasing the output voltage.

(3) By our observations, we can regulate the output voltage by opening and closing the regulator switch. However, an automatic system has been devised to open and close the switch, thus producing the regulator that we use today.

c. The first type of automatic regulator incorporated a relay with a set of normally closed contacts (fig 5). This is a simplified circuit but it can be used to explain the operation.

(1) The relay is voltage sensitive. Its sensitivity can be controlled, over a small range, by a rheostat or a variable resistor.

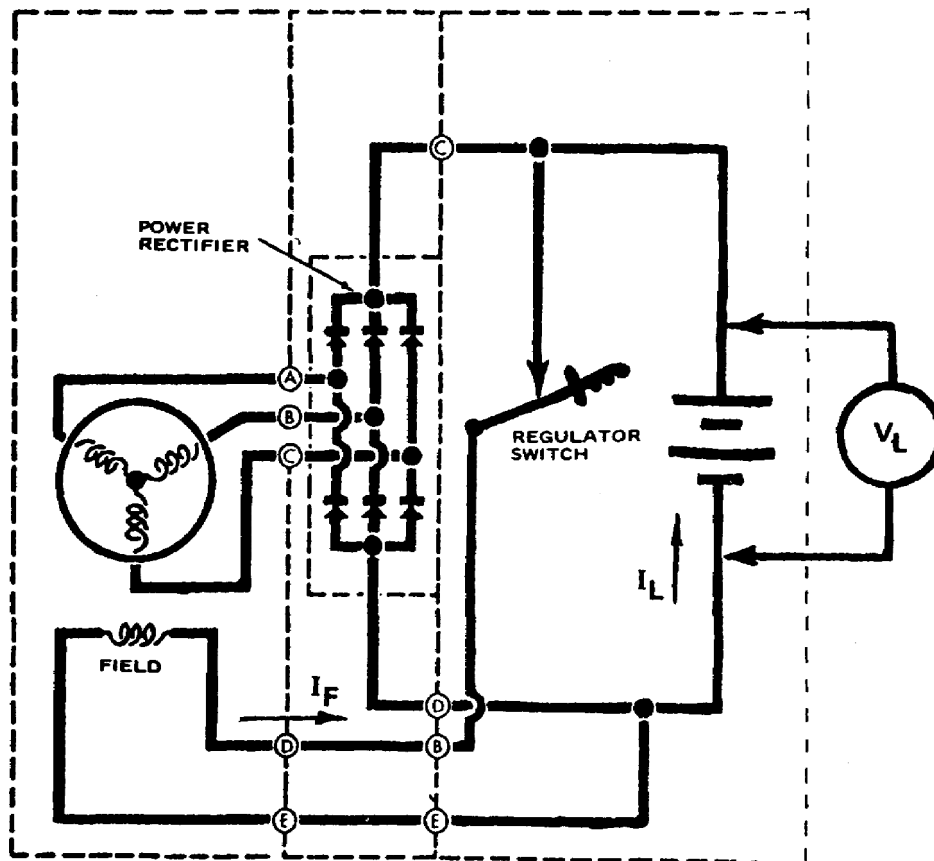


Figure 4. Regulator switch.

(2) When the voltage increases above normal enough current will flow through the relay to energize it. When it energizes, the field circuit is opened cutting off the current. The magnetic flux decreases lowering the output voltage.

(3) When the output voltage decreases, the current through the relay is reduced, thus applying less magnetic force to the spring-loaded contact. When the magnetic force of the relay coil is less than the force of the spring, the contact will once again close. Upon the closing of the relay contact, current once again flows through the field winding, which will cause the output voltage to increase.

(4) The opening and closing of the relay contacts are continuous; so, during normal operation, they vibrate. The rate of switching will vary according to the speed of the generator, thereby regulating the output voltage. The rate can be as low as 10 times per second and as high as 7,000 times per second.

d. There is one thing wrong with the circuit in figure 5 and that is, when the vehicle is stopped, the battery will be connected to the field winding continuously, thereby discharging the battery.

(1) Since a field winding can draw from 1 ampere to 10 amperes of current, depending on the size of the generator, it could run the battery down while the vehicle is sitting overnight.

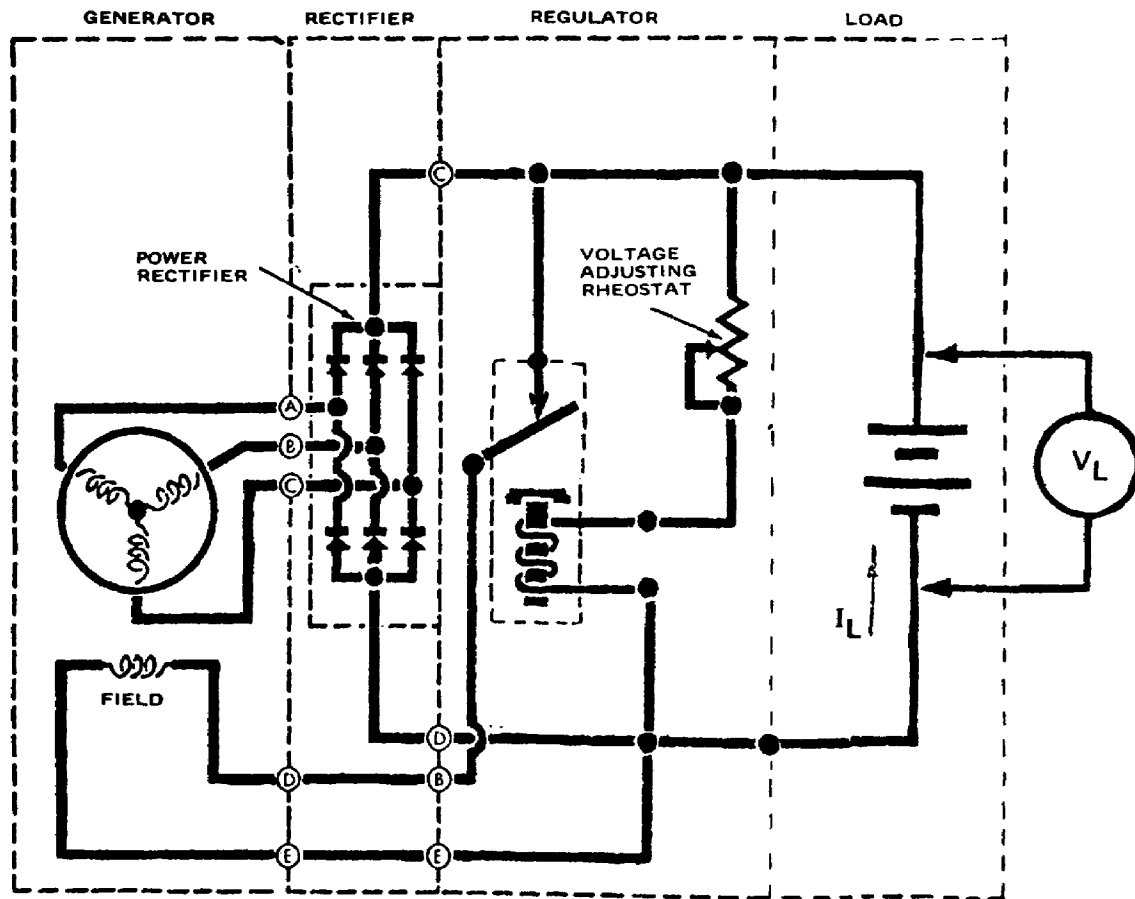


Figure 5. Automatic regulator.

(2) To keep the battery from discharging during the inoperational periods of the vehicle, another switch was required. So another relay, called a line switch, was incorporated as part of the regulator (foldout 1). The line switch relay is operated by the ignition switch, so when the ignition is turned OFF the battery is disconnected from the generator through the normally open switch contacts.

(3) Through the years the line switch relay has assumed many different names. The most common of these names are listed below.

- (a) Cutout relay.
- (b) Reverse current relay.
- (c) Load relay.
- (d) Circuit breaker.
- (e) Line switch relay.

e. Depending upon the application, the sensing relay for regulating the field current is of special design. Many regulators contained a current

regulator relay as well as a voltage regulator relay, such as shown in foldout 2. Please note that the line switch here is called a circuit breaker.

(1) Here the current regulator controls the amount of current going through the fields by adding resistance to the field windings. When the current output of the generator starts to go too high, the current regulator puts resistance into the field circuit. This resistance may be put into and taken out of the generator field circuit as many as 200 times a second. The result is that the average of this resistance will limit the current to a safe value and keep the generator from destroying itself.

(2) The third unit is the voltage regulator. It operates much like the current regulator, except that it senses voltage instead of current and limits the generator's voltage to a safe value. This protects the battery and other electrical components from a voltage high enough to damage them.

(3) The circuit breaker (also called cutout relay and reverse current relay) acts as an automatic switch that completes the circuit from the generator to the battery when the generator is charging, and opens the circuit when it is not. This last action prevents the battery from discharging through the generator when the generator is not charging.

3. CARBON PILE REGULATOR. This regulator consists primarily of a voltage regulator assembly, adjustable resistor assembly, load relay assembly, and capacitor assembly (fig 6 and 7).

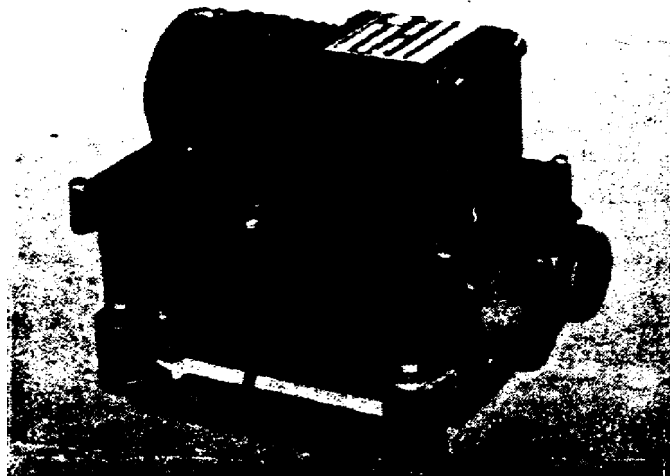


Figure 6. Carbon pile regulator.

a. The voltage regulator assembly contains a carbon pile whose electrical resistance varies inversely with the physical pressure on the ends of the pile. In other words, as pressures on the ends of the pile increase, resistance decreases; and as pressure is decreased, resistance increases. Since the field current for the generator flows through the carbon pile, the resistance of the pile will control the output voltage.

(1) A spring adjusted armature presses against one end of the carbon pile and tends to compress it to its minimum resistance. At the end of the carbon pile is a contact screw which is used to adjust the minimum resistance.

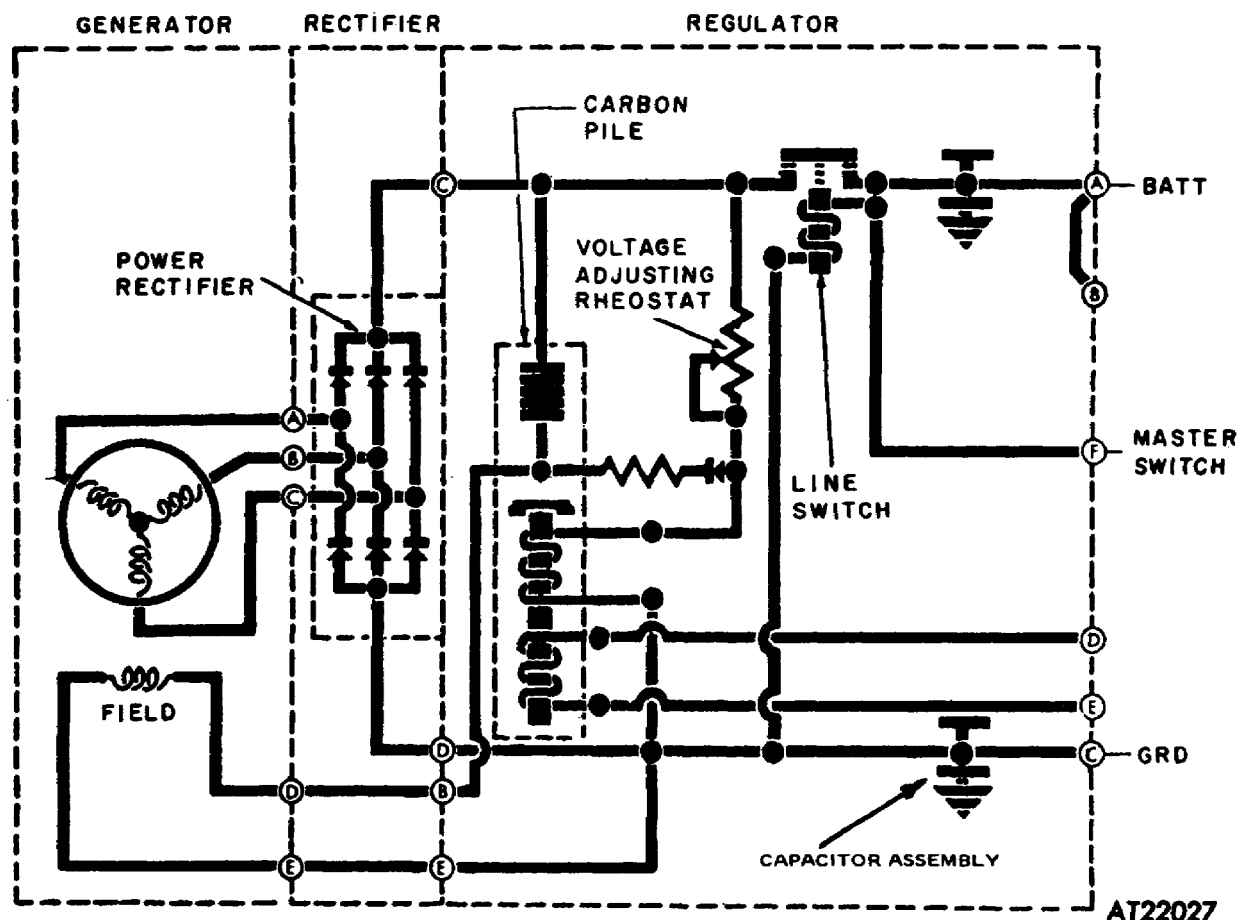


Figure 7. Simplified carbon pile regulator diagram.

(2) When current flows through the operating coil, the coil exerts a magnetic pull on the armature and decreases the pressure applied to the carbon pile. The magnetic pull exerted by the operating coil is proportional to the current flowing through it.

(a) Thus, as the output of the generator increases, a larger current will flow in the operating coil and the pressure exerted by the armature on the carbon pile decreases. The result is an increase in the carbon pile resistance, thereby reducing the generator field current and decreasing the output voltage.

(b) If the generator output decreases, the process is reversed. The pressure on the carbon pile increases because of the spring; in turn, this decreases the carbon pile resistance, thus increasing the generator field and the output voltage.

(c) When properly adjusted the voltage regulator will stabilize and maintain the proper voltage output.

(3) A paralleling coil in the voltage regulator is intended for use where two generators are being operated in parallel. It is normally inoperative.

b. The adjustable resistor is connected in series with the operating coil. It reduces the line voltage to a suitable value for application to the operating coil. The final adjustment of the voltage regulator operating voltage is made by means of this resistor.

c. The rectifier and fixed resistor stabilize the operation of the regulator by maintaining a minimum current flow through the field coil of the generator. The rectifier permits current to flow only in one direction. This means that a certain minimum current bypasses the carbon pile and flows during the entire operational range of the generator.

d. The coil of the load relay assembly is connected to the left engine ignition switch, and the contacts of the relay assembly are connected to the battery positive line. When the ignition switch is turned ON, battery current energizes the coil and the relay contacts close. This connects the generator (alternator) to the vehicle electrical system.

e. The capacitor assembly consists of two capacitors mounted in a bracket. The capacitors suppress radio interference. One capacitor is connected in the battery positive (+) line, while the other is connected in the battery negative (-) line.

4. SOLID-STATE REGULATOR. Today the solid-state voltage regulator is replacing the mechanical type of regulators. The reason for this is minimum mechanical parts, size, and maintenance. However, the solid-state regulator still contains the line switch or load relay.

a. A screwdriver adjustment is provided for setting the voltage output of a generator. Some will have two adjustments: one for current and one for voltage. Normally, these adjustments are accessible by removing a screwplug in the regulator cover. The screwplug incorporates an O-ring seal to keep out water and dirt.

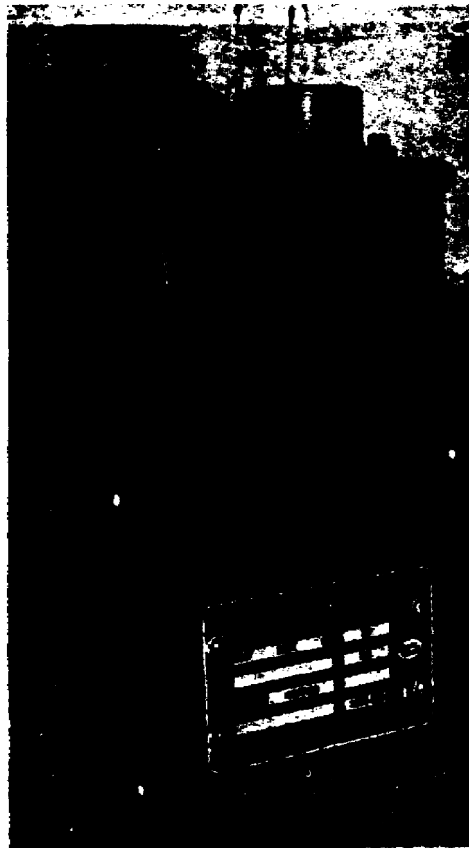
b. Tests that are performed on the solid-state regulator are simple. There is the line switch, or load relay test, and a test of voltage adjustment regulation. Normally, if these tests are not satisfactory, the regulator is turned in on a direct exchange basis or sent back to the manufacturer for repair. It will not be your responsibility to repair this item.

c. Typical of a solid-state regulator is the 100-ampere regulator shown in figure 8. Like the carbon pile regulator, the solid-state regulator contains a load relay which disconnects the charging system from the battery when the ignition switch is opened. A polarity protection diode is included in the relay circuit to prevent the relay from closing if reverse polarity is applied to the system.

d. This regulator also contains a transient suppression or snubber circuit which consists of a transistor and other components. Transient suppression capacitors and diodes are included for additional protection, and feed-through capacitors are used in the output leads for RFI reduction. A suppression network is also incorporated to reduce RFI caused by transistor switching action. These circuits are mounted on printed circuit panels. Voltage transients created by the relay coil or ignition system are bypassed by means of a diode shunted across the relay coil (fig A, foldout 3).

5. TEST AND ADJUSTMENT OF THE 100-AMPERE REGULATOR. Bench testing of the regulator requires a multimeter, such as the TS-352, and a 24-volt source, such as a battery. The test stand could be used by connecting to J1 and J2 (fig 9).

a. Load relay. Connect the negative lead of a 24-volt battery to male pin C of the regulator and the positive terminal to male pin F. The relay should close. While the battery is connected and the relay is closed,



Solid-State Regulator

Figure 8. Solid-state regulator.

connect an ohmmeter between male pin A and female pin C. Resistance should be zero ohms indicating that the relay contacts are closed. If relay does not close, either an open coil or open polarity diode is indicated and the relay assembly should be replaced. If this test indicates that the relay is okay, the polarity diode should be checked by connecting the positive battery lead to male pin C and the negative lead to male pin F. The relay should not close; if the relay closes, the polarity diode is shorted and the relay assembly should be replaced.

b. Socket assemblies. Sockets should be checked for signs of burning, arcing, or broken connectors. When replacing sockets, be sure that the leads are in their correct location and secure solder joints are made. Always use new gaskets when sockets are replaced.

c. Feed-through capacitor. Remove the shield plate which covers the capacitor assembly. Remove feed-through capacitor assembly by disconnecting leads and removing socket-head bolt which secures assembly in the case. Check for continuity between the stud at each end of the capacitor with an ohmmeter. If continuity is not obtained, replace assembly. Capacity may be checked by connecting a capacitor tester between the terminal stud and outer housing.

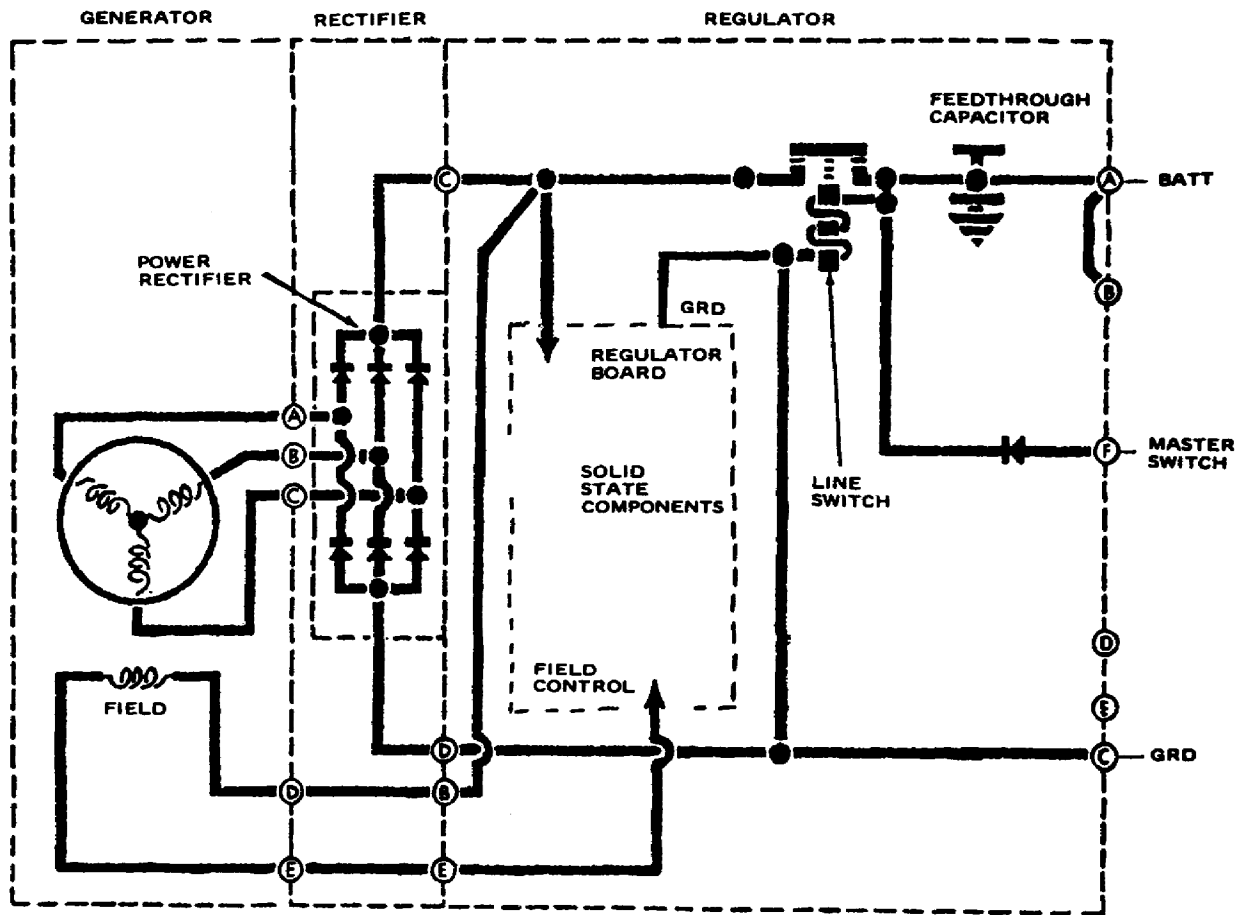


Figure 9. Simplified diagram.

(1) The cover and case should be inspected for cracks, stripped threads, or other damage and replacement made as needed. When cover is reinstalled, a new O-ring should be used to insure proper sealing. Lightly coat the O-ring with silicone grease prior to installation.

(2) If the preceding components check okay, it is fairly certain that only the regulator circuit board could be defective if the unit is non-operational.

d. Additional tests. To further test the regulator it must be connected to the test stand in an operational system. Procedures for this were covered in lesson 4, so you should know what precautions are required.

(1) In lesson 4, two functions of the regulator were tested. The first was a test of the line switch (load relay).

(2) The second was a regulation check, where the system was operated at 2,000 RPM and a 100-ampere load applied.

(a) During the regulation test the regulator was adjusted for an output of 28 volts DC.

(b) During the complete procedure after adjustment, the voltage should maintain stable between 27.5 and 28.5 volts no matter where the RPM or load is varied.

(3) You should now review the regulator testing procedures in lesson 4.

6. SUMMARY. In this lesson we studied the purpose, operation, and testing of regulators. The need for regulators was brought about by the instability of the generator output voltage.

a. To protect the battery and accessories is the big job of the regulator. It does it by controlling the generator.

b. The regulator does its controlling by varying the field current of the generator. This field current is turned ON and OFF at particular rates, thereby efficiently adjusting the output voltage.

c. The relay type, carbon pile, and action of the solid-state regulators were discussed. It was found that most every regulator has a line switch relay to remove the load from the battery.

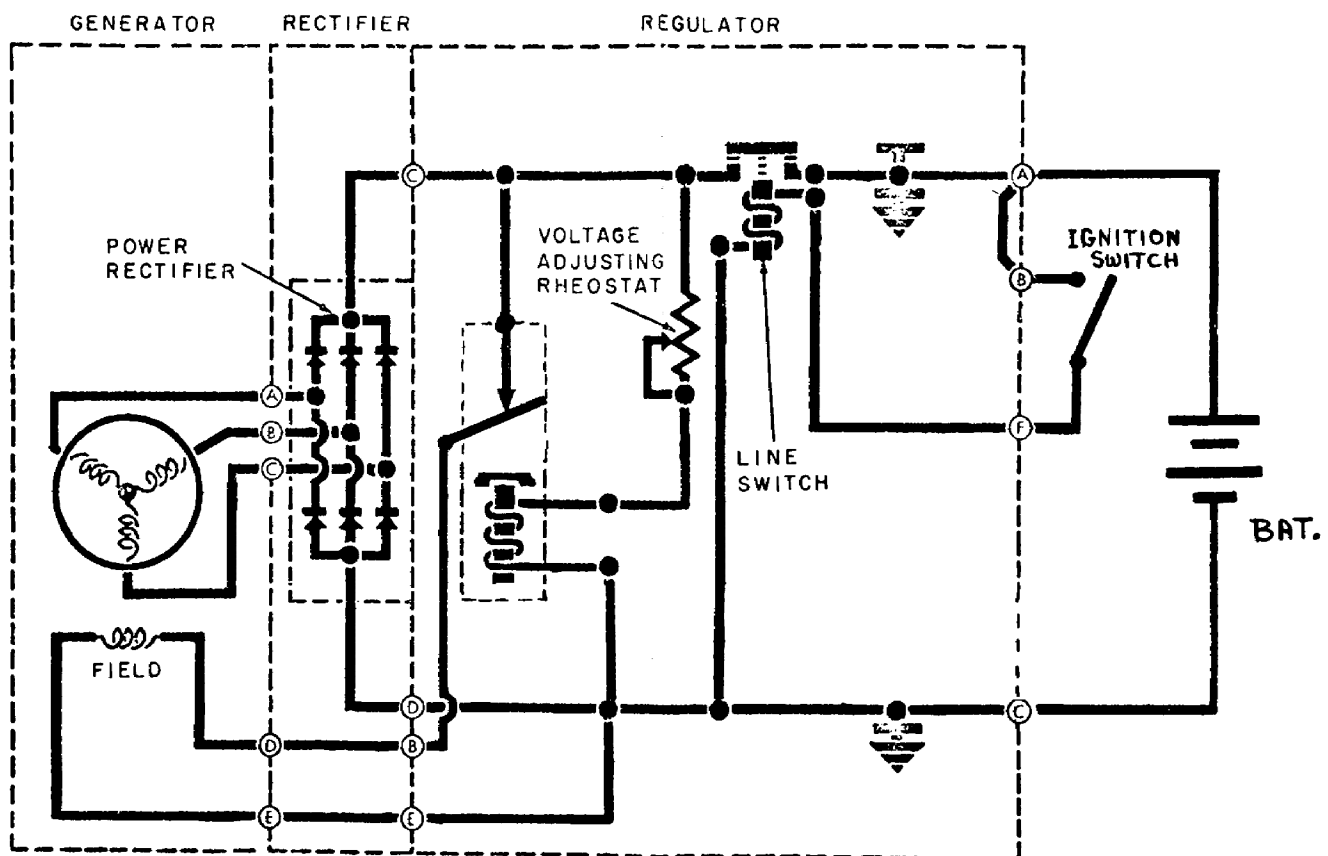
d. Tests are performed on the line switch relay and the function of regulation under load conditions.

EXERCISE

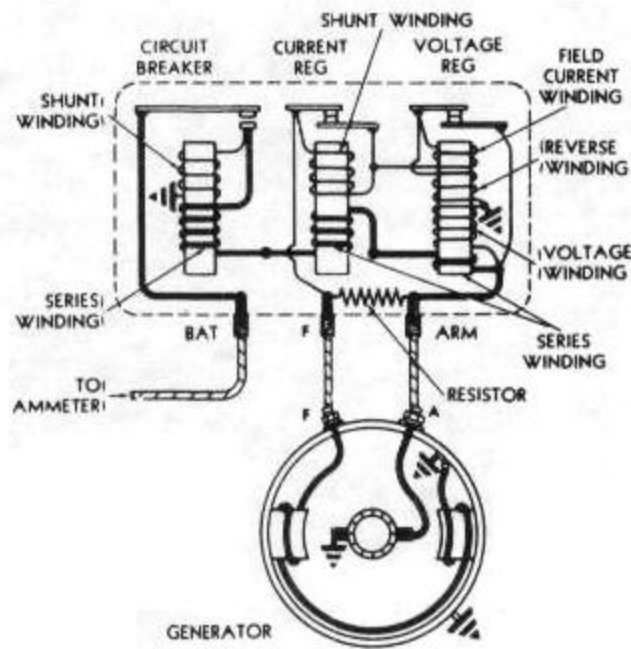
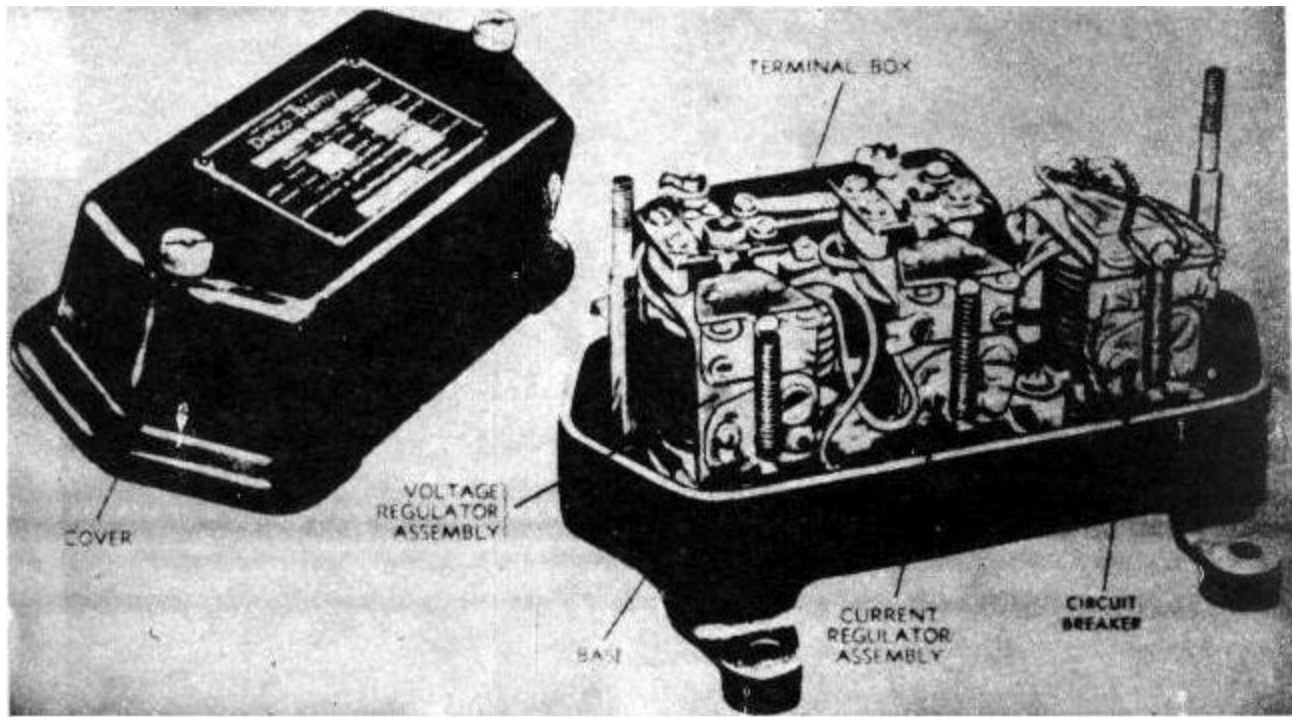
Note. - Refer to the exercise directions in lesson 1.

71. The purpose of a regulator is to limit the
 - a. generator revolutions.
 - b. battery current.
 - c. generator voltage.
72. The best way to control the generator voltage is with a variable
 - a. load resistance.
 - b. field resistance.
 - c. stator winding.
73. If you were controlling a generator manually, what should be done if the generator speed increases?
 - a. Increase the load resistance
 - b. Decrease the field current
 - c. Increase the field current
74. The principle used to regulate is by a
 - a. switching ON and OFF action.
 - b. variable regulated voltage.
 - c. variable regulated load.
75. The first type of regulator incorporated a voltage sensitive
 - a. relay.
 - b. carbon pile.
 - c. semiconductor.
76. The reverse current relay in a regulator disconnects the
 - a. stator winding.
 - b. battery circuit.
 - c. field winding.

77. Increasing the pressure on the carbon pile ends
- increases its resistance.
 - decreases its resistance.
 - decreases current flow.
78. The contact screw on the carbon pile sets the
- minimum resistance.
 - maximum resistance.
 - minimum current.
79. The purpose of the capacitor assembly is to
- stabilize the line voltage.
 - suppress radio interference.
 - protect the battery.
80. What is the purpose of a diode shunt across the relay coil?
- Protects the relay
 - Stabilizes the regulator
 - Bypasses voltage transients
81. The purpose of the reverse polarity diode is to
- bypass voltage transients.
 - prevent relay closing with wrong polarity.
 - protect relay from reverse polarity.
82. During bench testing a positive (+) battery lead is connected to C and the negative (-) lead to F male pins. What is being checked?
- Load relay (line switch)
 - Reverse polarity diode
 - Feed-through capacitor
83. After bench testing, an operational test is performed on the test stand. The regulator does not adjust for proper output voltage. What is the most probable trouble?
- Load relay (line switch)
 - Reverse diode
 - Regulator circuit board
84. In the test stand performance check, the regulator lead from the ignition switch is moved to J1 on the DC power supply. This is to check the
- load relay (line switch).
 - regulator circuit board.
 - reverse diode.
85. In the test stand performance check, the regulator is adjusted for a 28-volt output voltage. For an operational regulator, what is a normal indication as the load is increased? An increasing load current with
- an increasing output voltage.
 - a reduced output voltage.
 - a stable output voltage.



Foldout 1.



Foldout 2.

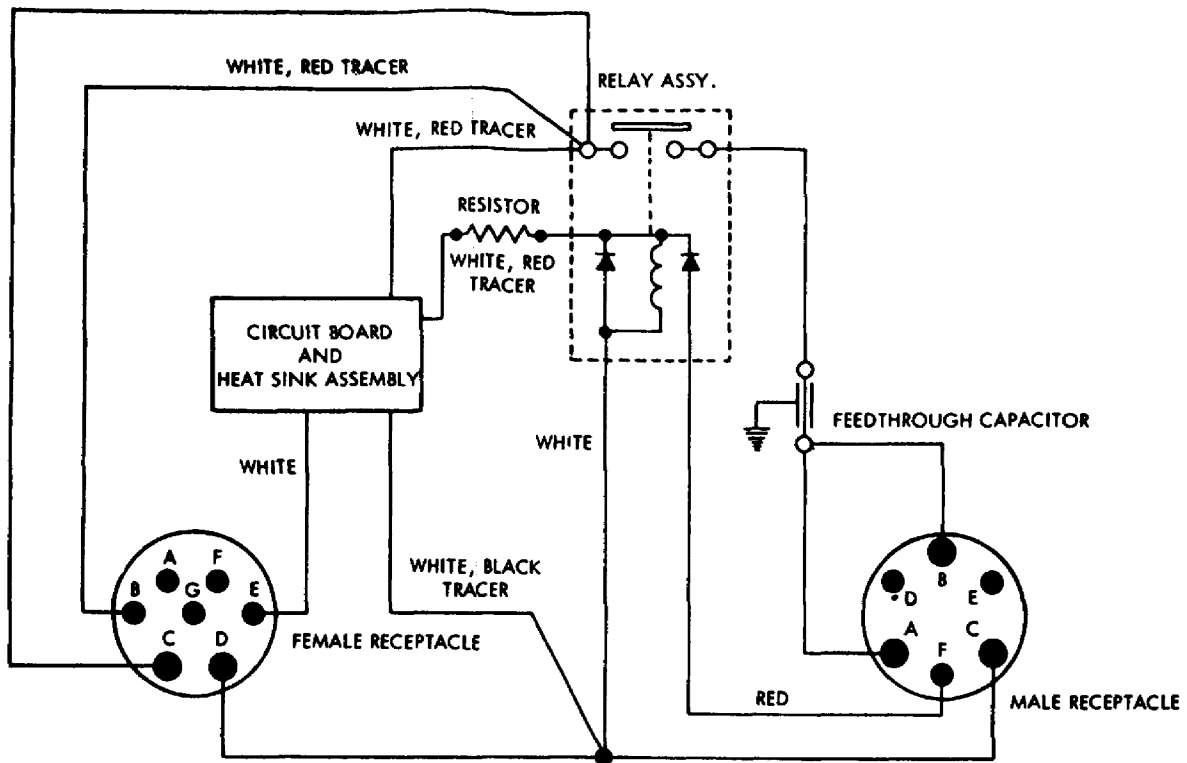
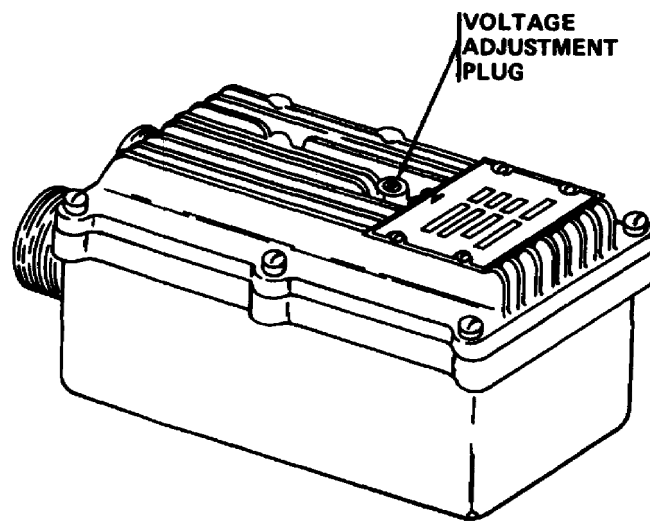


Figure A. Model 5027RC generator-regulator circuit diagram.



NOTE: ON REGULATORS WITHOUT ADJUSTMENT PLUGS, REMOVE REGULATOR COVER TO GAIN ACCESS TO ADJUSTING SCREW.

Figure B. Model 5027RC generator-regulator voltage adjustment screw.

Foldout 3.

C O R R E S P O N D E N C E C O U R S E
o f t h e
U S A R M Y O R D N A N C E
C E N T E R A N D S C H O O L



LESSON ASSIGNMENT

Ordnance Subcourse No 010..... Electrical System Component Repair

Lesson 6..... Testing and Overhaul of Prestolite Starter Motor

Credit Hours..... Three

Lesson Objective..... After studying this lesson you will be able to:

1. Describe the basic principles of starter motor operation.
2. State the most important considerations when performing the disassembly, assembly, cleaning, inspection, repair, and testing of the Prestolite starter.

Text..... Attached Memorandum

Materials Required..... Answer sheet and response list

Suggestions..... None

ATTACHED MEMORANDUM

SECTION I. STARTERS

1. STARTING MOTORS. Motors, like generators, are simply a means of changing energy from one form to another. In a generator we take the mechanical energy of the turning pulley and change it to electrical energy. A cranking motor does Just the opposite of the generator. Electrical energy sent to the motor is changed to mechanical energy to crank the engine. A practical motor must produce continuous rotary motion. In addition, it must develop a twisting or turning force called torque. In this lesson we shall see how the starter motor develops torque and how it is used to crank the engine.

2. REVIEW OF PRINCIPLES. The magnetic principle of attraction and repulsion, or unlike poles attract and like poles repel, is the principle applied in the development of the electric motor. Remember, that a wire carrying an electric current produces a magnetic field. When this wire is placed in the magnetic field of another magnet, mechanical motion is produced because the magnetic field around the wire is repulsed (pushed away) by the field around the other magnet.

a. To understand how mechanical motion is produced by magnetic repulsion, study the actions in foldout 1, in the back of this lesson. Notice the lines of force in the top picture. They are moving from the north pole to the south pole and are traveling in almost straight lines. In fact, the lines would be straight if the ends of the magnets were flat instead of curved. The magnetic lines of force moving between the north pole and south pole of any magnet always take the easiest path or route. The easiest path between the two poles is usually a straight line, because a straight line is also the shortest path.

b. In B of the foldout the lines of force around a current carrying conductor (wire) are illustrated. The + symbol on the end of the wire means the current is flowing away from you as you view the wire. With the current flowing in that direction, the lines of force in the magnetic field around the wire are moving counterclockwise (note the arrows on the lines of force). If the current is flowing toward you as you view the wire (notice the dot in the center of the wire in D of the foldout), the lines of force would be moving clockwise. In other words, the polarity would be reversed.

c. If a current carrying wire is placed in a magnetic field as in C of the foldout, notice what happens to the lines of force that are moving from the north pole to the south pole of the magnet. The lines of force traveling from north to south bend down in this case because they are pushed downward by the counterclockwise rotation of the lines of force around the current carrying wire. Because the lines of force from the north to south pole pieces of the magnet try to straighten out, they force the current carrying wire up (note the arrow). In D of the foldout, the current is moving in the opposite direction in the wire and the magnet's lines of force push down on this wire. Both C and D of the foldout are good examples of magnetic repulsion (like poles pushing away from each other).

d. In the starter motor, like the generator, increasing the strength of the pole shoes will increase the number of lines of force. Likewise, increasing the current flow through the wire will increase the strength of the magnetic field around the wire. When these magnetic forces oppose each other, as in views C and D of the foldout, they try to push each other away. The opposing forces can be very great if the wire is carrying enough current to make the magnetic field very strong.

e. Now, let's bend a wire to form a loop and place the loop in a magnetic field (fig 1). Nothing happens until we send current through the loop. If we send current flowing through the loop in the direction shown, the magnet's lines of force push up on the right side of the loop and down on the left side. This produces the torque to rotate the entire loop counterclockwise (to the left). Actually, the loop would probably move only 1/4 of a revolution (90°) because it would be out of the magnetic field of the magnet. The loop would then be straight up and down instead of straight across as shown.

f. To get continuous rotation we need a magnetic field large enough to contain the loop. We would also need commutator bars and brushes like we had in the generator.

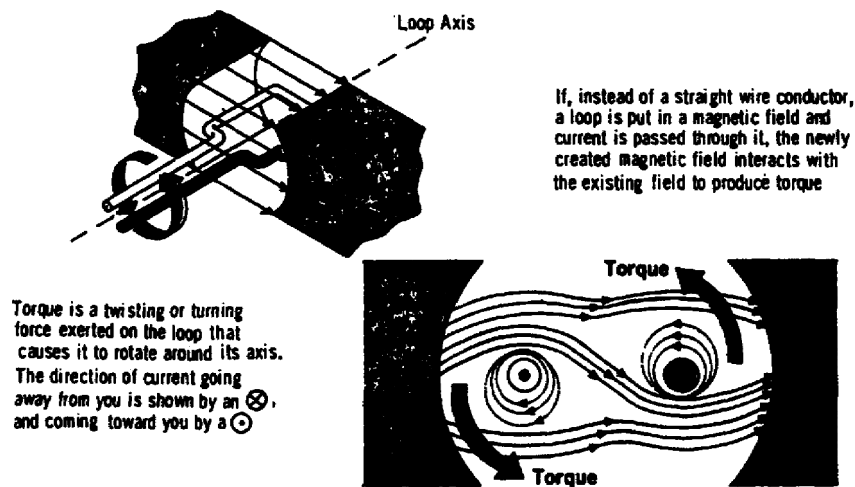


Figure 1. Loop in magnetic field.

g. In figure 2 we have added commutator bars and a larger field. In view A the left half of the loop is shown in black with an arrow to show the current is flowing from its commutator bar to the loop. The right side loop is pictured in white with an arrow showing the current flowing from it to its commutator bar. With battery current supplied through the brushes to the commutator bars, the loop would be forced to rotate clockwise. When the loop reaches and just passes the position shown in view B, look what happens. The commutator bar for the black half of the loop is now in contact with the positive (+) brush. The commutator bar connected to the white half of the loop is now in contact with the negative (-) brush. We have reversed polarity in the loop and it will continue to rotate clockwise. When it rotates another $1/2$ turn (180°), it will again reverse polarity and continue to rotate clockwise.

h. Of course a single loop would not produce enough torque to crank the engine. But, by using many loops, each with its own commutator bars, we can have a cranking motor that will produce all of the torque needed.

i. Most starter motors are series motors (fig 3). They are called series motors because the rotating loop and the windings around the magnetic poles are connected in one (series) path. The current flowing through the loop also flows through the windings. In an actual motor, the windings around the pole shoes are called field windings because they help produce the magnetic field. The purpose of the field winding is to produce a strong magnetic field so that the loop will receive a more powerful push. Note that the poles are curved. They are curved so the conductors of the loop can pass as close as possible to the poles as they move past. Since the magnetic field is strongest near the poles, the conductors in the loops are given a stronger push.

j. In the actual starter motor there are many rotating loops assembled into an armature. The armature consists of a shaft on which are mounted a laminated iron core and commutator. The loops, or windings, of the armature are mounted in the core and are insulated from one another and from the core. The commutator segments have riser bars, like the generator, to which the ends of the armature windings are connected by soldering.

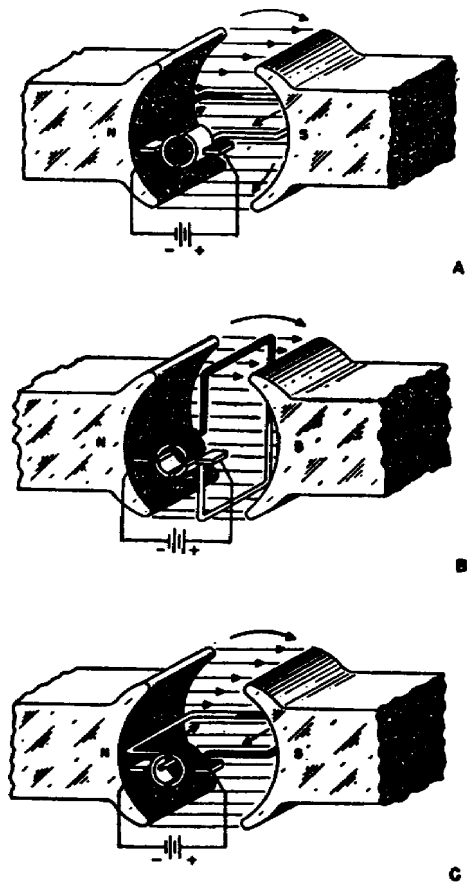


Figure 2. Armature loops.

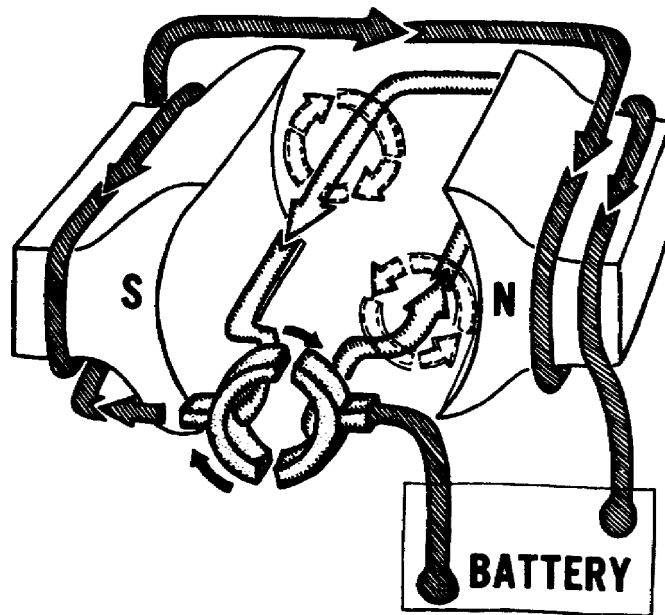


Figure 3. Series wound motor.

3. STARTER (CRANKING) MOTOR CONSTRUCTION. The vehicle cranking motor has only one job to do. That is to turn the crankshaft at a speed fast enough to start the engine. Since there are many different types and sizes of engines, there are many types and sizes of cranking motors. The common starter motor -used on military vehicles consists of the following five main assemblies: armature, field and frame, commutator end head, drive end housing, and drive mechanism. The field windings, frame, and armature are almost the same as in the generator which you have already studied, except that in the starter motor the windings are much heavier in order to carry a lot of current. The commutator end head houses the brush holders, brushes, and a bearing. The drive end houses the drive mechanism and usually the mounting flange to mount the starter to the engine.

4. STARTER DRIVES. The starter usually drives the engine through a pinion (small) gear mounted on the starter motor armature shaft. When the starter motor is running, the pinion gear engages (meshes) with a large gear mounted on the rim of the engine flywheel.

a. Two types of starter drive mechanisms are in common use. These are the Bendix drive and the over-running clutch drive.

b. The Bendix drive (fig 4) consists of a threaded sleeve, which is fastened to the armature shaft by means of a drive spring, and a drive pinion which is threaded on the sleeve. The pinion has a weight on one side to make it unbalanced. Think of the sleeve as a bolt and the pinion as a nut threaded to the bolt. A weight is attached to the nut. If we spin the bolt, the nut, because of the weight, tries to stand still. However, the spinning bolt would force the nut to move forward or backward on its threads, depending on which way the bolt was spinning.

(1) Now look at A of figure 4. The armature has started to turn and the pinion, which is not turning because of the weight on one side, is moving toward the flywheel ring gear. In view B the teeth on the pinion gear have meshed (engaged) with the teeth on the ring gear. The pinion has reached its stop and cannot move any further on the threaded sleeve. It is now locked to the sleeve and must turn with it. The now rotating pinion turns the flywheel gear, which in turn rotates the flywheel ring gear and engine crankshaft.

(2) As soon as the engine starts, its speed of rotation is faster than that of the pinion. The ring gear now drives the pinion because it is turning faster. The pinion then moves back on the threaded sleeve and disengages from the ring gear.

c. In the over-running clutch type of starter drive (fig 5) the pinion is shifted into engagement with the flywheel with a lever.

(1) The drive for the over-running clutch has internal (inside) splines which fit external splines on the starter armature shaft. The drive pinion is attached to a rotor which forms the inner half of the over-running clutch.

(2) Now look at the end view of the over-running clutch, which is really a one-way clutch. It can drive in one direction, but not the other. The outer shell is part of the splined sleeve, so it rotates when the starter armature rotates. The only connection between the shell and the rotor is the four spring-loaded rollers between them. Notice the rollers are in slots in the sleeve. They can move back and forth in the slots. The slots are tapered slightly. When the sleeve starts to rotate the rollers move in their tapered slots to a point where they become wedged (jammed) between the sleeve and the rotor. Then the whole clutch turns as a single unit. When the engine cranks, the rollers are forced to move the other way in their slots, because the pinion and rotor are now traveling faster than the over-running clutch sleeve.

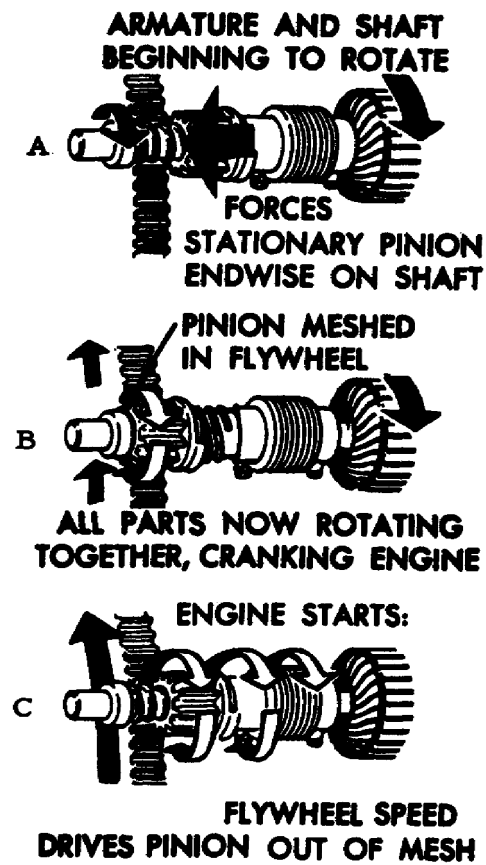


Figure 4. Bendix drive.

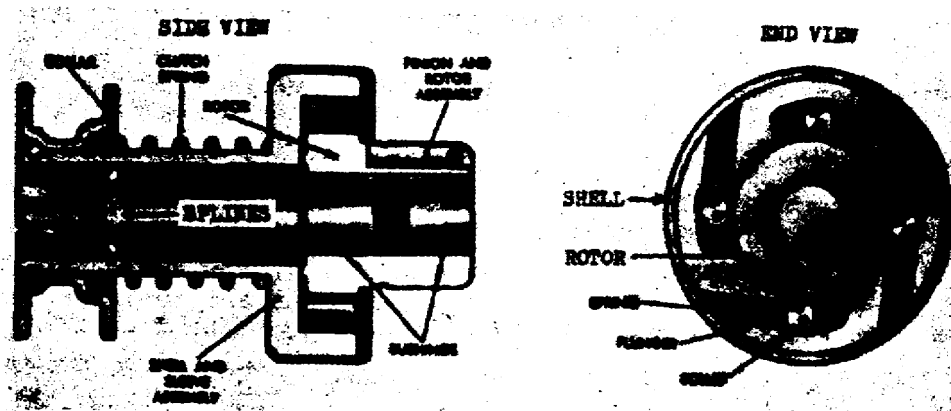


Figure 5. Over-running clutch.

(3) You can easily test the action of the clutch by gripping the sleeve with one hand and the pinion with the other. Try to turn the pinion in either direction. You will find you can turn it one way, but when you try to turn it the opposite way, it locks. In fact, if you can turn it both ways it is defective and must be replaced.

(4) A shift lever (also called a yoke lever) is used with the over-running clutch to shift the starter pinion into mesh with the flywheel gear. The lever may be operated manually through linkage or by an electromagnet.

d. When the over-running clutch type is used, a shift fork and linkage are used to shift the pinion into mesh with the flywheel gear. This shift fork and linkage are normally operated by a unit called a solenoid.

(1) A solenoid is an electromagnet with a moveable core or plunger. It is mounted on top of the starter motor. When the starter switch on the vehicle instrument panel is depressed (in some cases a key operated switch is used), the windings in the solenoid create an electric magnet.

(2) In view A of figure 6 the shift plunger is in its released position, being held there by the contact plunger spring. No current is flowing because the switch for the solenoid winding is open. The starter pinion is not engaged with the flywheel. In view B the operator has closed the switch to the solenoid windings and the solenoid coil is now an electromagnet. The electromagnet pulls the solenoid plunger to the left. This action shifts the pinion into mesh with the flywheel and then closes the starter switch. Now current flows through the starter motor causing the armature to rotate.

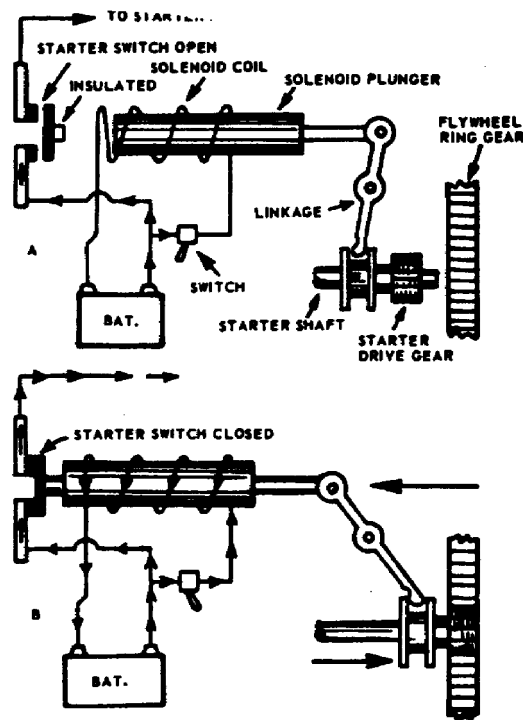
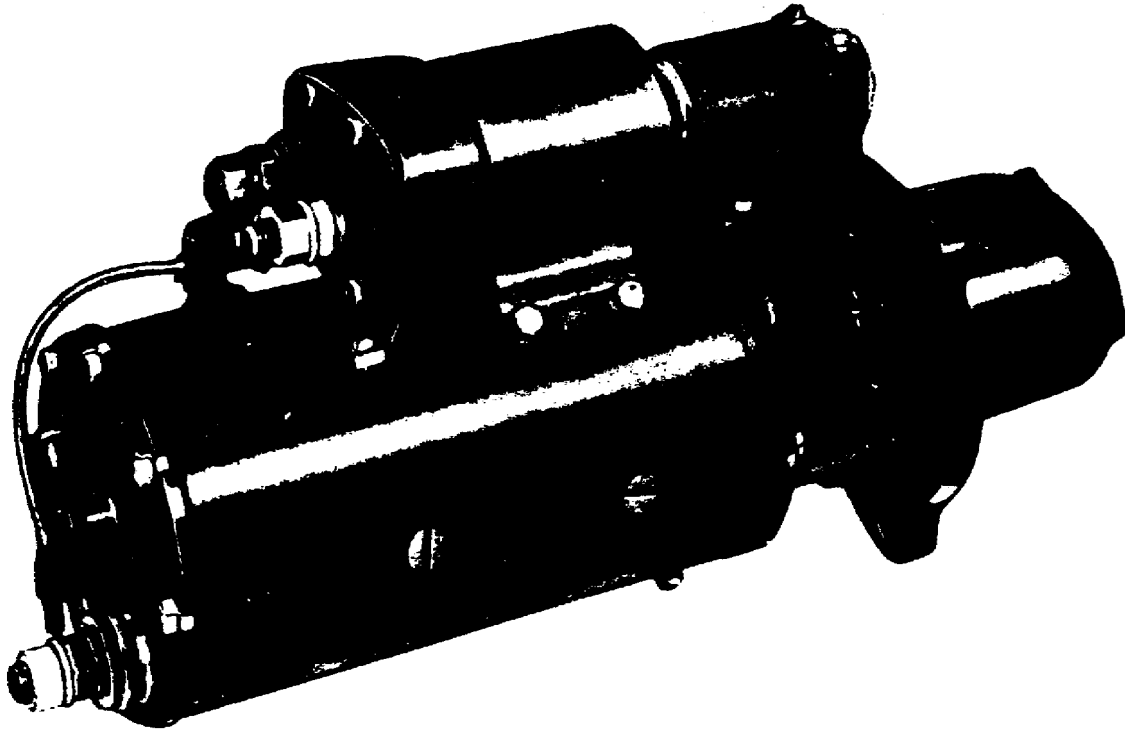


Figure 6. Shift plunger.

(3) When the switch for the solenoid winding is opened, the spring pushes the plunger back. This breaks the circuit to the starter and pulls the pinion back away from the flywheel.

SECTION II. PRESTOLITE STARTER

5. PRESTOLITE STARTER MOTOR. The Prestolite starter assembly is shown in figure 7. This electrical starter is a heavy-duty, 24-volt, insulated, waterproof, fungus and corrosion resistant, solenoid-operated, enclosed shift lever-type engine starter.



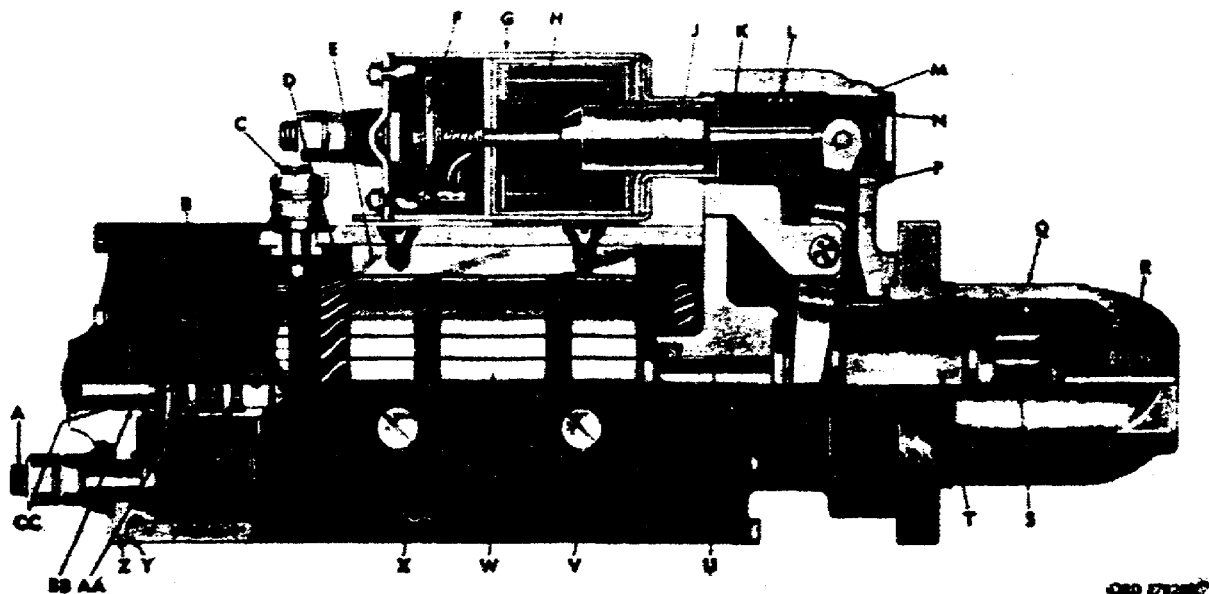
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Figure 7. Prestolite starter.

a. Components. The starter components are shown in figure 8. The principal components are the frame assembly (X), armature (W), commutator end head assembly (Y), brush holder (CC), brushes (B), drive assembly (T), pinion housing (Q), solenoid relay assembly (G), intermediate housing (M), shift lever yoke (P), and solenoid core (J).

(1) Frame assembly. The frame assembly (X) consists of the field coils (D), pole shoes (E), and field coil terminal stud (C), all supported by a heavy steel frame. The field coils are secured to the frame by the pole shoes and eight pole shoe screws (V). The coils are connected to the field coil terminal stud which is insulated from the frame. The frame has screw thread openings for mounting the solenoid relay.

(2) Armature. The armature (W) is made of copper and laminated steel assembled on a steel shaft. It is supported by three sleeve bearings (R, U, and BB). The armature has straight splines on the drive end of the shaft which engage splines on the drive assembly (T). A commutator, located at the brush end of the armature, is the electrical point of contact of the armature.



A	Brush holder terminal stud	K	Rubber boot	U	Sleeve bearing
B	Brush	L	Core spring	V	Pole shoe screw
C	Field coil terminal stud	M	Intermediate housing yoke cover	W	Armature
D	Field coils	N	Housing inspection plug	X	Frame assembly
E	Pole shoe	P	Shift lever yoke	Y	Commutator end head assembly
F	Contact assembly	Q	Pinion housing	AA	Brush springs
G	Solenoid relay assembly	R	Sleeve bearing	BB	Sleeve bearing
H	Solenoid relay coil	S	Drive pinion	CC	Brush holder assembly
J	Solenoid core	T	Drive assembly		

Figure 8. Starter assembly.

(3) Commutator end head assembly. The commutator end head assembly (Z) serves as an end closure for the frame and a bearing support for the armature.

(4) Brushes and brush holder assembly. The eight brushes (B), which function as the electrical contact to the commutator, are supported by four brush holders in the holder plate. They are held in contact with the commutator by eight helical torsion brush springs (AA). Two of the brush holders are connected to the brush holder terminal stud (A). This extends through the commutator end head. The remaining brush holders are connected to a field coil. The brush holder assembly is attached to the frame assembly with three screws.

(5) Pinion housing. The pinion housing (Q) serves as a bearing support for the drive end of the armature shaft. It is also a housing for the drive pinion (S). The starter is mounted to the engine with this housing. Three holes are provided for attachment to the engine.

(6) Intermediate housing. The intermediate housing (M) consists of two parts bolted together. The lower part serves as the armature center bearing support and end plate for the starter motor. The upper part houses the drive assembly (T) and shift lever yoke (P).

(7) Drive assembly. The drive assembly (T) is an over-running clutch-type drive consisting primarily of a shell, ratchet, spring sleeve, and drive pinion. The shell has internal splines which mesh with those of the armature shaft and external flanges which serve as contact surfaces for the shift lever.

(a) It also serves as a housing and outer contact surface for the ratchet. The sleeve supports the drive pinion and ratchet. The spring-loaded drive pinion has 12 external teeth and internal helical splines, which match with the splines on the sleeve.

(b) The ratchets engage the sleeve in a locked position when the starter is driving the flywheel. When the drive assembly reaches overrunning speed, the ratchets disengage and allow the drive assembly to run free until disengaged by the solenoid relay.

(8) Solenoid relay assembly. The solenoid relay assembly (G) consists of a case which encloses the solenoid relay coil (H), contact assembly (F), and terminal plate assembly.

(9) Solenoid core and shift lever yoke. A spring-loaded cylindrical solenoid core (J) is in the bore of the solenoid relay. It provides the shifting action when the solenoid is actuated.

(a) The spring returns the core to the disengaged position when the solenoid is deenergized.

(b) The shift lever yoke (P) is connected between the solenoid core and the drive clutch assembly, where it pivots at its center.

(c) A rubber boot (K) covers the core spring (L) and seals the end of the solenoid relay.

b. Operation. The solenoid relay makes possible the control of the starter from an outside source. When the switch circuit to the solenoid is closed, the coil energizes producing a magnetic field. The magnetic field applies a force to the core and causes it to move.

(1) As the core moves it exerts a pull on the shift lever yoke, which shifts the drive clutch pinion into mesh with the ring gear on the engine flywheel.

(2) Once the pinion meshes with the flywheel, the end of the core presses against the shaft of the solenoid relay contact assembly. When the contact assembly closes, the battery is connected to the starter motor.

(3) With current flowing in the starter, magnetic fields are formed about the field coils and armature. The current through the armature causes an interaction of the magnetic fields and it begins to turn or rotate.

(4) The armature torque is transferred to the engine through the drive assembly. When the drive ratchets lock the inner race on the sleeve to the outer race in the shell, the pinion rotates and torque is transmitted as the armature starts rotating. When the flywheel exceeds the speed of the armature, the ratchet slips between the sleeve and shell, thus protecting the starter.

(5) When the outside control circuit to the solenoid relay is broken, the solenoid deenergizes. The spring pressure then returns the core to its original position. This removes the contact disk and stops the current flow to the starter. At the same time the shift lever yoke pulls the drive assembly back to its original position and disengages the pinion from the engine flywheel ring gear.

SECTION III. MAINTENANCE

6. OVERHAUL OF PRESTOLITE STARTER. Overhaul consists of disassembly, cleaning, inspection, repair, reassembly, and testing. Before beginning disassembly operations, the exterior of the starter should be thoroughly washed with drycleaning solvent or mineral spirits paint thinner and then dried with compressed air. During the disassembly all preformed packing, gaskets, and oil seals are discarded. They are replaced with new parts during reassembly.

a. As in most operations, there is a sequence of disassembly to be followed. With the Prestolite starter, the first item to be removed is the pinion housing assembly.

(1) The position of the pinion housing with respect to the intermediate housing should be noted, so that they may be reassembled as they came apart. Therefore, it is a normal procedure to scribe a mark on the pinion housing and the intermediate housing to locate the relative position at assembly.

(2) Remove the six socket-head capscrews (B) (fig 9). This allows the pinion housing to be removed from the intermediate housing with the attached gaskets. The thrust washer (E) is loose so it should be removed from the armature shaft.

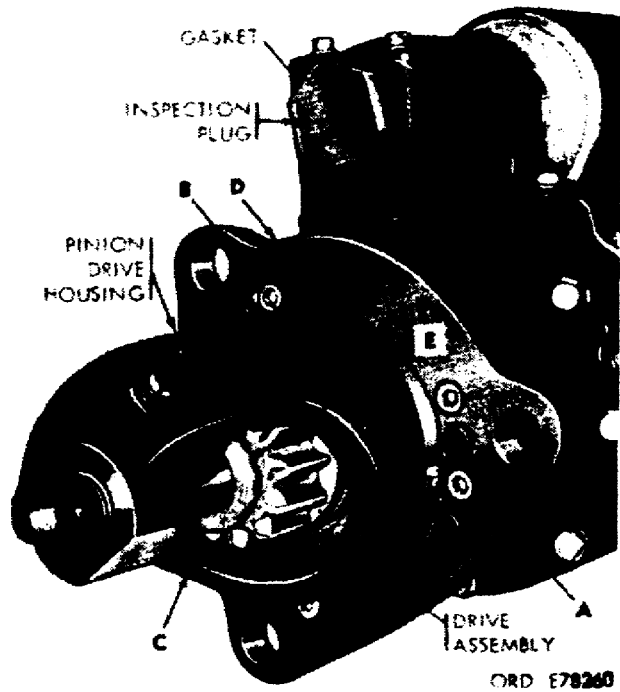


Figure 9. Pinion housing.

b. The drive assembly is now exposed. It would slide from the armature shaft if it weren't for the shift lever yoke (P) (fig 8). The yoke lever must be disconnected from the solenoid core. To do this, the inspection plug is removed to expose the solenoid shaft (N) for removal of the solenoid assembly.

(1) There is a self-locking nut on the solenoid shaft. It is removed with a 1/2-inch socket, hollow shaft driver, and a 5/32-inch Allen wrench.

(2) Slide the socket over the nut and the hollow shaft into the socket; then insert the Allen wrench into the solenoid shaft (fig 10). To remove the nut, the socket is turned with an open end wrench while the Allen wrench is held stationary.

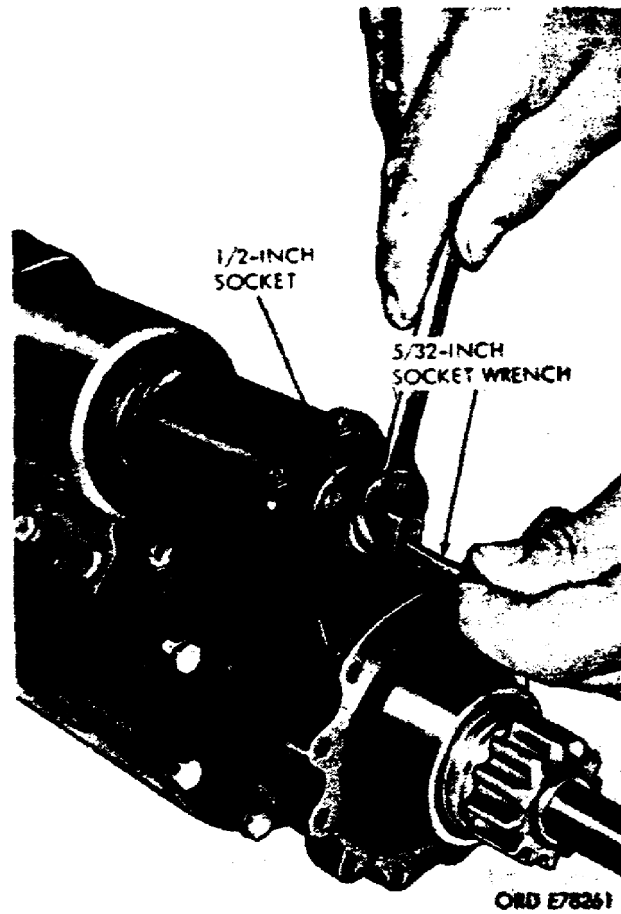


Figure 10. Removing or installing self-locking nut from solenoid relay shaft.

(3) To remove the solenoid relay assembly the cable, straps, and mounting bolts are disassembled (fig 11).

c. The shift lever yoke, controlling the drive assembly, is held in place by the yoke cover. The fillister-head screws (fig 12) are now removed to free the yoke cover from the intermediate housing.

(1) By lifting the yoke cover slightly, the yoke pin holding the shift lever yoke is exposed. Using a suitable drift punch, tap the yoke pin from the yoke cover (fig 13) and free the cover from the housing.

(2) The drive assembly and shift lever yoke may be removed from the intermediate housing and armature shaft by pulling on the drive assembly (fig 14).

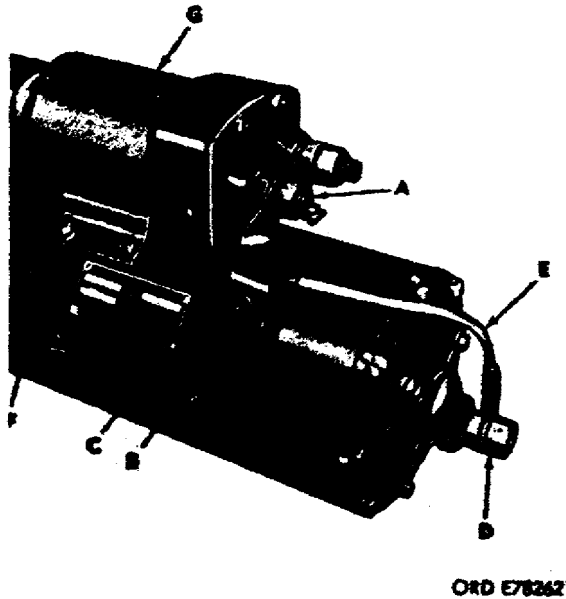


Figure 11. Removing or installing solenoid relay assembly.

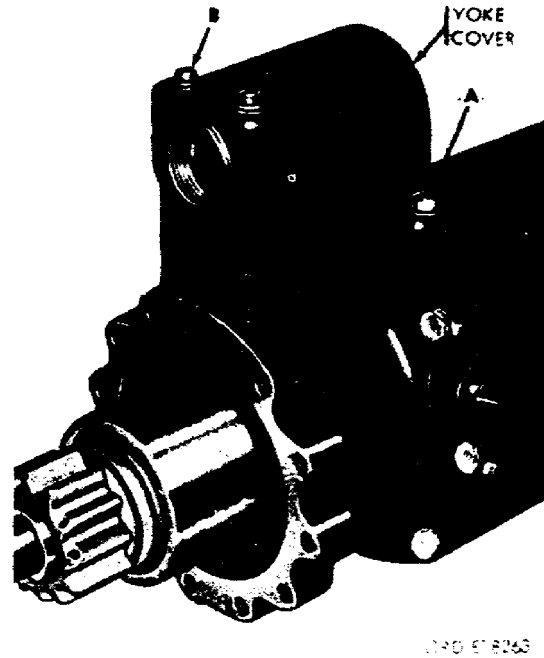


Figure 12. Removing or installing yoke cover attaching parts.

d. In order to remove the intermediate housing, the metal tabs locking the hex-head capscrews must be bent out. Remove the hex-head capscrews and intermediate housing by tapping the housing gently with a soft mallet or a piece of wood to free it from the frame (fig 15).

e. With the intermediate housing gone, the armature and the thrust washers at each end may be taken from the frame (fig 16).

f. Before removing the commutator end head assembly, scribe a mark on the end head to locate the relative position (fig 17).

(1) Next free the terminal stud of the hex-nut and associated washers.

(2) Bend the metal locking taps outward, remove the hex-head capscrews, and then the commutator end head assembly.

g. To remove the brush holder assembly, take off the bushing and insulating washer from the terminal stud; then remove the insulation around the brush holder. Remove the roundhead screws and self-tapping screws securing the brush leads and holder. Take out the brush holder assembly (fig 18).

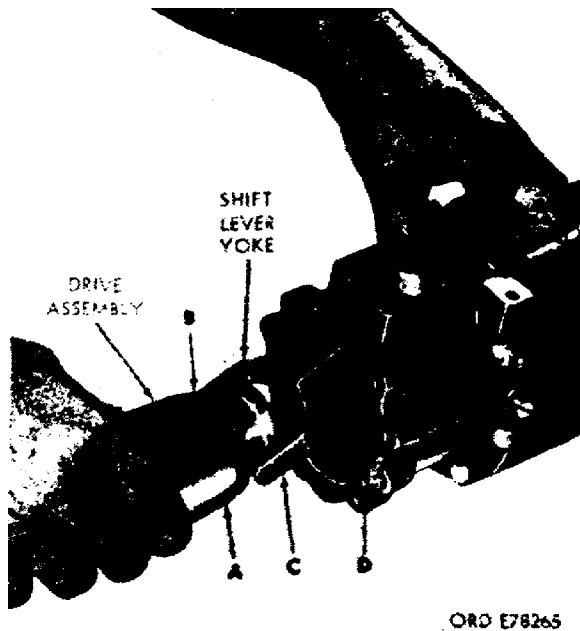


Figure 13. Drift punching.

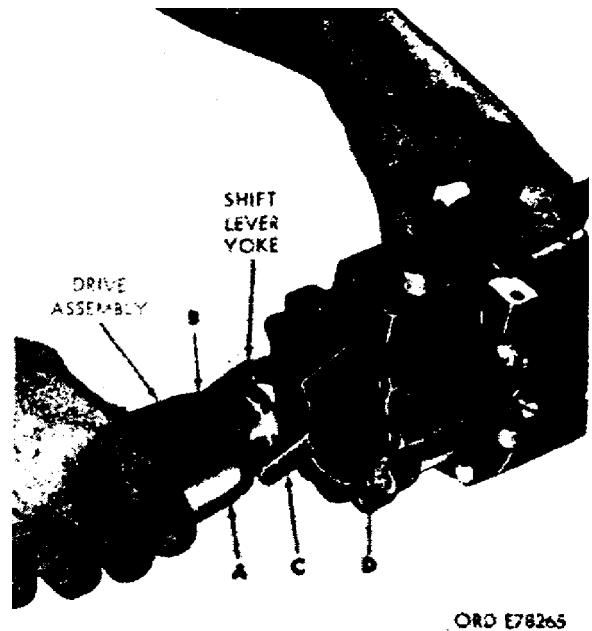


Figure 14. Drive assembly.

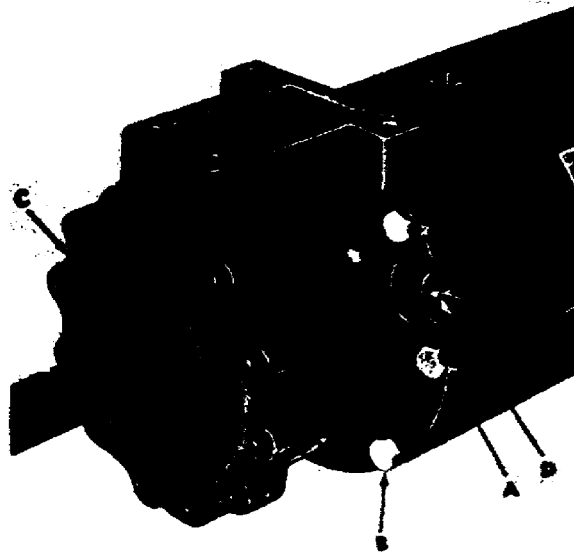
h. The starter has now been disassembled into its subassemblies. In overhauling, the subassemblies are broken down into bare parts. All rubber parts and oil seals are discarded and replaced with new ones. All bolts, screws, nuts, and plugs are inspected for worn or damaged threads.

7. CLEANING. Special instructions for electrical parts are detailed below. Clean all other parts in drycleaning solvent or mineral spirits paint thinner and dry with compressed air.

a. The field coils and frame are cleaned with a cloth dampened with drycleaning solvent. Be careful not to damage the insulation and fungus coating. Dry with compressed air.

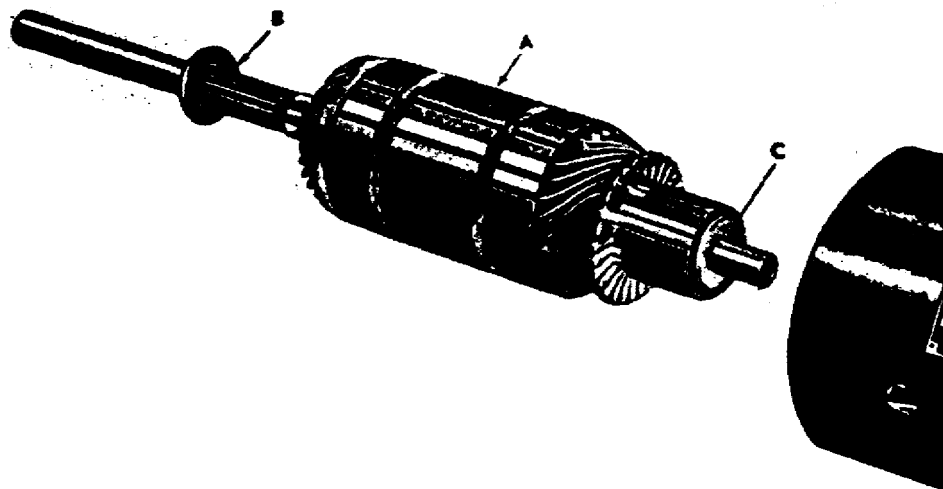
b. The armature is first blown with compressed air to remove loose particles and then wiped with a cloth dampened with drycleaning solvent. The commutator is cleaned lightly with No 00 sandpaper. The traces of dust are removed with low-pressure compressed air.

c. The brushes are cleaned with a dry cloth only. Do not permit drycleaning solvent to come in contact with the brushes.



ORD E78266

Figure 15. Intermediate housing.



ORD E78267

Figure 16. Armature.

d. The brush holder and springs are cleaned with a brush and drycleaning solvent. Clean the insulation and plate with a clean cloth dampened with drycleaning solvent. Dry all parts with compressed air.

e. The solenoid relay assembly parts are cleaned with a cloth dampened with drycleaning solvent and then dried with compressed air.

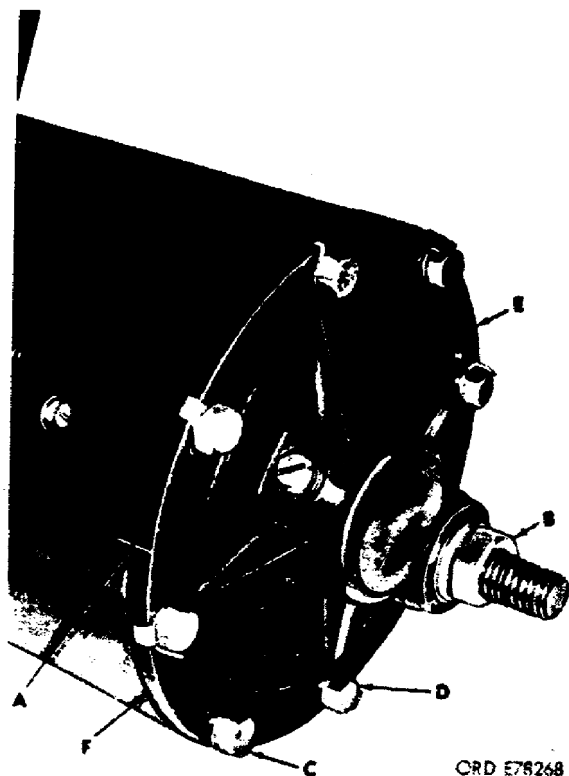


Figure 17. Commutator end head assembly.

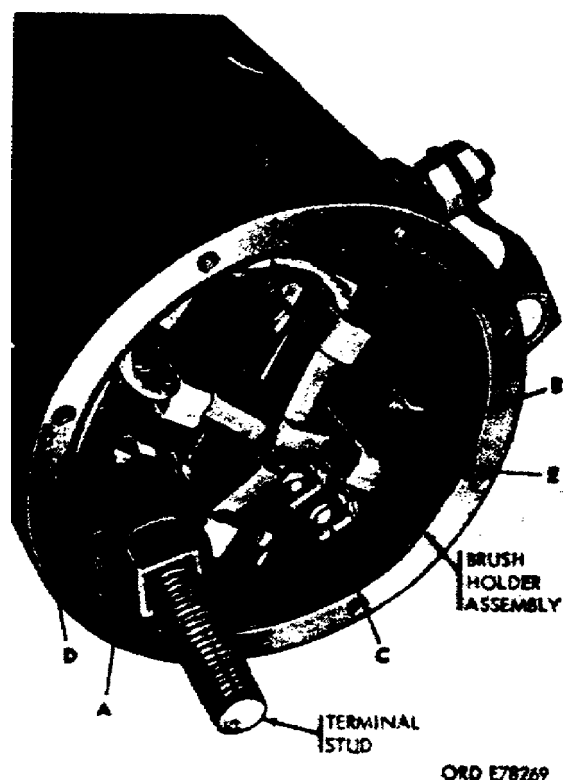


Figure 18. Brush holder assembly.

8. INSPECTION. Inspection consists of checking all components, parts, and assemblies for damage. All machined surfaces, splines, and gear teeth are checked for scratches, nicks, burs, and badly worn areas. Check all assemblies and parts for conformity to repair standards as shown in foldout 2.

a. Inspect threads in tapped holes in the assembly housings and frames for damage. If threads are stripped or damaged beyond repair, replace the item.

b. Inspect all bronze bearings for discoloration, rough spots, score marks, scratches, nicks, and wear. Bearings must not be loose in housings. The oil wicks are checked for tears, fraying, and wear.

c. Inspect all thrust washers for cracked or deformed conditions and proper thicknesses. If they do not conform to repair standards or are defective, replace them.

d. Electrical components are checked for cracked or broken conditions. Insulation breakdown, shorts, and grounds are checked with an ohmmeter.

(1) Inspect relay contact surfaces for severe burning or pitting. Minor burning and pitting is permissible. Do not use a file to clean surfaces. Relay should be replaced if severe burning or pitting has occurred.

(2) Inspect electrical terminal studs for burning or pitting and damaged threads. If studs are defective, replace the necessary assembly or component.

(3) Check brushes and springs for cracks, excessive wear, and conformance to repair standards. Replace springs as necessary. If any of the brushes are defective, replace entire set.

e. The armature is checked for conformity to repair standards. A growler is used to check the armature for grounds and shorts.

(1) Figure 19 shows the test probes of the growler when checking for armature grounds. The probes are connected to a lamp and high voltage source. By touching one of the test leads to the armature core and the other to the commutator bar riser, the continuity is checked. Test all commutator bar risers in this manner. If the light glows at any time, the armature is grounded.

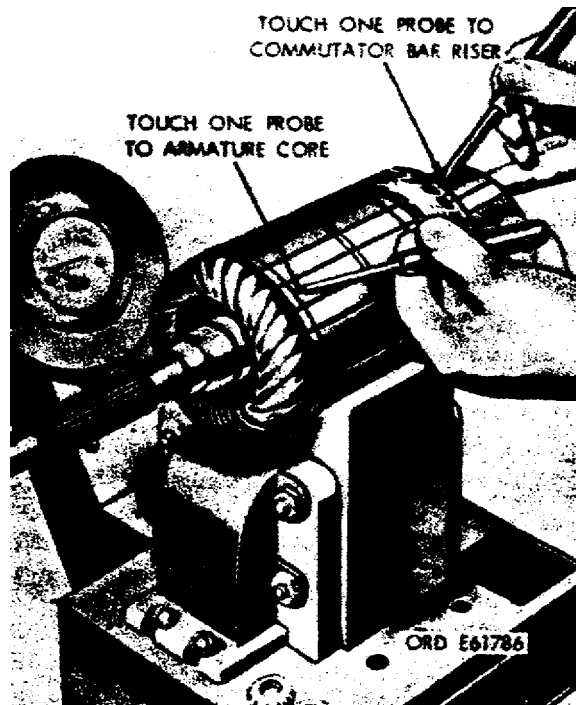


Figure 19. Armature ground checks.

(2) Figure 20 shows the growler being used to check the armature for shorts. It is done by holding a strip of steel, such as a hacksaw blade, about 1/32 inch away from the armature. While holding the steel strip in position, the armature is rotated slowly. A short circuit will pull the steel strip tightly against the armature core and cause it to vibrate.

(3) The commutator surface is inspected for an even, highly burnished, dark-copper color. If the contact surface is rough, pitted, scored, burned, or coated with hard carbon or oil, it must be resurfaced.

(4) Figure 21 shows the checking of the armature concentricity. This is done by using a lathe or a set of V-blocks and a dial indicator. As the armature is turned, the dial indicator will show deviation of the armature concentricity or the amount of roundness. If the indicated value does not conform to the repair standards, the commutator must be resurfaced.

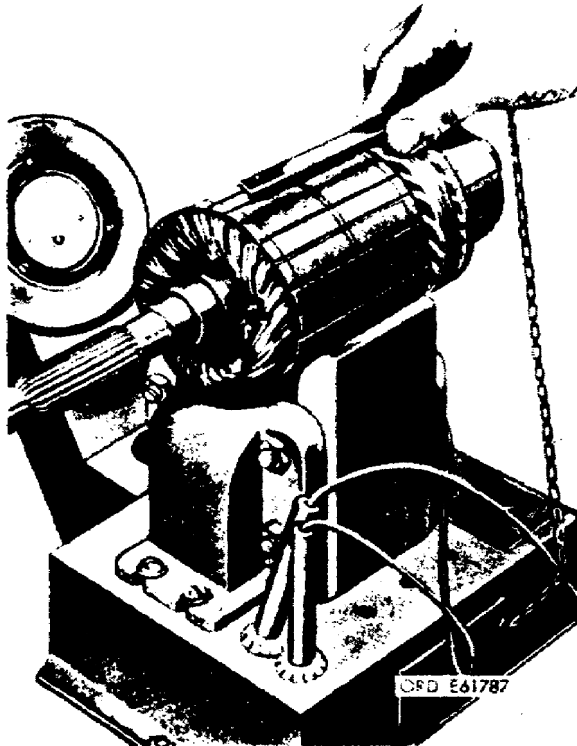


Figure 20. Short circuit check.

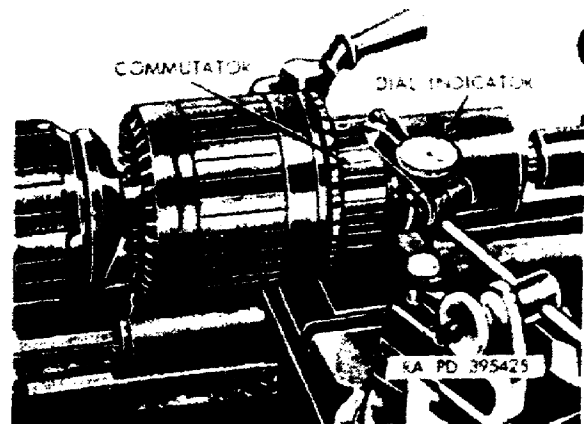


Figure 21. Concentricity check.

(5) Inspect the mica between the commutator segments. If it is not 0.025 to 0.032 inch below the segment surface, it must be undercut to the correct depth.

9. REPAIR. Repair consists of returning components to the minimum repair standards and to the best possible rebuilt condition.

a. Minor scratches, burs, and dents on machined surfaces, where there is minimum or no friction, such as the frame and housing, may be repaired by using a fine mill file.

b. Minor rough spots, score marks, and nicks on surfaces, where friction occurs continuously, should be repaired using a fine stone or crocus cloth dipped in drycleaning solvent. Such surfaces are the inside bores of bronze bearings, splines, pinion teeth, clutch contact surfaces, and the surfaces on the yoke pin.

c. The repair of the armature requires three operations: resurfacing the commutator, undercutting the mica, and polishing the commutator.

(1) Figure 22 shows the sharpening dimensions of the resurfacing tool to be used in a lathe. After grinding, hone the tool with a fine hard stone to insure a smooth cut during the lathe turning operation.

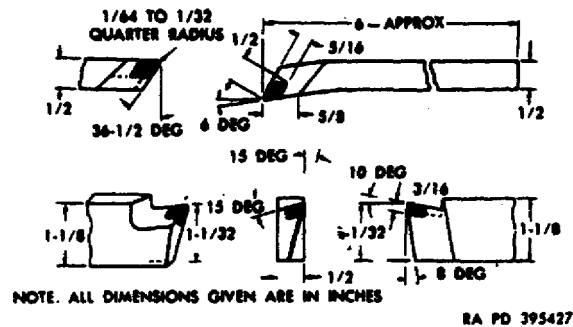


Figure 22. Cutting tool.

(a) Figure 23 shows the position of the cutting tool with respect to the commutator. With the lathe rotating the armature at 800 RPM, make very light cuts on the commutator. No more than 0.005 inch should be removed during any one cut and the final cut should not be more than 0.002 inch.

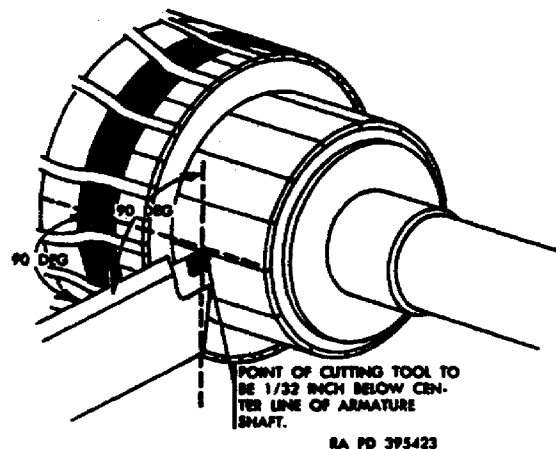


Figure 23. Positioning of tool.

(b) Once the commutator has been resurfaced, its dimensions are checked against the limits specified in the repair standards. Providing the dimensions are within limits of the repair standards, the mica is now undercut and the commutator refinished.

(c) After resurfacing the commutator the mica is undercut to a depth of 0.025 to 0.032 inch below the surface of the segment. Figure 24 shows a power driven mica cutting tool.

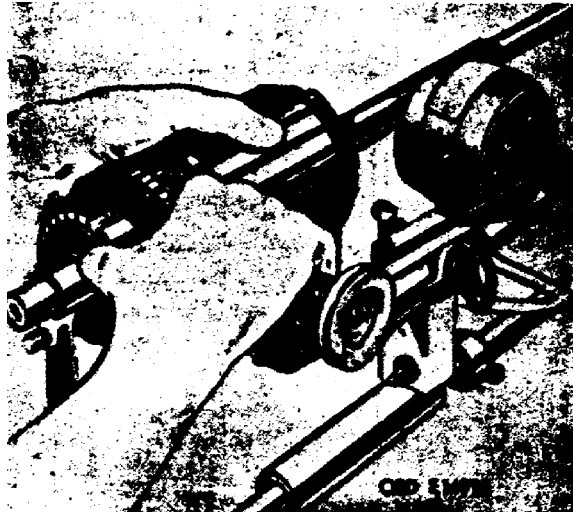


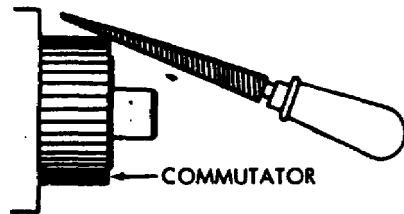
Figure 24. Power driven undercutting of mica.

1. Special care should be exercised when undercutting the mica. You do not want to widen the commutator slots by removing metal from the segments, nor do you want to leave a thin edge of mica next to the segment.

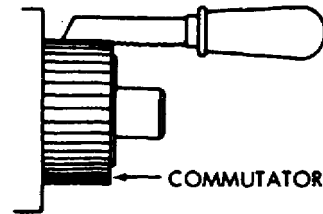
2. Figure 25 shows how the mica may be undercut by hand. First start a groove in the mica with a three-cornered file; then undercut with a piece of hacksaw blade. Also shown are illustrations of good and bad mica undercutting.

(2) With the mica now undercut, remove all copper and mica particles with compressed air. Install the armature on the lathe once again and rotate it to 1,500 RPM. Polish the commutator with No 2/0-sandpaper as shown in figure 26. After polishing, check the armature diameter to see if it has remained within the limit specified in the repair standards (foldout 2).

10. ASSEMBLY. In assembly it is important that the reverse procedure of disassembly be followed. A thread sealer should be applied to the pole shoe screws, pipe plugs, and solenoid relay mounting screws before assembly. The bronze bearing bushings have oiler holes; these holes must be alined with the oiler holes in the pinion drive housing (fig 9), intermediate housing (fig 15), and the commutator end head (fig 17).



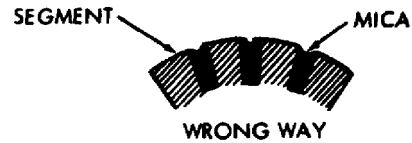
START GROOVE IN MICA
WITH 3 CORNERED FILE.



UNDERCUT MICA WITH PIECE
OF HACKSAW BLADE.



MICA MUST BE CUT AWAY
CLEAN BETWEEN SEGMENTS.



MICA MUST NOT BE LEFT
WITH A THIN EDGE NEXT
TO SEGMENTS.

ORD E16914

Figure 25. Hand method of undercutting mica.

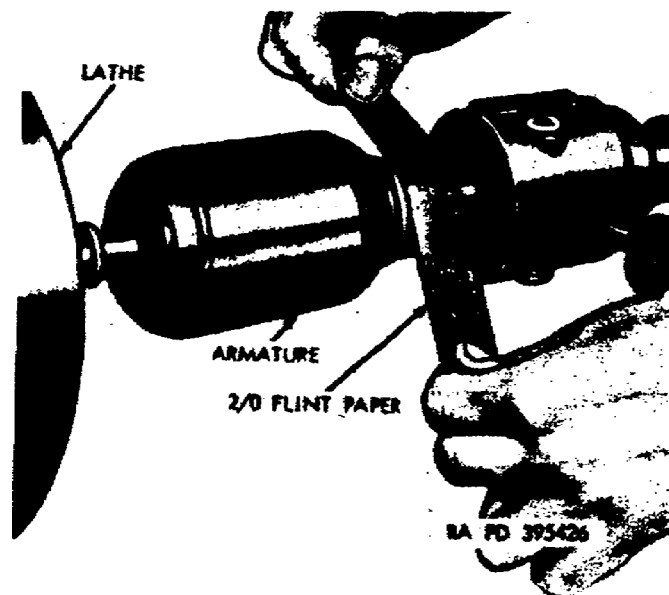


Figure 26. Polishing commutator.

a. Lubrication. The lubricants listed in table 1 should be available during assembly. The table lists the lubricant, the part to which it is applied, and the method of application.

Table 1. Lubrication Instructions.

Point of lubrication	Lubricant	Instructions
Drive assembly and armature splines.	GREASE, AIRCRAFT and INSTRUMENT (GL).	Coat splines.
Felt wicks and felt plugs	LUBRICATING OIL, INTERNAL COMBUSTION ENGINE (OE 10).	Soak wicks and plugs until saturated.
Drive assembly shell (shift lever yoke contact surface).	GREASE, AIRCRAFT and INSTRUMENT (GL).	Coat surface.
Preformed packings and gaskets	GREASE, GENERAL PURPOSE, medium grade.	Lightly coat preformed packings and gaskets.

b. Frame assembly. Once the frame is completely assembled with the field coils and everything secure, apply electrical varnish to the inside of the frame and-field coil assembly. It is necessary to leave 0.380 inch from each end of the frame free of varnish for installation of the end pieces. Allow to dry thoroughly before continuing.

c. Solenoid relay assembly. What is important here is the plunger shaft adjustment (fig 27). The solenoid is energized and the distance from the shaft shoulder to the straightedge is measured. The self-locking nut must be adjusted until proper alinement is achieved. Once this is done, the solenoid can be completely assembled.

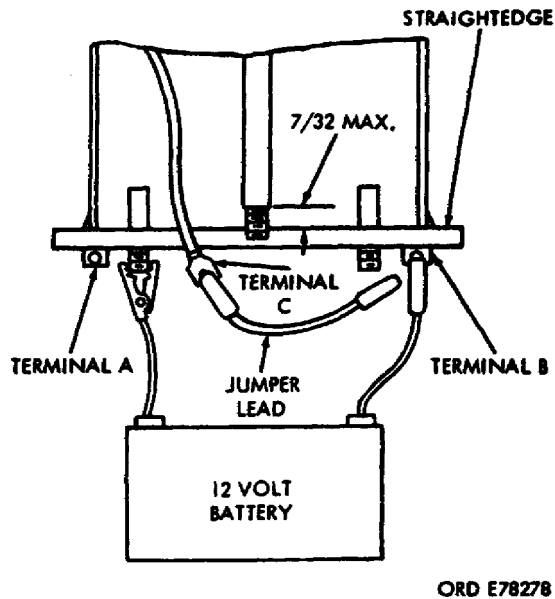


Figure 27. Plunger adjustment.

d. Other components. The intermediate housing, commutator end head assembly, and pinion housing are prepared for final installation on the starter. This includes filling of the oil reservoirs, saturating the felt wicks, and installing oil seals and preformed packings.

e. Brush holder:: Assemble the eight brushes and springs into the holder in preparation for final installation (fig 28).

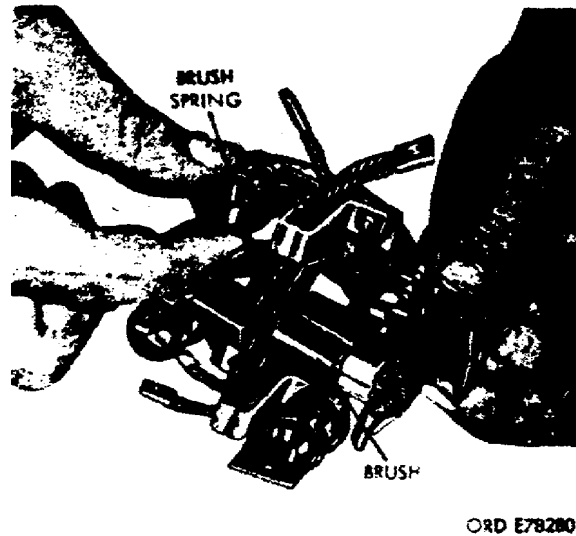


Figure 28. Brushes in holder.

f. Final assembly. First the brushes and the holder are installed into the frame. Then, the armature is put in place so the commutator and brushes are positioned properly.

(1) If new brushes have been installed they must be properly seated before proceeding.

(a) No 2/0 sandpaper is cut the width of the commutator and is installed between the commutator and brushes.

(b) The commutator end head is secured to the frame and the armature rotated three to five times, in a counterclockwise direction, to seat the brushes.

(c) Remove the commutator end head and inspect for satisfactory brush seats (fig 29).

(d) Remove armature from frame and blow away loose particles of sanding dust from the armature and frame.

1. Wipe off the armature with a clean cloth dampened with drycleaning solvent.

2. Wipe the-brushes clean with a dry cloth only.

(e) After coating the shaft and splines on the armature with grease, install the armature and continue the assembly.

(2) In the installation of the commutator end head, make certain the thrust washer is in place and that the scribe marks are properly alined.

(3) In the installation of the intermediate housing, don't forget the thrust washer and to check the armature end play. The maximum end play is 0.050 inch.

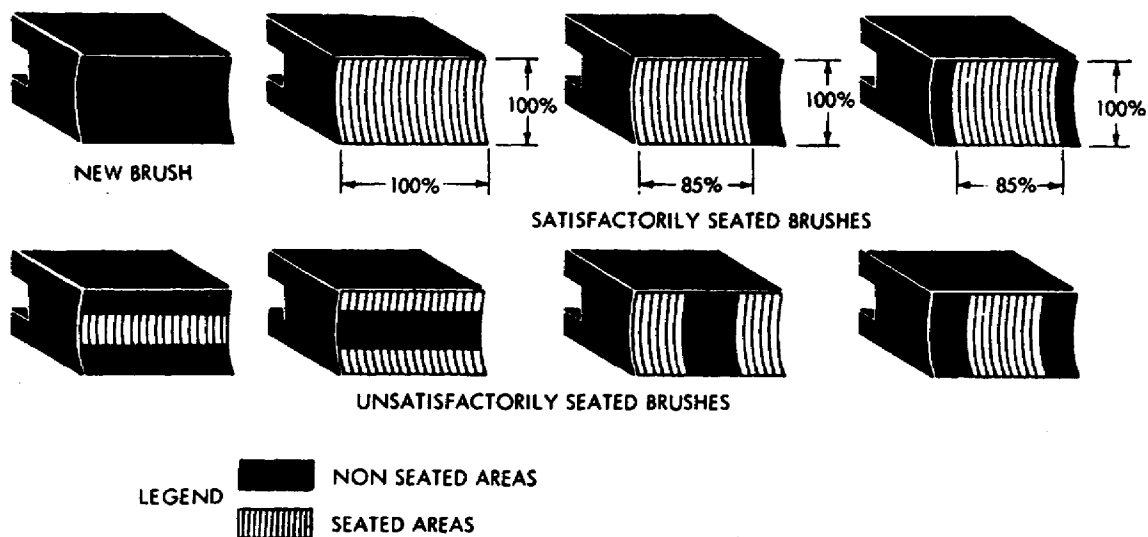


Figure 29. Brush seats.

(4) Install the drive assembly and yoke shift lever. Put the yoke cover in place and install the yoke pin for proper shift lever pivoting. Secure the yoke cover, observing that all seals and packing are in place.

(5) During installation of the solenoid relay there is a rubber boot that must be on the inside of the yoke cover and over the outside edge of the solenoid case for proper seal. Do not install inspection plug and gasket until final tests and adjustments are completed.

(6) Include the thrust washer during pinion housing installation. Next align the scribe marks on the pinion housing and intermediate housing. Torque tighten screws to 100 pound-inches.

g. Pinion clearance adjustments. The drive assembly is adjusted for proper shifting within the pinion drive housing. The clearance between the thrust washer and pinion is to be from 0.020 to 0.050 inch when the solenoid is energized (fig 30).

(1) To make this adjustment the starter motor is made inactive by disconnecting the field terminal and ground terminal on the starter frame.

(2) The solenoid is energized with a 24-volt battery. The pinion will move forward; therefore, before making the measurement, push the pinion back toward the armature to take up the slack movement.

h. Pinion block test. The pinion block test is a test of continuity of the solenoid relay. This controls the point of pinion travel and the application of current to the starter motor. For pinion travel of greater than 0.500 inch from the thrust washer, the solenoid contacts should be open; for less than 0.500 inch, the contacts will be closed, thereby applying current to the motor if it is connected.

(1) This distance is checked with a series of spacer blocks or thrust washers and a continuity tester. Figure 31 shows the spacer block between the pinion and thrust washer.

(2) If continuity is greater than 0.500 inch, then the pinion clearance is adjusted to its minimum limit of 0.020 inch and the block test is performed again to make sure an open circuit exists.

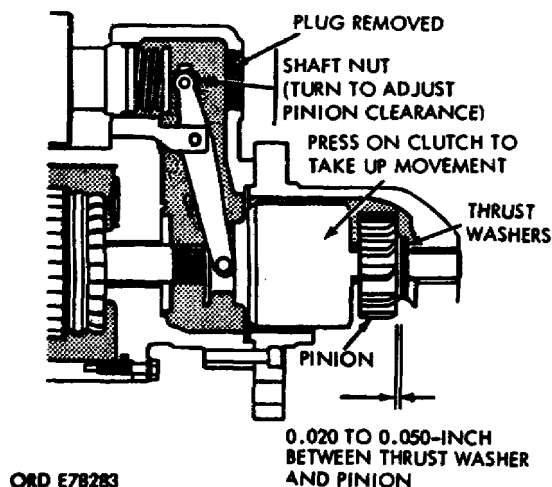


Figure 30. Pinion clearance.

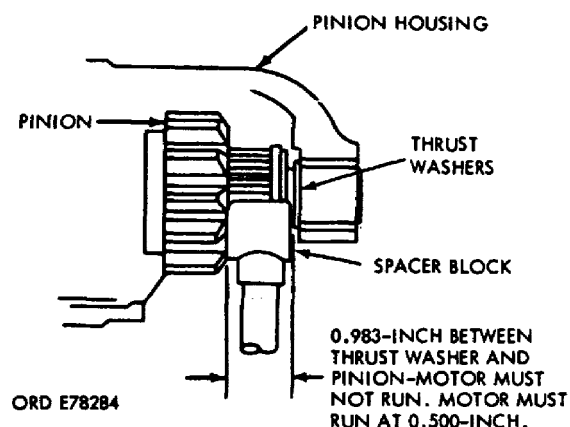


Figure 31. Pinion block test.

i. At the completion of the clearance and block tests, restore the cables to their normal functional connections. This completes the assembly of the starter.

SECTION IV. TESTING

11. TESTING. There are three types of tests used to determine starter performance: the no load test, where the starter free runs; stall torque test, where starter torque is measured: and a waterproof test, where the starter is submerged in water.

CAUTION: Never operate the starter more than 30 seconds at a time. Allow the motor to cool for at least 2 minutes between each cranking cycle. Overheating, caused by excessive cranking, will seriously damage the starter motor.

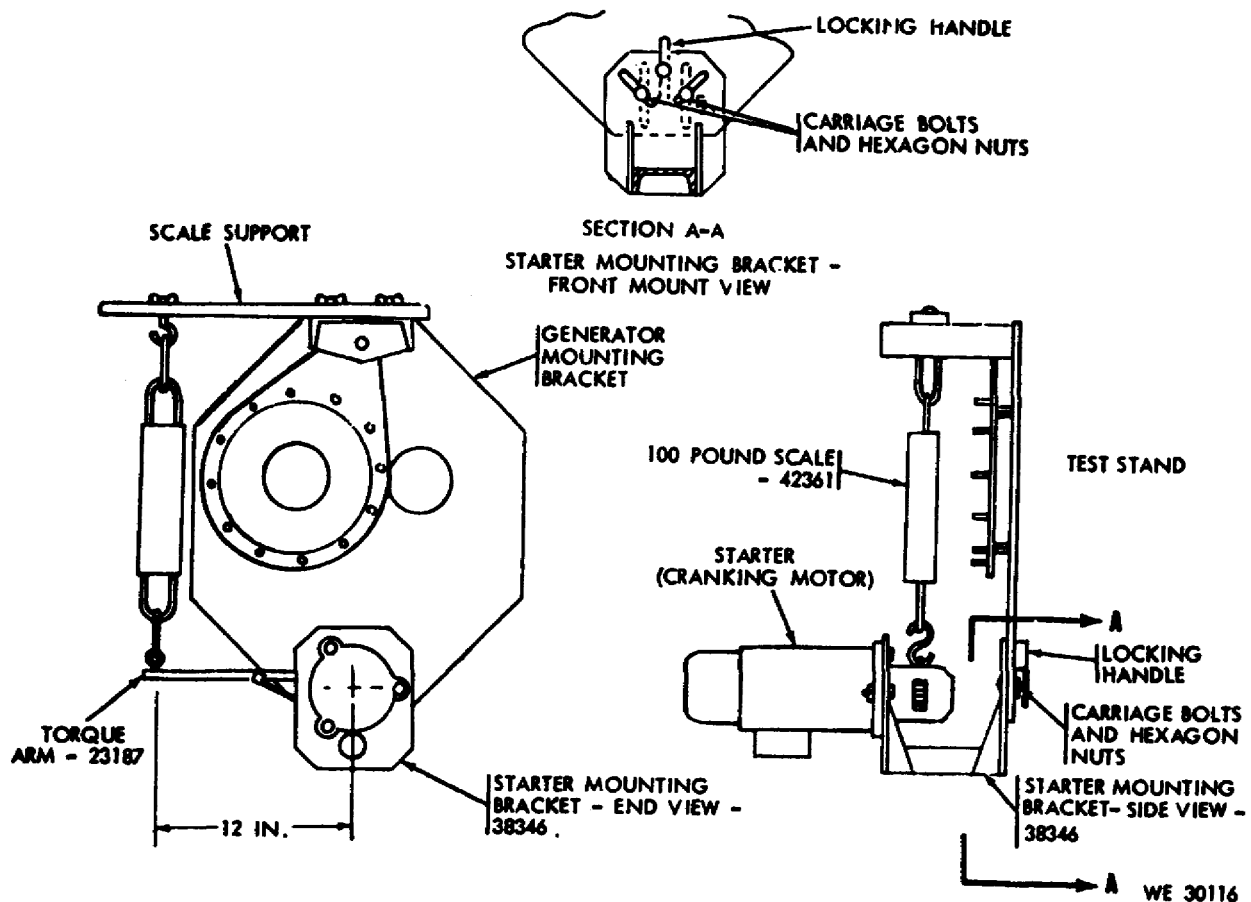
a. 500-ampere test stand. The tests performed on the 500-ampere test stand are the NO LOAD and STALL TORQUE tests. Figure 32 shows the mounting requirements for stall torque testing. The starter NO LOAD or FREE RUN tests are performed with the starter mounted in the same manner as for the stall torque test, but without the torque arm.

(1) The NO LOAD test is performed to indicate the functioning of the starter. When there is no load connected, it will run freely at a specific minimum RPM and current drain.

(a) For the no load test, the test leads are connected between the positive (+) field winding terminal (B, fig 33) and the ground terminal (A, fig 33). The solenoid is not energized for this test.

(b) The parallel connection to J17 and J28 on the test stand is the input to the DC voltage meter which monitors the voltage across the starter.

(c) The DC ammeter is wired internally to indicate the starter current. This current is controlled by knob (24), which is a variable resistance device called a carbon pile.



Starter torque test

Figure 32. Starter torque test.

(d) The starter is activated by turning the starter switch (27) to the ON position. A hand tachometer is used to measure the starter RPM.

(e) Vary starter voltage adjuster control (24) until a voltage of 22.0 volts is obtained on the DC voltmeter.

1. The minimum speed should be 7,000 RPM.
2. The maximum current draw should be 90 amperes.

(2) The stall torque test (fig 34) is performed to determine the amount of torque, in foot-pounds, exerted by the starter when under load. This test must be short in duration and the torque arm must be securely attached with the scale support bolted down securely (fig 32).

(a) Figure 34 shows the connections to the 500-ampere test stand. The main difference between free run and torque connections are the DC ammeter shunts. Since the starter is not allowed to turn, it doesn't build up any back EMF. Therefore, the starter will have a very low resistance and cause an extremely high current drain.

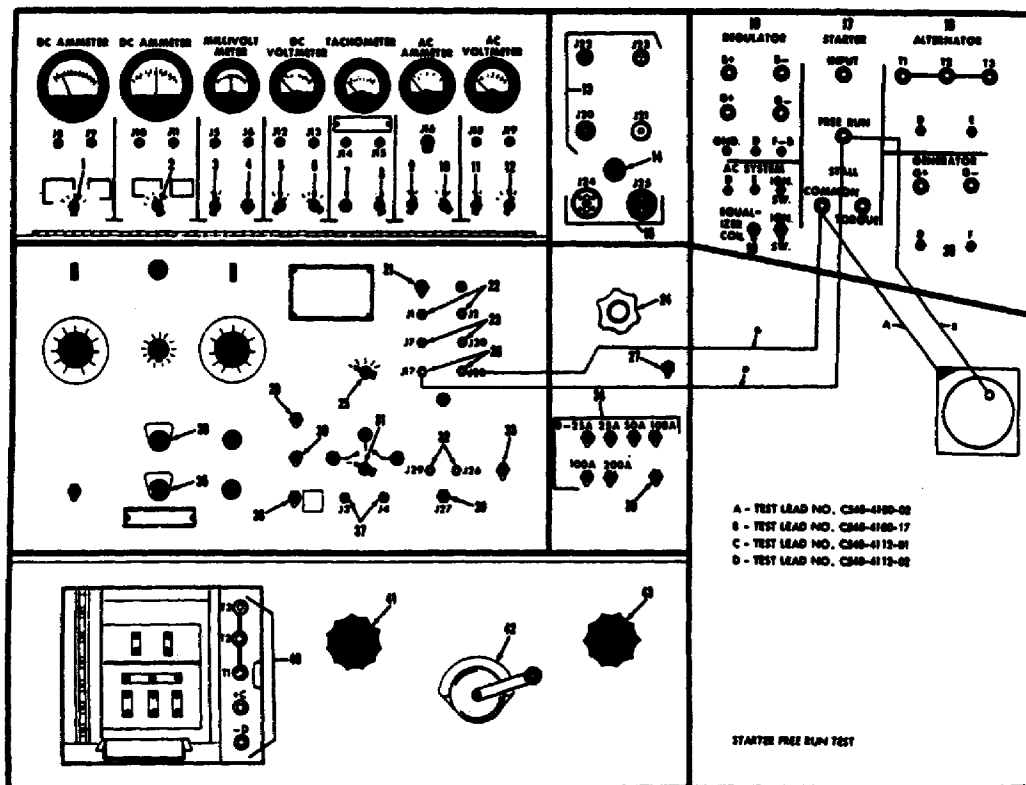


Figure 33. No load test.

(b) When performing the stall torque test it is necessary to provide a means of shifting the starter pinion. The shift must be maintained for the engagement of the torque arm Jaws. Do not depend on the torque arm Jaws to maintain the shifted pinion position. The starter shifting levers must be blocked, wedged, or clamped to hold the pinion in the operative position to prevent possible body injury.

(c) Stall torque is seldom, if ever, performed at the nominal rated voltage of the starter, because of the high current drain. The battery selector (31) should be set to the 6-volt position.

(d) Balance the scale so that it indicates a zero reading on the scale.

(e) The DC ammeter range selector is set to the 1000A position.

(f) The DC voltmeter range selector is set to the 10V position.

(g) Set the starter voltage adjuster (24) to the fully counterclockwise position.

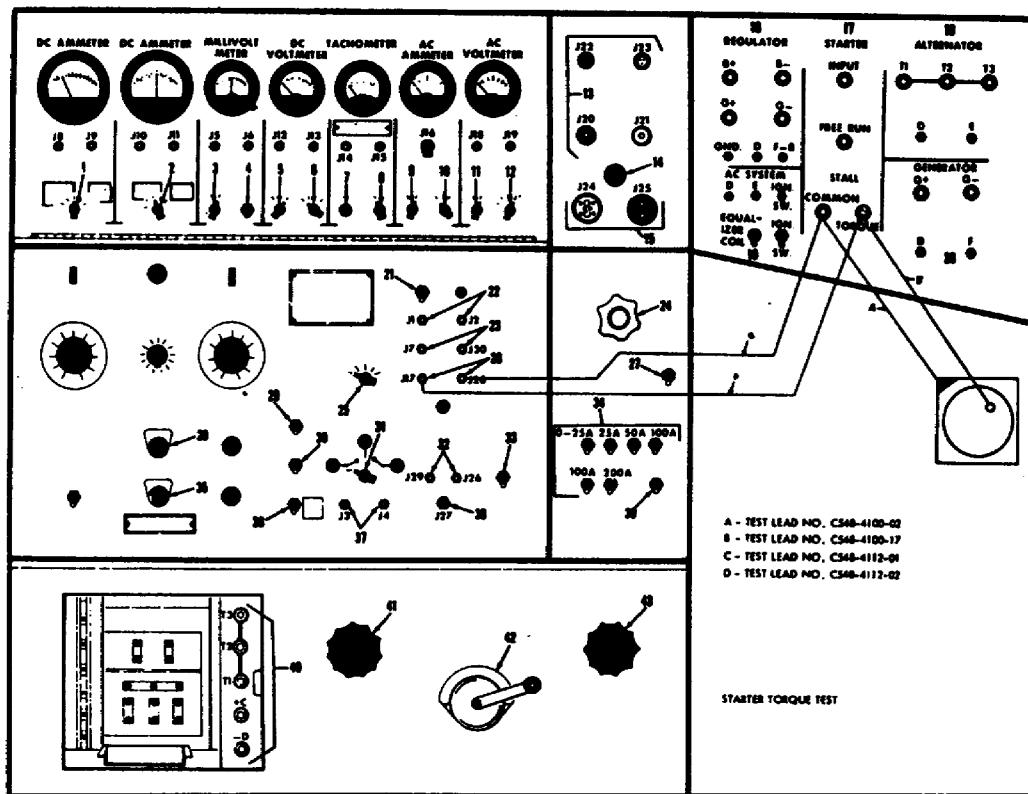


Figure 34. Torque test.

(h) Activate the starter switch (27) to the ON position.

(i) Vary the starter voltage adjuster (24) for an approximate voltage of 4.0 volts.

1. The maximum current draw should be 400 amperes.
2. The minimum torque should be 22 pounds per foot.

b. Waterproof test. The waterproof test is performed by piping air into the frame of the starter. The starter is then submerged in water. Air bubbles from the starter indicate bad seals.

(1) In figure 7, at the bottom of the frame next to the intermediate housing, there is a 1/8-inch pipe plug that must be removed.

(2) To connect the air line a fitting is installed into the plug hole.

(3) The starter is submerged in clean water up to the pinion housing and clutch assembly area. Do not allow water to enter the pinion housing or clutch area.

(4) Apply air pressure slowly and watch the water for air bubbles. Increase the air pressure to 6 PSI and allow the starter to remain submerged for a period of 1 minute.

(5) No leaks should be indicated. If leaks appear, the preformed packing and gaskets must be replaced.

SECTION V. SUMMARY

12. SUMMARY. In this lesson starter motors were discussed as well as the general principles of operation, construction, and driving mechanisms. The Prestolite starter was discussed in detail and starter overhaul was covered.

- a. The disassembly and assembly procedures showed the proper sequences to be followed.
- b. Special cleaning instructions were given for electrical and other parts.
- c. Details of what to look for during inspection were covered; also, the methods of checking the armature were treated.
- d. The repair section included commutator resurfacing and mica undercutting procedures.
- e. In the final assembly the process to seat new brushes was covered.
- f. The no load, stall torque, and waterproof tests were treated.

13. JOB KNOWLEDGE. Here we presented the procedures for overhauling and testing a starter. Knowing how to do the job properly will make you a better supervisor. It is hoped the knowledge gained here will help you in the future. By completing the following exercise your job knowledge will be reinforced.

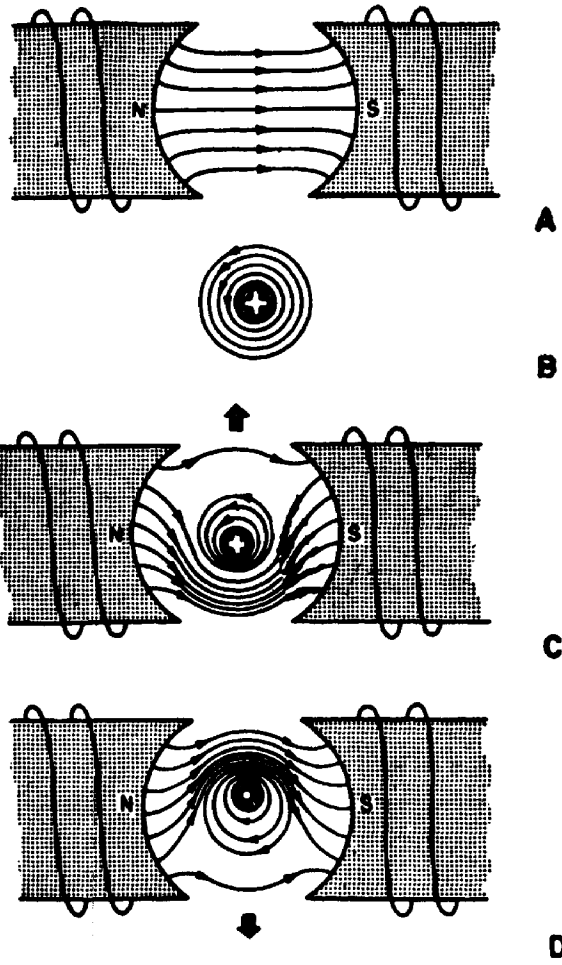
EXERCISE

Note. - Refer to the exercise instructions in lesson 1.

- 86. The force against a wire in a magnetic field is caused by the
 - a. induced EMF in the wire.
 - b. length of the wire.
 - c. current flowing in the wire.
- 87. Most starter motors are
 - a. shunt wound.
 - b. series wound.
 - c. parallel wound.
- 88. The over-running clutch type of starter drive
 - a. activates before the armature rotates.
 - b. activates after the armature rotates.
 - c. is always engaged to the flywheel rim.
- 89. The shifter lever type engine starter uses a
 - a. Bendix drive shift lever.
 - b. over-running clutch drive.
 - c. free-running clutch drive.

90. The Prestolite drive assembly is located at the armature
- commutator end.
 - splined end.
 - threaded sleeve end.
91. What makes it possible to control the starter from an outside source?
- Solenoid relay
 - Starter switch
 - Voltage regulator
92. During disassembly of the Prestolite starter, what is first to be removed?
- Solenoid assembly
 - Pinion housing assembly
 - Intermediate housing assembly
93. In the Prestolite starter the shift lever yoke is held by the
- intermediate housing.
 - solenoid housing.
 - yoke cover.
94. Before the yoke cover can be freed in the Prestolite starter, the
- drive assembly must be removed.
 - intermediate housing must be removed.
 - yoke pin must be tapped from the cover.
95. Before the armature can be freed during disassembly of the Prestolite starter, the
- commutator and head assembly must be removed.
 - intermediate housing must be removed.
 - brush holder assembly must be removed.
96. The brushes of the Prestolite starter are cleaned
- with a dry cloth only.
 - and soaked in drycleaning solvent.
 - with a cloth dampened in drycleaning solvent.
97. To inspect for armature grounds the continuity is checked between the armature
- commutator riser bars.
 - core and rotor shaft.
 - core and commutator riser bars.
98. What is used to inspect the armature for shorts?
- Growler and steel strip
 - Growler and continuity test leads
 - Lathe and dial indicator
99. What is used to inspect the commutator concentricity?
- Growler and steel strip
 - Growler and continuity test leads
 - Lathe and dial indicator

100. When splines have score marks and nicks, they are repaired by using a
- a. fine stone.
 - b. fine mill file.
 - c. fine sandpaper.
101. The minimum time between each cranking cycle, during performance tests, should be at least
- a. 1 minute.
 - b. 2 minutes.
 - c. 3 minutes.
102. What performance parameters are measured during the NO LOAD test?
- a. RPM and current
 - b. RPM and voltage
 - c. RPM and torque
103. What performance parameters are measured during the STALL TORQUE test?
- a. Voltage and current
 - b. Voltage and torque
 - c. Torque and current
104. What important precaution is observed to prevent body injury during the STALL TORQUE test?
- a. Proper test stand cable connections
 - b. Blocking of the yoke shifting lever
 - c. Balance scale to zero pounds reading
105. During assembly of the Prestolite starter, which is installed in the frame assembly first?
- a. Armature
 - b. Brushes and holder
 - c. Intermediate housing



Foldout 1.

<i>Reference</i>	<i>Point of measurement</i>	<i>Sizes and fits of new parts</i>	<i>Direct and general support wear limits</i>
Brushes and Springs			
	Brush length	0.7500	0.3750
	Brush spring tension	52 to 65 oz.	50 to 65 oz.
Thrust Washers			
	Thrust washer thickness (Commutator end of armature shaft).	0.0312 to 0.0930	0.0250
	Thrust washer thickness (Drive end of armature shaft).	0.0950	0.0900
	Thrust washer thickness (Intermediate bearing).	0.0312	0.0280
	Maximum end play of armature	0.0300	0.0500
	Thrust washer thickness (outer washer)	0.0650	*
Yoke (Shaft Lever)			
	Yoke pin diameter	0.2790 to 0.2810	0.2740
	Yoke bore for pin	0.2820 to 0.2830	*
	Fit of pin in yoke	0.0010L to 0.0040L	*
	Fit of pin in cover	0.0010L to 0.0050L	*
	Cover bore for pin	0.2820 to 0.2840	*
Solenoid Relay Springs			
Contact spring:	Free length	0.6250 in.	*
	Solid length	0.2400 in.	*
	Load at 0.3750-inches length	5 to 6 lbs.	5 lbs.
Core spring:	Free length	2.7920 in.	*
	Solid length	0.6510 in.	*
	Load at 1.56-inches length	13.5 to 14.5 lbs.	13.5 lbs.
Bronze Bearings			
	Commutator end head bronze bearing inside diameter.	0.6260 to 0.6270	0.6320
	Armature shaft diameter at commutator end	0.6230 to 0.6250	0.6200
	Fit of shaft in bearing	0.0010L to 0.0040L	*
	Commutator end head bore	0.7510 to 0.7520	*
	Commutator end head bronze bearing outside diameter.	0.7540 to 0.7550	*
	Fit of bearing in end head	0.0020T to 0.0040 T	*
	Intermediate housing bronze bearing inside diameter.	0.8740 to 0.8760	0.8780
	Armature shaft diameter	0.8700 to 0.8720	0.8670
	Fit of shaft in bearing	0.0020L to 0.0060L	0.0080L
	Runout of shaft bearing with end bearing	0.0050 TIR	
	Intermediate housing bore	0.9990 to 1.0000	*
	Intermediate housing sleeve bearing outside diameter.	1.0030 to 1.0040	*
	Fit of bearing in housing	0.0030T to 0.0050T	*
	Pinion housing bearing inside diameter	0.7470 to 0.7480	0.7520
	Armature shaft diameter (Drive end)	0.7450 to 0.7460	0.7420
	Fit of shaft in bearing	0.0010L to 0.0030L	0.0060L
	Pinion housing bore	0.8740 to 0.8750	*
	Pinion housing bronze bearing outside diameter.	0.8770 to 0.8780	*
	Fit of bearing in housing	0.0020T to 0.0040T	*
	Pinion housing bearing inside diameter	0.7500 to 0.7530	0.7550
	Armature shaft diameter (Drive end)	0.7450 to 0.7460	0.7420
	Fit of shaft in bearing	0.0040L to 0.0080L	0.0100L
Commutator			
	Commutator diameter	1.6800	1.6480
	Commutator minimum turned diameter	1.6700	1.6470
	Commutator diameter T.I.R. runout with shaft diameters at bearings.	0.0020	0.0030

Foldout 2.

C O R R E S P O N D E N C E C O U R S E
o f t h e
U S A R M Y O R D N A N C E
C E N T E R A N D S C H O O L



LESSON ASSIGNMENT

Ordnance Subcourse No 010..... Electrical System Component Repair

Lesson 7..... Maintenance of 500-Ampere Test Stand

Credit Hours..... Two

Lesson Objective..... After studying this lesson you will be able to:

1. Discuss supervisory responsibility with respect to the general inspection task.
2. State operator, crew, and organizational preventive maintenance responsibilities.
3. Discuss how the supervisor can have a personal knowledge of equipment condition and assure himself that the preventive maintenance task is accomplished.
4. State troubleshooting and repair responsibilities as they relate to operator, crew, and organizational maintenance and direct support.
5. Discuss the cleaning and lubrication of the 500-ampere test stand.
6. State procedures followed to prevent the early failure of lead acid batteries.
7. Discuss the basic circuits of DC voltmeters and DC ammeters.
8. State how you as a supervisor can improve the skill level of assigned personnel.

Text..... Attached Memorandum

Materials Required..... Response list and answer sheet

Suggestions..... None

OS 010, 7-P1
February 1975

ATTACHED MEMORANDUM

1. INTRODUCTION.

a. The quality and quantity of service provided by an organization depend on the serviceability of its equipment and the skill of its assigned personnel. Supervisors are responsible for all men and equipment under their control. They must know the capabilities and limitations of both. Effective supervisors use their time wisely and are able to remain in control of the changing situation.

b. Good supervisors know what the situation is and how to manage it. They can determine if enough skilled personnel and serviceable equipment are available within the organization to produce quality results at the required level. Being aware of both internal and external factors which affect the organization's mission, they can give commanders a realistic appraisal of a situation. Commanders respond to specific information.

c. Supervision is a full time job. To be in control the supervisor must know the organizational situation, how it developed, what it is now, and what it is likely to become in the future. This lesson discusses 500-ampere test stand maintenance. Upon completion you will have acquired the knowledge necessary to Judge the men and equipment in this area of the shop.

2. GENERAL INSPECTION.

a. General inspection is the responsibility of all individuals in an organization. Supervisors must make that fact clear to all assigned personnel. The general inspection is a continuing procedure which insures that all items are lubricated, in good condition, correctly assembled, properly stowed, secure, not excessively worn, and not leaking. The general inspection is as important as any specific procedures and must be performed automatically by all personnel.

b. Supervisors must insure that general inspection is performed continuously during the course of normal operations. All personnel must be familiar with general inspection terms.

(1) GOOD CONDITION means not bent, twisted, chafed, burred, broken, cracked, bare, frayed, dented, collapsed, torn, cut, or deteriorated. Inspection for good condition is a visual inspection to determine if an item is damaged beyond safe or serviceable limits.

(2) EXCESSIVELY WORN means worn beyond serviceable limits or to a point likely to result in failure.

(3) TIGHTEN, ADJUST IF NECESSARY, and REPLACE IF NECESSARY are self-explanatory as applied to a specific situation. It is understood that when inspection reveals the need, the necessary action will be taken.

(4) CORRECTLY ASSEMBLED and CORRECTLY STOWED mean that all parts are present and in their correct relative position.

c. Ignorance or disregard of general inspection tasks within an organization are the direct cause of high maintenance costs and low operational efficiency. Supervisors must assure themselves, by continuous observation, that their personnel are attending to this detail.

3. PREVENTIVE MAINTENANCE CHECKS AND SERVICES.

a. The general inspection is a preventive maintenance action. It is performed automatically by all personnel. No specific written procedure is necessary. Each item of equipment requires some amount of regular servicing. These required services must be organized in specific written procedures. Operator/crew preventive maintenance responsibility for the 500-ampere test stand is shown in figure 1. Figure 2 details preventive maintenance tasks performed by organizational maintenance personnel. Supervisory remarks must be carefully directed. By studying figures 1 and 2 you can learn who is responsible for performing specific preventive maintenance tasks. This will enable you to direct your comments to the responsible individuals.

Item Number	Interval					Item to be inspected	Procedure
	Operator						
	Daily						
	B	D	A	W			
1	X		X	X	Instrument panel and cabinet.	a. Clean outside surface of panel and cabinet. b. Inspect painted surfaces for chips and peeling, and compartment fasteners for distorted or bent condition. Notify organizational-maintenance personnel if surfaces require refinishing or fasteners require repairs.	
2	X		X		Meters	a. Check lens of each meter for loss of antistatic coating. Run hand across lens without touching it and check meter needle for fluctuation.Recoat lens if required.	
3				X X	Knobs	b. Adjust needle of each meter to zero if required. Tighten setscrew in knobs of switches and controls if loose. Be sure pointer of the knob is set in correct position on indicator dial before tightening setscrew.	
4	X				Stowage compartments	Remove all items of equipment that may interfere with operation of test stand.	
5				X	Test leads and cable harness.	a. Remove accumulation of corrosion and other foreign matter from clips, sockets, and ferrules. Keep a light coating of automotive and artillery grease (GAA) MIL-G-10924 applied to clips, sockets, and ferrules to prevent further corrosion.	
	X					b. Inspect electrical cables and leads for frayed, broken, cracked, and burned insulation.	
6		X			Toggle, selector, and control switches.	c. Wipe clean and roll-up neatly. Store in stowage compartments provided in test stand. Observe operation of toggle switches for nonpositive action, also check selector or control switches for binding when rotated.	
7		X			Lamps	Inspect for burned out condition (observe whether lamp is lit when test stand is operating).	
8	X				V belts	Inspect the V belts provided with equipment for fraying, cracks, and other indications of excessive wear.	
9	X		X		Gear case level	Observe oil level sight glass and check for proper oil level.	
10		X			Speed control	Observe operation for unusual feel, binding, or excessive free play.	

Figure 1. Preventive maintenance checks and services (operator/crew).

Sequence No.	Item to be inspected	Procedure
1	Painted surfaces of	Inspect for deterioration of painted surfaces. Remove rust or scaled or loose paint, grease, and dirt. Repaint surfaces.
2	Binding posts on instrument panels and rectifier compartment.	Inspect for corrosion and damaged threads. Clean by removing corrosion and repair threads using a wire brush or file to dress up threads.
3*	Regulator resistor fuses and fuse holders.	Inspect fuses for being secure in holder and the fuse metal ends free from corrosion or grease preventing positive contact.
4	Generator, alternator and starter mounting bracket assembly.	Inspect the bracket for secure mounting and positive action of chain vise. Check threads for dirt, rust, etc. Clean as required and lubricate threads and chain as prescribed in lubrication chart.
5*	Blower motor fuses in high voltage compartment.	Check fuses for corrosion and loose seating in fuse holders. Clean and reset fuses in holder if required. WARNING: Be sure the main circuit breaker is "OFF" before working in area of above items.
6	Terminals, binding posts and terminal boards.	Inspect terminals for corrosion and loose connections. Clean off corrosion and tighten terminal screws if required. WARNING: Be sure external power supply is disconnected before working in area of above items.
7*	Varidrive reversing switch.	Inspect switch for positive contact and corrosion on knife connections. Clean and tighten knife contacts if required. WARNING: Be sure external power supply source is disconnected before working in area of above items.
8	Varidrive assembly and V belt.	Inspect the varidrics of the varidrive assembly for scored, greasy, or otherwise damaged condition. Inspect the V belt for frayed, cracked, and excessive wear. Prevent over-lubrication as specified in lubrication chart.
9	Binding posts in battery compartment.	Inspect for corrosion and damaged threads. Clean by removing corrosion and repair threads using a wire brush or file to clean or dress threads.

* — To be accomplished upon failure of test stand operation instead of monthly if this condition exists.

Figure 2. Preventive maintenance checks and services (organizational).

b. Good supervisors take a strong position on preventive maintenance. They set the example for their organization and check on their equipment and personnel regularly. The checks used are not time consuming but they must be done regularly. The procedure used to check meters for antistatic coating (fig 1) is a good example of a check that can be done quickly by the supervisor. By utilizing several checks of this type regularly, the supervisor can have a personal knowledge of equipment condition. Time is very important to the supervisor. Study figures 1 and 2 then develop a list of checks which can be done quickly.

4. GENERAL OPERATIONS.

a. Troubleshooting is a systematic determination of malfunctions and defective components by indication, symptoms, and tests. Figures 3 and 4 designate the troubleshooting responsibilities of operator/crew and organizational personnel. The corrective action column designates those troubles which should be referred to direct support maintenance by organizational maintenance. Supervisors must insure that each level of maintenance stays within its own area of responsibility. Close adherence to individual areas of responsibility will materially reduce the time required to restore equipment to normal operation.

b. Repair parts are supplied to the using organization for replacement of those parts most likely to become unserviceable. The parts provided allow the unit to accomplish all repairs which fall within the scope of the organizational maintenance function. No special tools or equipment are required at unit level to accomplish the assigned maintenance mission. Common tools and equipment which have general application to the 500-ampere test stand are authorized by tables of allowances and tables of organization and equipment.

c. Operators and organizational mechanics must be thoroughly trained in their duties. Performance of preventive maintenance, maintenance, troubleshooting, repair, and recordkeeping tasks must be automatic. Supervisors must insure that this level of competence is achieved within the organization. By providing sufficient time for formal and informal training, the supervisor can create and sustain a high level of efficiency in the unit.

5. LUBRICATION.

a. The primary function of a lubricant is to decrease wear and maintain efficiency by reducing frictional heat. Lubricants should be stored in a clean dry place away from external heat. Every precaution must be taken to prevent lubricant contamination. When a lubricant becomes contaminated with dust, dirt, water, etc, it cannot perform its function. Oil cans and other lubricating equipment should be cleaned before and after lubricating operations. When exposed to air, lubricants form a spongy film. Airtight containers must be used for storage.

b. Lubrication should take place in a clean protected environment. Protect open containers from contamination and use a clean dry cloth to wipe excess lubricant from the machine being serviced.

c. Specific information on the cleaning and lubricating procedure for the 500-ampere test stand is contained in figures 5 and 6. Personnel should be familiar with the color, texture, and consistency of the lubricants used on various parts of the mechanism. Every once in awhile lubricants are improperly manufactured or improperly labeled. This can be disastrous. Using a lubricant with the wrong characteristics causes rapid equipment failure in many situations. Complicated tests are required to classify lubricants which have similar characteristics. However, alert personnel can spot lubricant differences which could bring about the disastrous situation.

Malfunction	Probable causes	Corrective action
1. Test stand fails to operate.	a. Main circuit breaker switch is "OFF". b. Air intake and exhaust vents restricted. c. Interlock switch open. d. Other causes	a. Place switch in "ON" position. b. Remove any obstructions from intake and exhaust vents. c. Close compartment tightly d. Refer other causes to organizational maintenance personnel for correction
2. Incorrect reading noted on meters.	a. Meter require zero adjustment b. Knob loose on switch or control shaft. c. Switch set in open position (between markings on dial). d. Other causes	a. Zero adjust meters b. Set knob in correct position and tighten setscrew c. Set knob of switch to selected markings on switch dial. d. Refer other causes to organizational maintenance personnel for correction.
3. Indicator lamps fail to light.	a. Fuses burned out b. Other causes	a. Replace fuses b. Refer other causes to organizational maintenance personnel for correction
4. Battery charger fails to operate.	a. Batteries not connected properly to charger. b. Timer on battery charger not set properly. c. Setscrew loose or missing.	a. Check for proper hook-up b. Refer to instructions
5. Knob turns on switch shaft or control shaft, or knob is set in wrong position on switch dial.	a. Other causes	a. Turn shaft of switch or control to the extreme left or right position and align pointer of knob with extreme lower left or right lined marking on switch or control dial. Replace and/or tighten setscrew in knob. b. Refer other causes to organizational maintenance personnel for correction.
6. Binding posts do not hold leads securely.	a. Threads on binding dirty or corroded. b. Other causes	a. Clean threads b. Refer other causes to organizational maintenance personnel for correction.
7. Incorrect speed noted on tachometer indicator.	a. Tachometer indicator circuitry requires adjustment. b. Other causes	a. Adjust tachometer indicator circuitry b. Refer other causes to organizational maintenance personnel for correction.
8. Generator or alternator (pulley driven) vibrates excessively, when revolving, while undergoing test.	a. Not clamped securely in mounting bracket. b. Other causes	a. Tighten screws or nuts of mounting bracket, or secure chain onto frame undergoing test b. Refer other causes to organizational maintenance personnel for correction.
9. Varidrive assembly noisy.	.....	Refer malfunction to organizational maintenance personnel for correction.
10. Varidrive assembly operates but drive heads run erratic or do not turn.	.....	Refer malfunction to organizational maintenance personnel for correction.

Figure 3. Operator/crew troubleshooting.

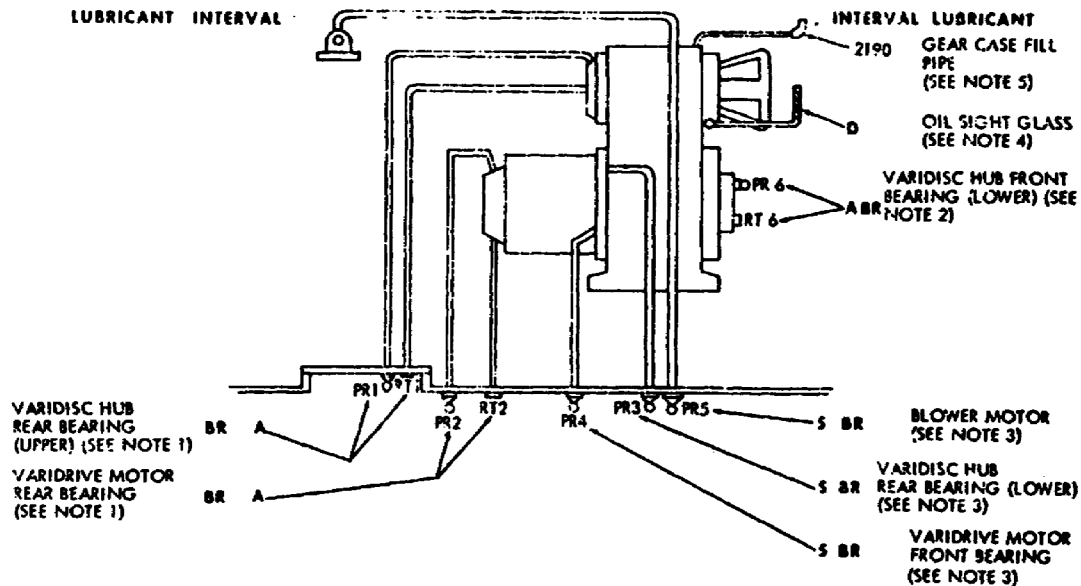
Malfunction	Probable causes	Corrective action
1. Test stand fails to operate.	a. High voltage compartment not tightly closed. b. Loose terminals on power input cable. c. Circuit breaker switches in "OFF" position. d. Burned-out heater elements. e. Other causes	Check to see interlock switch is closed. b. Check wiring and terminal board. c. Check circuit breaker switches for correct position. d. Check heater elements using a multimeter. Replaces heater elements if required. e. Refer other causes to direct support maintenance personnel for correction.
2. Incorrect reading noted on meters.	a. Meter lens statically charged b. Other causes	a. Clean and recast meter lens b. Refer other causes to direct support maintenance personnel for correction.
3. Indicator lamps fail to light	a. Lamp (bulb) burned out. b. Other causes	a. Check lamp (bulb) for continuity using a multimeter, replace lamp (bulb) if required b. Refer other causes to direct support maintenance personnel for correction.
4. Battery charger fails to operate	.....	Refer malfunction to direct support maintenance personnel for correction.
5. Variable circuit fails to operate	.....	Refer malfunction to direct support maintenance personnel for correction.
6. Knob turns on switch shaft or knob is set in wrong position on switch dial	.....	Refer malfunction to direct support maintenance personnel for correction.
7. Binding posts do not hold leads securely.	a. Threads on post cross threaded. b. Other causes	a. Use appropriate size file and dress threads and/or repair threads by chasing, if practicable. b. Refer other causes to direct support maintenance personnel for correction.
8. Incorrect speed noted on tachometer.	.....	Refer malfunction to direct support maintenance personnel for correction.
9. Generator, alternator, or starter (cranking motor vibrator excessively, when revolving while undergoing test.	.....	Refer malfunction to direct support maintenance personnel for correction.
10. Varidrive assembly noisy.	.....	Refer malfunction to direct support maintenance personnel for correction.
11. Varidrive assembly operates but drive heads run erratic or do not turn.	a. Check V belt and varidrive for greasy deposits or frayed, cracked, and excessive wear. b. Other causes	a. Clean grease from V belt and varidrive. Replace V belt if unserviceable. b. Refer other causes to direct support maintenance personnel for correction.

Figure 4. Organizational troubleshooting.

**TEST STAND, AUTOMOTIVE GENERATOR, ALTERNATOR AND STARTER,
10 TO 50-V, 500-AMP, DC, AND 25 TO 50-V, 100 TO 400AMP, AC,
TESTING RANGES, (SUN ELECTRIC CORPORATION MODEL AGT-9)
(4910-767-0218)**

INTERVALS ARE BASED ON NORMAL OPERATIONS. REDUCE TO COMPENSATE FOR ABNORMAL OPERATION AND SEVERE CONDITIONS OR CONTAMINATED LUBRICANTS. DURING INACTIVE PERIODS, INTERVALS MAY BE EXTENDED COMMENSURATE WITH ADEQUATE PRESERVATION.

CLEAN LUBRICATION POINTS BEFORE LUBRICATING. CLEAN PARTS WITH THINNER, PAINT, MINERAL SPIRITS (TPM), OR SOLVENT, DRY CLEANING (SD). DRY BEFORE LUBRICATING.



KEY -

LUBRICANT		EXPECTED TEMPERATURE			INTERVALS
2190	LUBRICATING OIL, 2075 GENERAL PURPOSE	ABOVE + 32°F	+ 40°F TO - 10°F	0°F TO-65°F	D - DAILY W - WEEKLY S - SEMI-ANNUALLY A - ANNUALLY
2135		2190	2135	2075	
3042		2135	2075	3042	
BR - GREASE, BALL AND ROLLER BEARING		ALL TEMPERATURES			
PL - LUBRICATING OIL, PRESERVATIVE, SPECIAL					

NOTE:

1. FOR LUBRICATING FITTINGS IDENTIFIED AS "PR1 AND PR2", REMOVE THE PLUGS DESIGNATED "RT1, RT2". PUMP GREASE THROUGH EACH OF THESE SYSTEMS UNTIL A HALF-CUP OF GREASE HAS BEEN EXPELLED FROM THE TUBES IDENTIFIED AS "RT". RUN TEST STAND 5 MINUTES, TO RELIEVE GREASE PRESSURE ON THE BEARINGS, PRIOR TO INSTALLING THE PLUGS ON THE TUBES DESIGNATED AS "RT".

2. FOR LUBRICATING FITTING IDENTIFIED AS PR6, REMOVE THE BACK PANEL ON THE TEST STAND AND REMOVE THE PLUG DESIGNATED RT6. FORCE HALF-CUP OF GREASE THROUGH THE BEARING. RUN THE TEST STAND 5 MINUTES PRIOR TO INSTALLING PLUG "RT6".

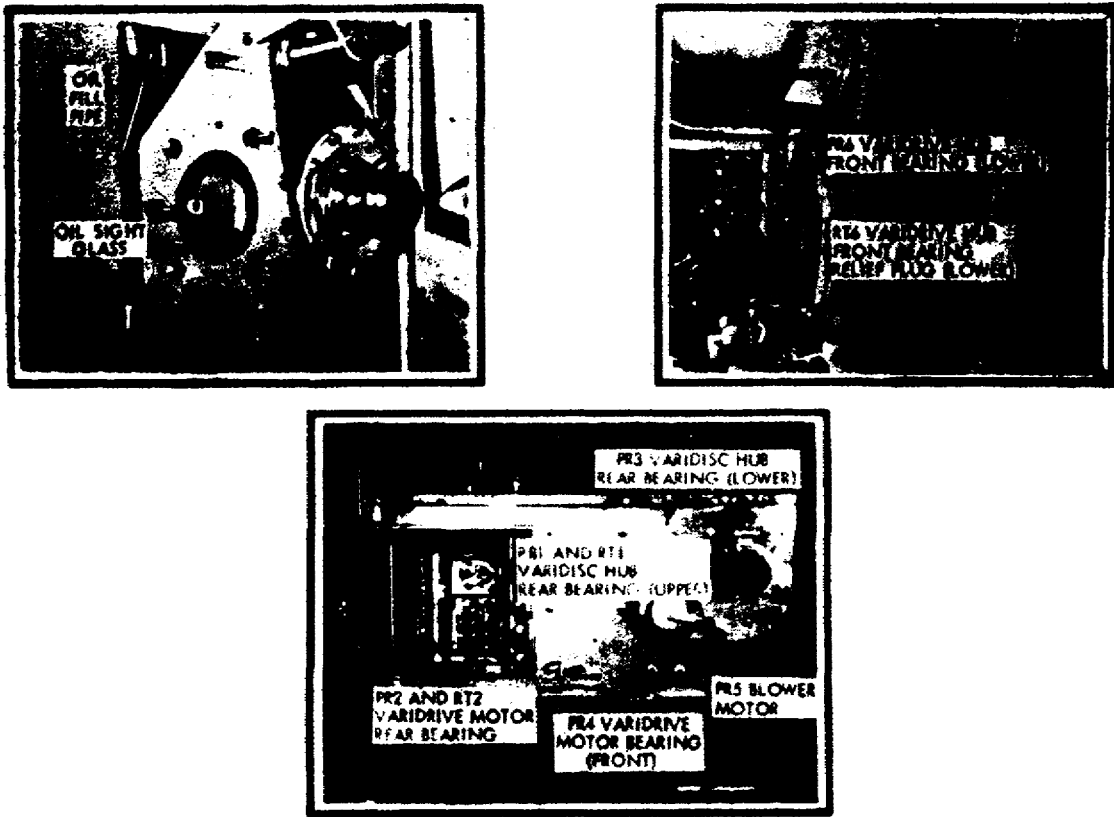
3. FOR LUBRICATING FITTINGS IDENTIFIED AS PR3, PR4 AND PR5, APPLY HAND GREASE GUN AND PUMP 3 OR 4 STROKES INTO THE FITTING.

4. OBSERVE SIGHT FEED GLASS DAILY. OIL MUST BE WITHIN 1/2 INCH OF THE TOP OF THE GLASS.

5. ADD OIL TO THE GEAR CASE, AS REQUIRED, THROUGH THE OIL FILL PIPE.

6. REMOVE DRAIN PLUG AND DRAIN OIL FROM THE GEAR CASE AT LEAST ANNUALLY, MORE FREQUENTLY IN DUSTY CONDITIONS.

Figure 5. Lubrication chart.



WE 38349

Figure 6. Lubrication points.

d. Study figure 5 carefully--it contains much information. The proper materials, intervals, and cleaning and lubricating procedures are detailed. Lubrication intervals specified are for normal operation where moderate temperature and humidity conditions prevail. Lubrication intervals should be reduced under extreme conditions. The protective qualities of a lubricant will be quickly destroyed when any one of the following conditions exists.

- (1) Extreme high or low temperature.
- (2) Prolonged periods of high speed operation.
- (3) Operation in a sand or dust environment.
- (4) Exposure to moisture (to include prolonged high humidity).

6. MAINTENANCE OF LEAD-ACID BATTERIES.

a. In nearly all cases of early failures of batteries the cause can be traced to a lack of preventive maintenance. When given proper care batteries generally will give no trouble until they are worn out. The equipment operator and organizational level personnel are responsible for performing preventive maintenance on the batteries assigned to their unit. The batteries should be thoroughly inspected and serviced once a week by doing the procedures explained in paragraphs (1) through (5) below.

(1) Inspect the top of the batteries very carefully and clean them if needed. They must be kept clean to prevent them from discharging through collected dirt, etc. To clean, tighten the vent plugs and wash the batteries with a brush dipped in an alkaline solution, such as a mixture of bicarbonate of soda (baking soda) and water. Foaming will occur due to the reaction between the cleaning solution and battery electrolyte. After the foaming stops, rinse off the batteries with clean water and wipe dry with a clean cloth.

(2) Inspect the battery terminals to see that they are clean and the cable clamps tight and free of corrosion. If they are corroded, remove the cable clamps and clean the clamps and battery posts with a solution as described above. Then reconnect and tighten the cable clamps. Coat the terminals with a light coat of general purpose grease to fight off corrosion. Dirt will collect on the grease, but it can be removed each time the batteries are cleaned and the terminals then recoated with grease.

(3) Remove and inspect the vent plugs to see that the ventholes are open. Use a short length of stiff wire to run through the ventholes to make sure they are not plugged.

(4) Inspect the electrolyte level and add water if it is low. Filling instructions are usually located on the vent plugs or the cell covers. When correct, the electrolyte level will be at least $\frac{3}{8}$ of an inch above the plates. Distilled water should be used to fill batteries if it is available; if it is not available, the second choice is rainwater. Do not store battery water in metal containers. Minerals that are found in water from streams, wells, or water stored in metal containers can damage and shorten the life of a battery. Water that is used for drinking purposes can be used, but only when distilled water or rainwater is not available. A battery will be damaged less by using clean water that has some minerals than by letting the electrolyte level drop below the top of the plates.

(5) Check the specific gravity of each cell with a hydrometer.

b. Battery capacity is greatly reduced by low temperatures because the electrolyte thickens and is less active. In order to perform satisfactorily in cold weather the battery must be kept in peak condition, so when the temperature drops you will have to keep a closer watch on the battery. In cold weather do not let the specific gravity drop below 1.250. The electrolyte is subject to freezing; the exact freezing point depends on the specific gravity. In a fully charged battery the electrolyte will freeze at -90° . As the specific gravity drops, the freezing point rises. Figure 7 shows the freezing point for various specific gravities. If the battery electrolyte does freeze, the ice forces active material from the plates and can crack plates and containers. Let a frozen battery thaw out in a room at normal temperature before charging. In this way the battery can be saved if freezing has not already caused too much damage.

Specific gravity	Freezing point, degrees F
1.000	+32
1.100	+19
1.150	+ 5
1.200	-16
1.250	-62
1.280	-90

Figure 7. Specific gravity and freezing point.

c. The high temperatures found in the tropics create their own maintenance problems that you will have to adjust to if you are assigned in one of these areas. Rapid evaporation of the water will result due to the heat, so keep a close watch on the electrolyte level. Every effort should be made to keep the compartment, in which the batteries are installed, as cool as possible during and after operation. Do not obstruct ventilation or the heat will damage the batteries. At high temperatures the acid in the electrolyte is more active, so using a weaker solution will give good results and cause less damage to the plates and separators.

d. Electrolyte solution used for tropical climates should have a specific gravity of 1.200 to 1.225. You will have to weaken the solution yourself. Do this by drawing electrolyte from supply that is already mixed to 1.280 specific gravity; then add battery water until the mixture has a specific gravity of 1.200 to 1.225. You will need to add about 1 quart of water to 1 gallon of electrolyte.

e. If the battery was in use before it was sent to the tropics, change the electrolyte in the following manner. Make sure that the battery is fully charged so there will be no acid left in the plates. Then remove the vent plugs and tip the battery upside down to drain all the old electrolyte. Refill the battery with electrolyte that has been weakened to 1.200 to 1.225 specific gravity. Be careful to avoid getting any of the electrolyte on yourself or your clothes. The acid can cause painful burns and will eat holes in your clothing.

f. Figure 8 shows various specific gravities and the state of charge for batteries that contain weakened electrolyte for use in the tropics. When the electrolyte in a battery has been weakened, a tag showing the full charge specific gravity should be attached to the battery. These batteries should also be identified by painting a white dot about 1 inch in diameter on the top of the battery where it can be easily seen. Do not put the paint on top of the service date that is stamped on the battery.

Specific gravity of electrolyte used in tropical climates	State of battery charge
1.200 - 1.225	Fully charged
1.180	75%
1.135	50%
1.090	25%
1.045	Discharged

Figure 8. Tropical use.

7. BASIC METER CIRCUITS.

a. Unit personnel are not responsible for the repair of any major electrical malfunctions. Most electrical components are repaired and replaced by direct support maintenance personnel. Organizational maintenance personnel should, however, be familiar with the electrical wiring diagram and basic circuits which are likely to malfunction. They can greatly assist direct support maintenance personnel by reporting equipment malfunctions in detail and by isolating the problem when possible.

b. Organizational maintenance personnel should understand basic monitoring systems in the 500-ampere test stand. Meter movements by themselves are unable to measure high voltages or currents. When used in ammeter circuits, the larger part of the current to be measured is shunted around the meter movement; when used in voltmeter circuits, the current is kept at a low value by placing a high resistance in series with the meter movement.

c. A 2,000-ohm (2K), 50 microampere (50 μ A) meter movement is being used in the circuits illustrated in figures 9 and 10. The 2K states the internal resistance of the movement and the 50 μ MA states the amount of current required to deflect the movement's needle to the full scale mark. By using Ohm's law the voltage across the meter, when the meter is indicating full scale, can be determined:

Example:

- (1) $E = I \times R$
- (2) $E = (50 \times 10^{-6}) (2 \times 10^3)$
- (3) $E = 100 \times 10^{-3}V$
- (4) $E = .1V$

To use the meter movement by itself we would have to be satisfied with an ampere range of 0-50 μ A or a voltage range of 0-.1V. These ranges are unsatisfactory for most applications.

d. Figure 9 shows the simplified schematic diagram of a typical DC voltmeter. The meter movement and associated circuit provides voltage measurement ranges of 0-2.5VDC, 0-10VDC, 0-50VDC and 0-1,000VDC. When 2.5VDC is correctly applied between the negative meter input and the 2.5V Jack, 50 μ A will flow in the circuit and the meter will deflect to full scale. The current is limited to 50 μ A by the combination of the 48K resistance in the circuit and the 2K resistance of the meter movement.

Example

- (1) $E = I \times R$
- (2) $E = (50 \times 10^{-6}) (48 \times 10^3 + 2 \times 10^3)$
- (3) $E = (50 \times 10^{-6}) (50 \times 10^3)$
- (4) $E = 2,500 \times 10^{-3}$
- (5) $E = 2.5VDC$

The 48K resistor which was selected to be placed in series with the meter movement's resistance of 2K established the voltage which full scale deflection represents. Use Ohm's law to analyze the 10V, 50V, 250V and 1,000V ranges. In each case, 50 μ A will flow through the meter when the maximum voltage for the range is applied. The scales on the meter face are marked off in appropriate increments. When 2VDC is applied on the 2.5V range, the meter movement's pointer will move from zero to 4/5 of full scale. Therefore, the scale graduation at this point would indicate a 2VDC input.

e. Organizational maintenance personnel should be able to isolate the cause of simple meter malfunctions. The meter shown in figure 9 responds to voltages applied on the 2.5VDC, 10VDC and 50VDC ranges, but the pointer remains at zero when voltage is applied to the 250VDC or the 1,000VDC ranges. What is wrong? The answer to this question should be obvious to organizational maintenance personnel. When requesting repair they would state "R14

probably open" not "DC voltmeter bad." By being specific they can assist repair personnel and insure rapid return of the equipment to a serviceable condition.

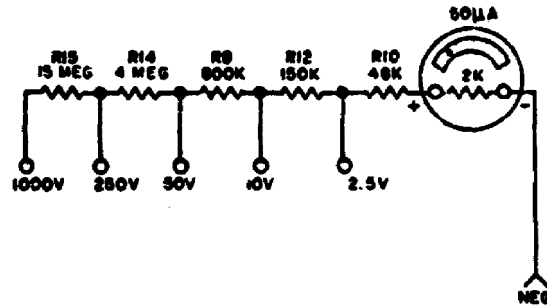


Figure 9. DC voltmeter.

f. Figure 10 shows the simplified diagram of a typical DC ammeter. The ammeter circuit must shunt most of the current being measured away from the meter movement. On the 10 milliampere (10mA) range, the meter movement resistance of 2K ohm is in series with the 3K ohm resistance of R11. R17, R18, R19 and R22 are in series with each other and are in parallel with R11 and the meter movement. Resistive values have been selected so that 50µA will flow through the meter and R11 and 9.950mA will flow through R22, R17, R19 and R18 when 10mA is being measured. The truth of this statement can be proved using Ohm's law. Let "x" be equal to the amount of current flowing through the meter when there is a 10mA current input to the circuit. The voltage across both parallel sections of the circuit must be equal so:

$$(1) \quad x(2K \div 3K) = (.01 - x)(.025 \div .475 \div 2 \div 22.5)$$

$$(2) \quad x(5K) = (.01 - x)(25)$$

$$(3) \quad 5000x = .25 - 25x$$

$$(4) \quad 5025x = .25$$

$$(5) \quad x = \frac{.25}{5025}$$

$$(6) \quad x = .0000497 \text{ ampere or } 49.7\mu\text{A}$$

Ohm's law proves the validity of the circuit; 49.7µA is close enough to 50µA to produce the required accuracy.

h. When the circuit selector switch is moved from the 10mA to the 100mA position, R18 is placed in series with R11 and the meter movement. This circuit change will allow a full scale deflection on the meter to be representative of a 100mA input current. Using Ohm's law, calculate the meter current at full scale under these circuit conditions. Again, your answer should be 49.7µA.

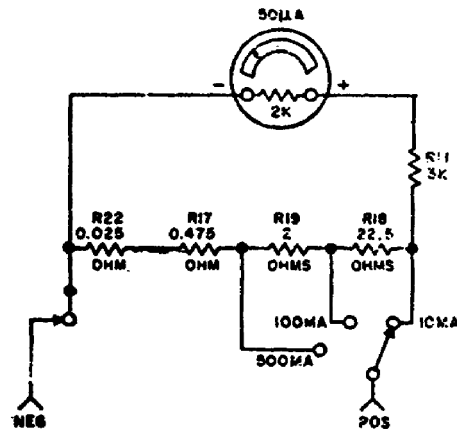


Figure 10. DC ammeter.

g. What you have learned about basic DC voltmeters and ammeters apply directly to five of the seven test stand metering circuits (fig 11). M1 through M5 on the schematic are representations of meter movements similar to the one discussed. Organizational maintenance personnel should be able to state the probable cause of a malfunction in meter circuits M1 through M5. Supervisors should check to insure that the reporting of malfunctions is as specific as possible. Specific reporting of malfunctions will help the repairman to quickly return the equipment to a serviceable condition.

8. ELECTRICAL WIRING DIAGRAM ANALYSIS (FIGURE 11).

a. Organizational maintenance personnel should be able to analyze the 500-ampere test stand electrical wiring diagram. You, as a supervisor, must be able to determine their ability to perform that task. An analysis of the 24VDC battery charging function of the test stand is included in this lesson. After reading this analysis you will know what should be expected from organizational maintenance personnel analyzing any function of the test stand.

b. AC power input to the test stand is converted to DC power and used for 24VDC battery charging. One phase of the AC input is applied to the primary of transformer T1 from the L1-L3 input. Closing CB1 completes the circuit from L1 through the knife switch to the right side of the T1 primary and completes the circuit from L3 to the left side of the T1 primary. The AC power coupled to the T1 secondary powers the 0-32VDC supply, 0-28VDC supply, and 28VDC supply. When CB1 is closed DS1 will illuminate, indicating that AC power has been applied to this part of the circuit.

c. AC power is connected from the secondary of T1 to the primary of T6 when CB6 is closed. AC power coupled to the secondary of T6 is rectified by bridge rectifier CR3. The 28VDC rectified output, existing between wires P56 and P49, energizes several relays if CB7 is closed. S20, the battery voltage selector, would be in the 24V position for 24VDC battery charging. Therefore, the K7 relay would be energized and DS7 would illuminate. The ground polarity switch should be in the (-) position, thus energizing relay K9. The regulator load resistor selector (S24) is set to OFF, which allows K11 to energize.

This is a complex electrical wiring diagram for a vehicle's powertrain and auxiliary systems. The diagram includes the following major sections:

- Power Input Section (Top Left):** Shows a 60V 3-phase input connected through fuses (F1, F2) and circuit breakers (CB1, CB2) to various components.
- Generator/Alternator Section (Top Right):** Details the internal connections of a generator or alternator, including field windings, armature, and brush holder assembly.
- Battery and Charging System (Bottom Left):** Illustrates the battery bank, a battery charger, and associated voltage regulators and switches for starting and charging.
- Control and Monitoring Circuits (Center):** Includes a tachometer, a pulse calculator (PUL-CAL), and various interlocking circuits for safety and operational control.
- Wiring Harness Connections (Right Side):** A dense network of wires connecting the main components to terminal blocks labeled with letters (A-M) and numbers (1-12).
- Labels and Components:** Numerous labels identify specific parts such as "GENERATOR FIELD", "BATTERY REGULATOR", "ARMATURE REGULATOR", "FIELD + REGULATOR", "LOAD BANK SELECTOR", "TACHOMETER", "PULSE CALCULATOR", "CHARGE INDICATOR", "STOP", "START", "BLOWER", "DRIVE ON", "OFF", "ON", "LAMP", "RELAY", "CONTACTOR", "CIRCUIT BREAKER", "FUSE", "SWITCH", "MOTOR", "SOLENOID", "VALVE", "COIL", "INDUCTOR", "CAPACITOR", "RESISTOR", "DIODE", "TRANSFORMER", "INDUCTION MOTOR", "SYNCHRONOUS MOTOR", "ASYNCHRONOUS MOTOR", "DIRECT CURRENT MOTOR", "ALTERNATING CURRENT MOTOR", "ELECTRIC MOTOR", "ELECTRIC GENERATOR", "ELECTRIC ALTERNATOR", "ELECTRIC DYNAMO", "ELECTRIC MACHINE", "ELECTRIC APPARATUS", "ELECTRIC EQUIPMENT", "ELECTRIC SYSTEM", "ELECTRIC CIRCUIT", "ELECTRIC WIRING", "ELECTRIC CONNECTION", "ELECTRIC LINK", "ELECTRIC JUNCTION", "ELECTRIC TERMINAL", "ELECTRIC POINT", "ELECTRIC END", "ELECTRIC BEGINNING", "ELECTRIC START", "ELECTRIC FINISH", "ELECTRIC COMPLETION", "ELECTRIC OPERATION", "ELECTRIC FUNCTION", "ELECTRIC ACTION", "ELECTRIC REACTION", "ELECTRIC INTERACTION", "ELECTRIC COOPERATION", "ELECTRIC COLLABORATION", "ELECTRIC ASSISTANCE", "ELECTRIC SUPPORT", "ELECTRIC BACKUP", "ELECTRIC REDUNDANCY", "ELECTRIC CONTINGENCY", "ELECTRIC EMERGENCY", "ELECTRIC SAFETY", "ELECTRIC PROTECTION", "ELECTRIC SECURITY", "ELECTRIC GUARANTEE", "ELECTRIC WARRANTY", "ELECTRIC INSURANCE", "ELECTRIC RISK", "ELECTRIC LIABILITY", "ELECTRIC OBLIGATION", "ELECTRIC RESPONSIBILITY", "ELECTRIC ACCOUNTABILITY", "ELECTRIC TRANSPARENCY", "ELECTRIC INTEGRITY", "ELECTRIC HONESTY", "ELECTRIC FAITHFULNESS", "ELECTRIC LOYALTY", "ELECTRIC COMMITMENT", "ELECTRIC DEDICATION", "ELECTRIC PASSION", "ELECTRIC ENTHUSIASM", "ELECTRIC ENERGY", "ELECTRIC VIGOR", "ELECTRIC ZEST", "ELECTRIC SPIRIT", "ELECTRIC MOOD", "ELECTRIC TEMPERAMENT", "ELECTRIC CHARACTER", "ELECTRIC PERSONALITY", "ELECTRIC IDENTITY", "ELECTRIC ESSENCE", "ELECTRIC CORE", "ELECTRIC HEART", "ELECTRIC SOUL", "ELECTRIC SPIRIT", "ELECTRIC GHOST", "ELECTRIC PHANTOM", "ELECTRIC GHOST", "ELECTRIC PHANTOM", "ELECTRIC GHOST", "ELECTRIC PHANTOM".

OS 010, 7-P15

[illegible]

OS 010, 7-P15 (continued)

d. When CB4 of the 0-28VDC supply is closed and the battery charger timer has been properly activated, closing S2, AC power is applied from the T1 secondary to DS3 and T4. The illumination of DS3 indicates that AC power is available in this part of the circuit. The AC power from T4 to the primary of T5 is controlled by the setting of the battery charger control located on the front panel. When the control is fully counterclockwise, the wiper arm of T4 has been moved down and no power is applied to the T5 primary. When the control is rotated clockwise, the AC power to the T5 primary is increased. The available AC power coupled to the secondary of T4 is rectified by bridge rectifier CR2. The output of CR2 ranges from 0-28VDC as T4 wiper is moved from the counterclockwise position. The voltage output of the rectifier is between P20 and P73 when CB5 is closed. To provide a charging current to the batteries, the voltage output of the rectifier must be slightly higher than the voltage output of the batteries.

e. Meter movement M4 and associated circuitry is used to monitor the voltage being applied to the batteries. The 50VDC range is used for 24VDC battery charging. To make the measurement a small current is drawn from the CR2 rectifier. This current flows from the negative side of the rectifier through connection P20 to the B- battery regulator terminal. A bus bar link (not shown on the electrical wiring diagram) connects the B-battery regulator terminal to the G- armature regulator terminal. The current, therefore, flows from B- to G- and along P68. You should note that P68 and the negative side of the CR2 rectifier were placed at case ground when relay K9 energized and closed contacts K9-1. The current flowing in P68 flows to S13, the DCVM range selector. With S13 set to the 50V range, the current is directed through R25 and the M4 meter movement. The voltmeter circuit selector S14 is in the BAT position so the current from the meter will flow through the switch and along P21. The current then flows through closed contacts K11-1 and K7-1, along P4 to R42, through R42 to P73, CB5, and P74. This monitoring current exists only when the output of the 0-28VDC supply is set to an output slightly higher than the battery voltage. When the 0-28VDC supply output is set too low, the current to deflect the meter is drawn from the battery.

f. The current in the voltage monitoring circuit is less than 1mA, while the battery charging current is normally several amperes. This current from the negative side of CR2 flows along P20 to R35, R33, and R31. P1 provides the connection from R31 to the negative side of the batteries. This charge current flows from negative to positive through the batteries reversing the normal chemical reaction and restoring the batteries to full charge. From the positive terminal of the battery the charge current flows along P4, through R42, along P73, through CB5, and along P74 returning to the positive side of rectifier CR2.

g. The charge current is monitored by two ammeter circuits. The load and starter DC ammeter (M1 and associated circuits) monitors the current to the negative battery terminal. It is set to the 50A range during the charging process. The field and battery charger DC ammeter (M2 and associated circuits) measures the charge current coming from the positive battery terminal plus the small monitoring current used by the DC voltmeter circuit. The field current range selector (S10) is set to the 30A DC position during the charging process. It was mentioned before that the DC voltmeter monitor current is extremely small; therefore, both ammeters will indicate the same current flow, for all practical purposes. When a noticeable difference in meter readings exists, there is something wrong. Usually the problem can be traced to the battery compartment. The spillage of electrolyte or the accumulation of dirt and grime in this area can cause undesirable paths for current flow.

h. Organizational maintenance personnel should be able to give a general explanation of all test stand functions. The discussion of 24VDC battery charging is an example of the type of explanation you, as a supervisor, should expect from these personnel. Remember, they are highly skilled

but are not electrical engineers. By observing and listening you can determine the skill level of your personnel. Once this is determined you can initiate actions which will develop their skills. This will allow you to meet the supervisor's training responsibility and increase the effectiveness of your organization.

9. SUMMARY. During this lesson you have become familiar with many details which you must know to adequately supervise 500-ampere test stand maintenance. Your knowledge of the preventive maintenance, maintenance, troubleshooting, and repair tasks will enable you to provide informed supervision. Proper utilization of the information contained in this lesson will allow you to maintain control of the operational situation for which you are responsible.

EXERCISE

Note. - Refer to the exercise directions in lesson 1.

106. Which item is inspected by the operator/crew during operation?
- a. Meters
 - b. Lamps
 - c. V-belts
107. Which item is inspected weekly by the operator/crew?
- a. Stowage compartments
 - b. Test leads and cable harness
 - c. Toggle, selector, and control switches
108. Which item is inspected by the operator/crew after operating the test stand?
- a. Knobs
 - b. Speed control
 - c. Gearcase level
109. Which item can be safely inspected with the main circuit breaker switch ON?
- a. Blower motor fuses
 - b. Varidrive reversing switch
 - c. Regulator resistor fuses and fuse holders
110. What is the lowest level of maintenance responsible for replacing the antistatic coating on meters?
- a. Operator/crew
 - b. Organizational
 - c. Direct support
111. The gearcase oil level is found to be low when you are making a supervisory check on the test stand. Who should you contact?
- a. Operator/crew personnel
 - b. Organizational maintenance personnel
 - c. Direct support maintenance personnel
112. What should be done when lubricating the varidisc hub rear bearing?
- a. Remove plugs PRI completely
 - b. Use general purpose lubricating oil 2190
 - c. Run test stand five minutes before replacing RT1

113. To properly lubricate the varidrive motor rear bearing, how much grease, in cups, must be forced through the bearing?
- a. 1/4
 - b. 1/2
 - c. 1
114. How often should the oil be drained from the gearcase under normal conditions?
- a. W (weekly)
 - b. S (semiannually)
 - c. A (annually)
115. What is used to clean the top of a lead-acid battery?
- a. Carbon tetrachloride
 - b. Baking soda and water
 - c. Drycleaning solvent (SD)
116. What identifies a battery adapted for use in tropical climates?
- a. White dot about 1 inch in diameter on top of the battery
 - b. Red band about 2 inches wide around the battery
 - c. Yellow vent plugs
117. What is the potential, in volts, across a 2,000-ohm, 50-microampere meter movement when it is reading full scale?
- a. 0.1
 - b. 2.5
 - c. 4.0
118. What value resistor (ohms) must be placed in series with a 2,000-ohm, 50-microampere meter movement to make full scale deflection representative of a 2.5VDC input?
- a. 998K
 - b. 198K
 - c. 48K
119. What value shunt resistor (ohms) must be used with a 50 microampere, 2,000-ohm meter movement to make full scale deflection representative of a 20-ampere input?
- a. 0.025
 - b. 0.010
 - c. 0.005
120. Which control is used to set the correct battery charging voltage?
- a. Battery charger timer
 - b. Battery charger control
 - c. Battery voltage selector

C O R R E S P O N D E N C E C O U R S E
o f t h e
U S A R M Y O R D N A N C E
C E N T E R A N D S C H O O L



LESSON ASSIGNMENT

Ordnance Subcourse No 010..... Electrical System Component Repair

Lesson 8..... Maintenance of Electrical System Test Equipment

Credit Hours..... Four

Lesson Objective..... After studying this lesson you will be able to explain operator, crew, and organizational maintenance personnel responsibilities as they apply to the:

1. Armature test set.
2. Ignition timing light.
3. Magneto timing light.
4. Magneto test stand.
5. Distributor tester.
6. Heater test stand.
7. TS-352 B/U multimeter.
8. Low voltage circuit tester.

Text..... Attached Memorandum

Materials Required..... Response list and answer sheet

Suggestions..... Study the figures carefully as you study the text.

ATTACHED MEMORANDUM

1. INTRODUCTION.

 a. This lesson will familiarize you with several additional items of equipment used to service and maintain a wide variety of motor vehicles. These items will require your attention as a supervisor. While studying this lesson you should try to develop an understanding of the tasks which your operator/crew and organizational maintenance personnel must perform.

b. Remember, as a supervisor, the responsibility for both men and equipment is yours. You must by observation assure yourself of equipment condition. You must check the state of training within your organization and arrange for additional training experiences to keep your personnel informed. The supervisor must stress the applicability of the general inspection task to all items of organizational equipment. Performance of this task will materially reduce the cost of maintenance and equipment downtime.

c. The primary function of preventive maintenance is to prevent breakdowns and therefore the need for repair. Time intervals are based on normal operations. A month, for example, is defined as approximately 30 calendar days of 8-hour-per-day operation. If equipment is operated 16 hours a day, the monthly preventive maintenance checks and services should be performed at 15-day intervals. Adjustment of maintenance intervals must be made to compensate for any unusual operating conditions.

2. ARMATURE TEST SET MAINTENANCE.

a. Maintenance personnel perform a wide variety of tests on starter and generator armatures using the armature test set (fig 1). The test set operates on 115-volt, 60-hertz power and is housed in its own steel case. There are three basic circuits in the test set: growler circuit, ammeter circuit, and test lamp circuit.

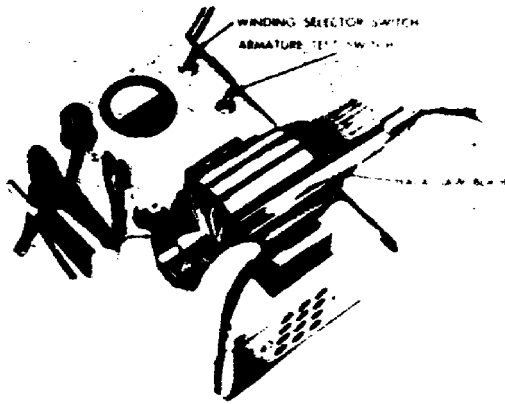
b. A primary coil and a portion of the iron of a transformer form the growler circuit. Positioning the armature under test completes this magnetic circuit. Passing an alternating current through the growler primary sets up an alternating magnetic field around the armature under test. This approximately reproduces the magnetic effect under which the armature normally operates. Under these simulated conditions the repairman can perform the short test, open test, and ground test on armatures.

c. The ammeter circuit is activated by induced current generated in the armature being tested on the growler circuit. The ammeter indicates the flow of current through each armature coil in relation to the other coils as the armature is slowly rotated. Reversed coils, open circuits, and incorrect number of turns can be located by observing the ammeter indications.

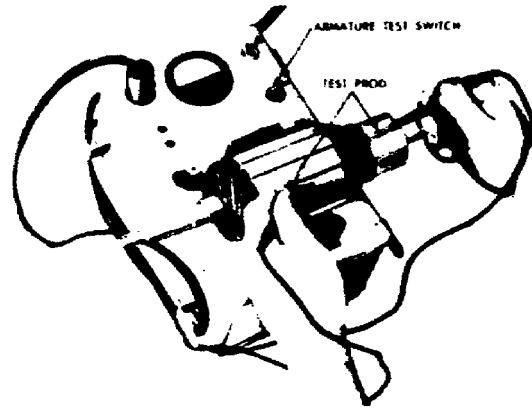
d. The test lamp circuit is used in testing brush holders for grounds, armatures for grounds, and field coils for grounds and open circuits. The lamp is powered directly from the powerline. Test probes are connected to the lamp by leads and are used to complete the circuit when performing tests.

e. The armature test set can be used to magnetize or demagnetize tools and other iron objects. 'Manufacturer's instructions must be followed closely to avoid damage to the test set during magnetizing or demagnetizing operations.

f. Maintaining the armature test set is an easy task. So easy that there is a tendency to neglect it. Supervisors must insure that the Job is being done by making occasional observations of the equipment. The operator should check the equipment for completeness and general condition daily. Exterior surfaces and receptacles must be clean and undamaged. The meter glass should be clean and unbroken. The meter must be static free and properly zeroed. During operation switches are checked for proper mechanical action and the operator must be alert for abnormal indications.



Testing armature for shorted condition.



Testing armature for grounds.

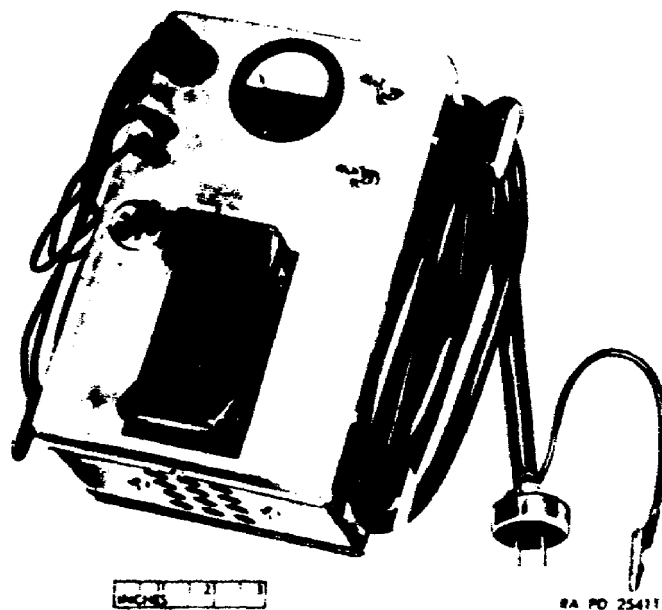


Figure 1. Armature test set.

g. During weekly maintenance checks external wiring is inspected for cracks, cuts, fraying, and kinks. The equipment should be free of bare spots, rust, and corrosion. "All screws, brackets, and other external hardware should be secure and ,undamaged. Monthly maintenance includes all of the actions above plus a check for possible MWO's and technical publication changes.

h. The three circuits in the armature test set are very basic and good troubleshooting techniques will isolate problems quickly. A defective meter, burnt-out bulb, and defective switch or transformer are corrected by replacement. Open and shorted circuits can be repaired or replaced easily. When properly maintained the armature test set will give many years of trouble-free service.

3. IGNITION TIMING LIGHT MAINTENANCE.

a. The ignition timing light (fig 2) is a simple electrical device used by maintenance men to set the ignition timing of engines. The light is activated by the high voltage surge to a specific spark plug on the engine used as a timing reference (usually the number 1 cylinder plug). The light flashes allow the maintenance man to observe the timing of the engine while it is running and adjust the distributor for peak engine performance.

b. Supervisors when checking this instrument should pay particular attention to the condition of the leads and overall cleanliness of the instrument. The operator is responsible for cleaning the instrument and is required to check the condition of the leads before and after use. During use the operator checks for overheating and erratic light operation.

c. The ignition timing light is an essential item which is normally trouble free. A simple, basic, circuit design makes rapid troubleshooting and repair possible. Malfunctioning components and open or shorted wires can be quickly located by repairmen with good troubleshooting techniques. Continuity checks are normally used when troubleshooting this equipment.

4. MAGNETO TIMING LIGHT MAINTENANCE.

a. Maintenance men use the magneto timing light (fig 3) to obtain breaker point synchronization. Efficient firing of the combustible mixture in the engine cylinders is accomplished by means of identically delivered magneto ignition sparks. This equipment is used for synchronizing two sets of breaker points on a single magneto, or for synchronizing two different magnetos to the same engine.

b. Operators should inspect the leads, case and headphone prior to energizing the circuit. Then the toggle switch is placed to the ON position. Both lamps should light and the audio tone of the vibrator should be heard on the headphone. If the lamps and vibrator operate, the battery can be Judged "OK" and the equipment is ready to use.

c. During operation the equipment user should check for correct lamp operation and overheating. The operator's after-operation procedure requires a cleaning and general inspection of the instrument.

d. Periodically the battery should be checked with a voltmeter (1,000 ohms per volt or better). Replace the battery when the voltage drops below 4 volts with the magneto timing light ON. Check lamp sockets, headphone jack, and vibrator socket for dirt and corrosion during periodic servicing. The frequency of periodic services should be determined by the individual unit. If, for example, battery failure is occurring during normal daily operations, the frequency of periodic checks should be increased.

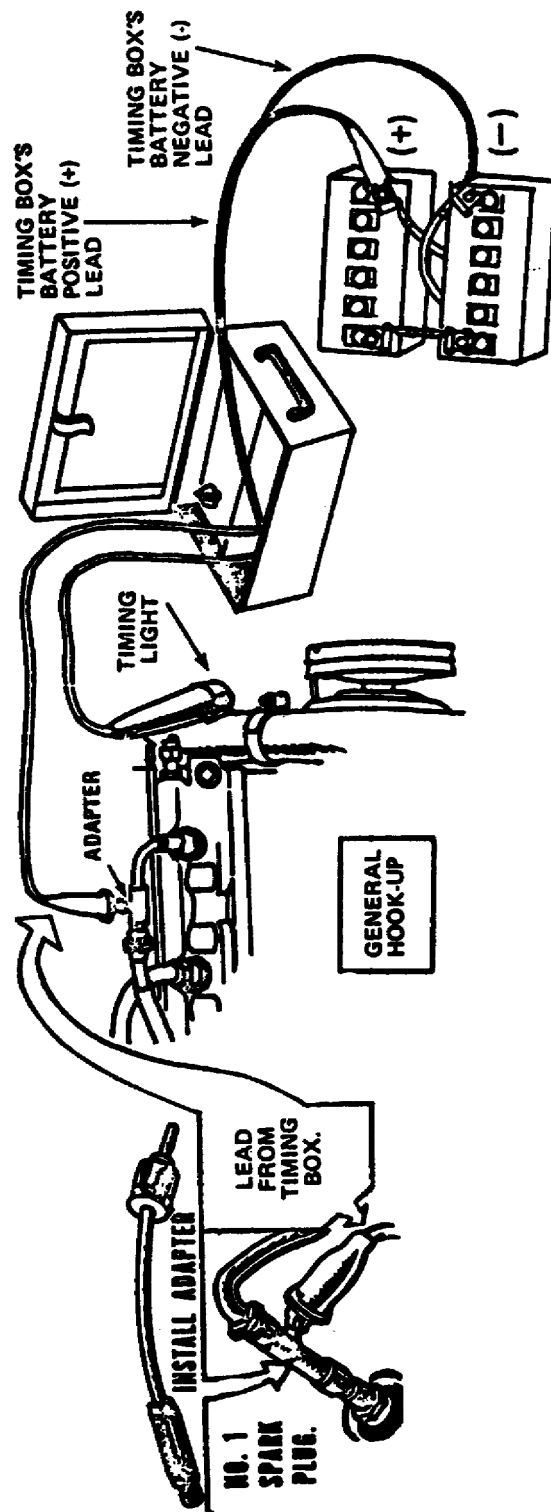


Figure 2. Ignition timing light.

e. Troubleshooting of an inoperative magneto timing light should begin with a battery check. If the battery checks out OK, a multimeter should be used to make a continuity check of the switch and then a continuity check of the transformer primaries. Vibrator operation should then be checked if the battery, switch, and transformer primaries check out OK. Glow lamps and transformer secondaries are checked out next. The small capacitors connected across each glow lamp provide a leakage path and cause both lamps to glow. When a capacitor is open the associated lamp will not light. If only one lamp lights switch the bulbs to determine that both lamps are OK. If both lamps are OK, then the capacitor across the inoperative circuit is open. Following this troubleshooting sequence will find the problem quickly and the malfunctioning component can be replaced. All leads and interconnecting wires should be checked for continuity during this troubleshooting sequence.

5. MAGNETO TEST STAND MAINTENANCE.

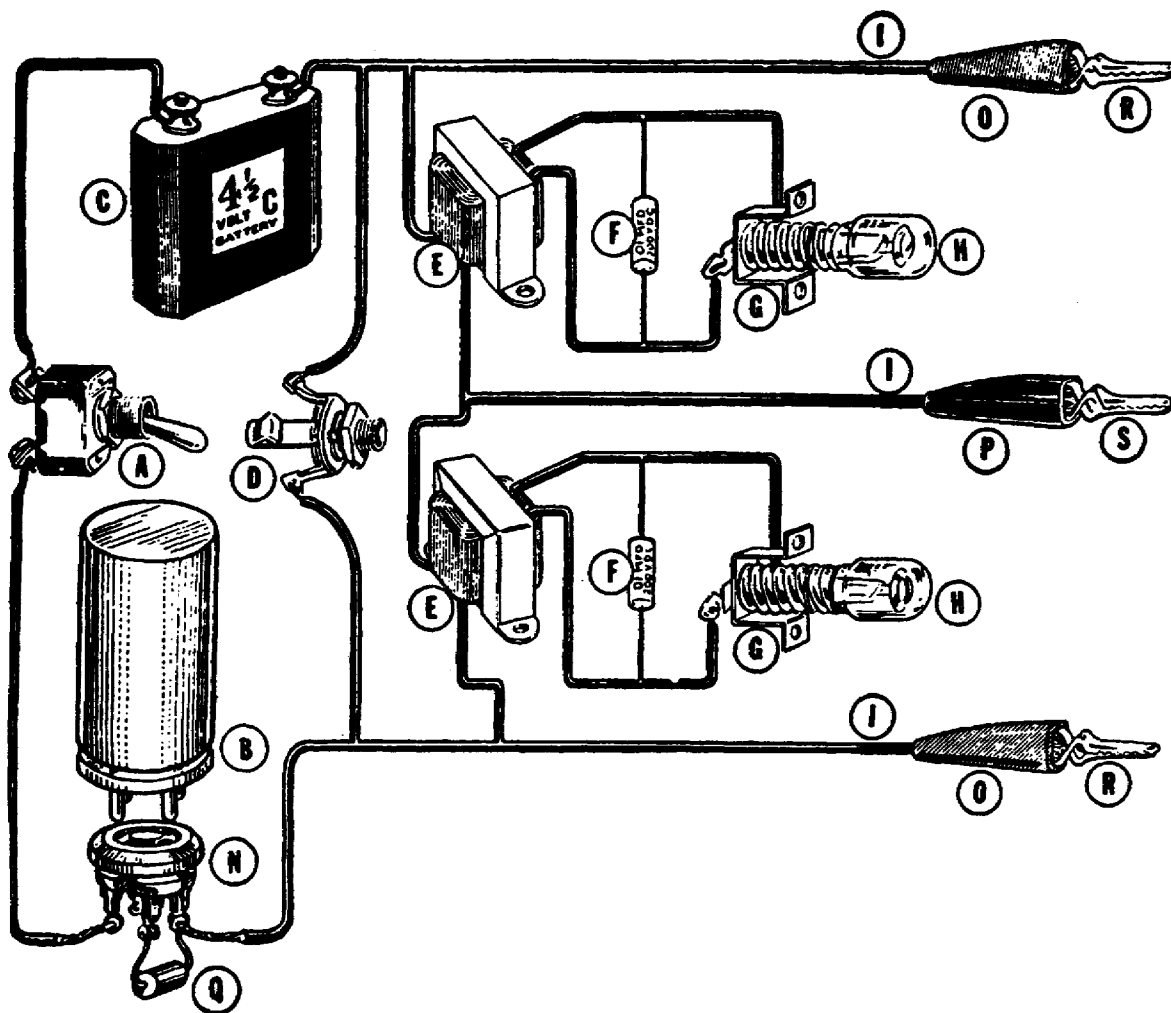
a. The magneto test stand (fig. 4) is designed to functionally test various ignition magnetos over a variable speed range of 0-4,200 RPM (revolutions per minute). Connection to a 220/440-volt, 3-phase, 60-hertz, electrical power source is required. All test stand components are housed within a steel cabinet assembly. Magneto mounting adaptor and instrument and control panel components are conveniently located and clearly nameplated for ease of operation. The removable cover completely encloses the instrument and control panel when the instrument is not in use. Magneto ignition capacitors, including feed-through types, can be checked for capacitance, series resistance, ground, and leakage resistance on the test stand.

b. Normal daily and monthly maintenance and lubrication services are listed in figure 5. This schedule is intended as a guide and should be adjusted to meet specific local conditions. Top speed (4,200 RPM) will decrease as the drivebelt wears. When this occurs, maintenance men will have to make the variable speed drive high speed stop adjustment listed in the technical manual. A check for top speed can be done quickly by the supervisor during his regular inspection of the equipment. This check, plus a visual inspection of the test stand, can help the supervisor in determining the quality of maintenance being performed by his unit.

c. A regular schedule for calibrating the capacitor tester section of the test stand should be established by the unit. Environmental conditions and frequency of use will have a bearing on what time interval is appropriate. The procedure for calibrating the capacitor tester section is in the technical manual. Small adjustments are normally required during calibration. The need to make large adjustments would indicate that the frequency of calibration should be increased.

6. DISTRIBUTOR TESTER MAINTENANCE.

a. The distributor tester (fig 6) is an electrically operated device for testing battery ignition distributors removed from the engine. Using the tester, maintenance personnel can determine if a distributor will meet specific tolerances required for satisfactory operation when installed on an engine. A variable speed device, consisting of a belt-driven cone, movable idler, and disk, is used to control the speed and direction of rotation of the distributor under test. The variable speed device is driven by an electric motor which operates from 115 volts, 60-Hz, single-phase, line power. Manifold vacuum is simulated by a vacuum pump which is an integral part of the variable speed device. A stroboscope is provided for accurately checking cam angle, spark advance, and cam lobe accuracy. Both single and dual breaker point distributors can be tested. A tachometer measures the revolutions per minute of the distributor shaft.

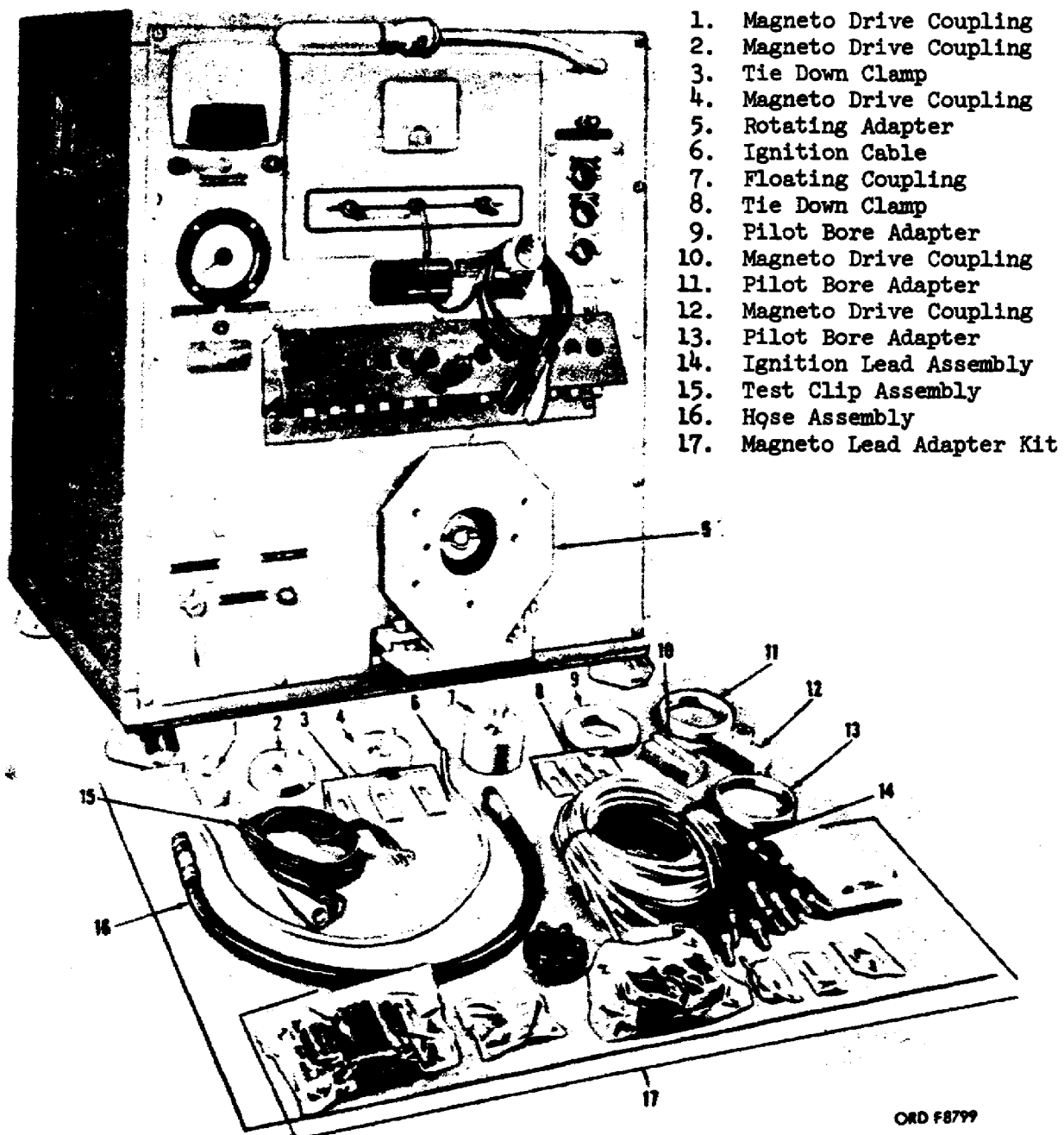


A-Toggle switch
 B-Vibrator
 C-Battery
 D-Headphone jack
 E-Transformer
 F-Capacitor
 G-Lamp socket
 H-Glowlamp

I-Test lead wire
 N-Vibrator
 O-Clip insulator (red)
 P-Clip insulator (black)
 Q-Resistor
 R-Alligator clip (positive)
 S-Alligator clip (negative)

Figure 3. Circuit diagram and parts identification-magneto timing light.

b. Operators are responsible for performing daily preventive maintenance and for assisting organizational maintenance men in performing scheduled periodic services. Before-, during-, and after-operation preventive maintenance checks are detailed in figure 7. Figure 8 details the operator's troubleshooting responsibilities. Operators are not supplied repair parts, so most malfunctions are referred to organizational maintenance personnel for correction.



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Figure 4. Test stand, ignition magneto.

ITEM	PERIOD	PROCEDURE
Hardware	Daily	Check for loose or defective hardware. Tighten or replace part as required.
Test Stand	Daily	Clean all accumulated dirt from interior and exterior.
Drive Belts	Daily	Check for wear or breakage. Check V-belt tension, tighten as required. Replace as required.
Air Compressor	Monthly	Remove air intake filter and clean in solvent. Federal Specifications, P-S-661. Dry and replace.
Vari-Drive	Monthly	Lubricate at zerk fittings, accessible from the back of the stand. Use a good grease similar to MIL-G-21164.

Figure 5. Maintenance and lubrication schedule.

c. Organizational maintenance is provided the repair parts, tools, and equipment necessary to accomplish most repairs on the distributor tester. Figure 9 details their preventive maintenance and troubleshooting responsibilities. Except for the vacuum pump piston and valve, all moving parts of the tester are lifetime lubricated. Lubrication of the pump is accomplished by applying six drops of OAI instrument oil (9150-257-5449) through the vacuum hose while the pump is running. Under normal conditions this should be done every 60 days.

7. HEATER TEST STAND MAINTENANCE.

a. Several models of personnel and engine heaters can be performance tested using the heater test set (FSN 4910-671-6613). The test set (fig 10) may be operated from a 120-volt, 60-Hz, single-phase, AC power source or from a storage battery power source. The test set is equipped with complete controls and accessories for operating the heater under test. The test set incorporates a cradle for mounting the heater being tested. Fuel tank, fuel filter, and electric fuel pump supply fuel to the heater. A voltmeter and ammeter measure the current and voltage being supplied to the heater. An air pressure gage measures the combustion and ventilating air blower output. A fuel flowmeter determines the rate of fuel flow through the heater fuel control valve.

b. A circuit analyzer (fig 11) is one of the accessories of the heater test stand. It can be used during all phases of operation to check heater electrical circuits. The analyzer can be used with the heater installed in the vehicle or with it mounted on the test set. Its voltage selector switch makes the analyzer adaptable for use with 6-, 12-, and 24-volt heater units. Maintenance men can easily check the electrical circuits of a heater by properly connecting the circuit analyzer and observing its indicator lights as they follow the checkout procedure.

c. Operator preventive maintenance is confined to the inspection of gages, switches, fuel lines and fittings, exhaust duct, air pressure lines, and electrical wiring cables and connections. Organizational maintenance is responsible for periodic service and testing of the test set. Organizational preventive maintenance checks and services are shown in figure 12.

d. Testing of the test set is accomplished by organizational maintenance personnel utilizing the procedures listed below, the schematic wiring diagram (fig 13), and the troubleshooting chart (fig 14). Satisfactory completion of the procedures insures proper operation of the test set.

- (1) Place all test set panel ON-OFF switches in OFF positions.
- (2) Connect the test set to a 120-volt, AC, 60-hertz, power supply.

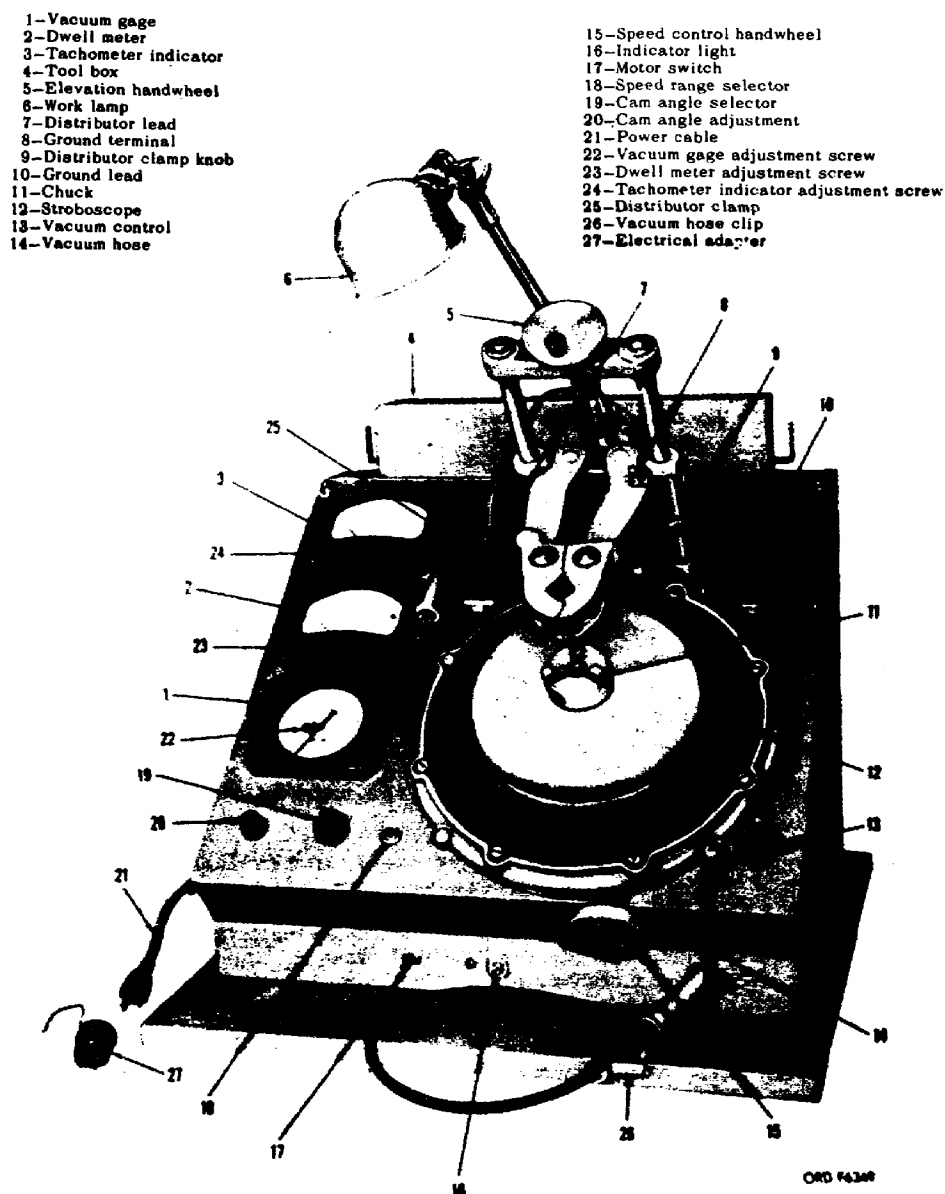


Figure 6. Distributor tester.

Interval and sequence			Daily Schedule	
Before operation	During operation	After operation	Items to be inspected	Procedure
1	---	---	Cables and leads----	Inspect each cable and lead for frayed insulation and other damage.
2	---	---	Switches-----	Snap switches and check for positive action. After check make sure all switches are in the "off" position.
3	---	---	Meters-----	Zero all meters-----
	4	---	Unusual operational noises or vibration.	Loosen distributor jaws slightly and turn distributor right or left to center drive shaft.
		5.	Distributor tester--	Wipe all grease and dirt from the tester. Remove equipment, store in its proper place and cover the tester.

Figure 7. Preventive maintenance checks and services.

Malfunction	Probable cause	Corrective action
1. Distributor tester fails to start.	a. Power cable not connected-----	a. Insert plug of power cable into power source receptacle so it makes good contact.
	b. Other causes-----	b. Refer other causes to organizational maintenance personnel for correction.
2. Work lamp fails to light-----	-----	Refer malfunction to organizational maintenance personnel for correction.
3. Tester chatters or vibrates under speed.	a. Shaft or distributor off center--	a. Loosen distributor clamp and center distributor shaft.
	b. Rubber jaws on distributor chuck set before distributor clamp was tightened.	b. Loosen distributor clamp and distributor chuck, align distributor and tighten distributor clamp and chuck jaws. Tighten clamp before chuck jaws are set.
	c. Other causes-----	c. Refer other causes to organizational maintenance personnel for correction.
4. Vacuum pump fails to create desired vacuum control to distributor.	a. Vacuum hose not tight on adapter of vacuum control.	a. Secure vacuum hose tightly on adapter.
	b. Other causes-----	b. Refer other causes to organizational maintenance personnel for correction.
5. Speed meter, cam dwell meter, and vacuum meter do not register same upon testing more than one distributor.	a. Meters not zeroed-----	a. Zero each meter prior to testing each distributor.
	b. Other causes-----	b. Refer other causes to organizational maintenance personnel for correction.

Figure 8. Troubleshooting.

- (3) Place voltmeter INT-EXT switch in INT position.
- (4) Place ammeter IN-OUT switch in IN position.
- (5) Place CIRCUIT BREAKER in ON position.
- (6) Place VOLTAGE SELECTOR switch in 6V, 12V, or 24V position.
- (7) Place CIRCUIT SELECTOR switch in A position.

(8) Place AC-OFF-DC switch in AC position.

(9) Check operation of voltage regulator for regulation from 0 to 30 volts as indicated on VOLTMETER. Set for 6-, 12-, or 24-volt indication.

Preventive-Maintenance Checks and Services

Monthly Schedule

Sequence number	Item to be inspected	Procedure
1.	Work lamp ----	Check for damaged or frayed wire. Replace unserviceable incandescent lamp.
2.	Electrical clips	Straighten bent electrical clips or replace as necessary ----
3.	Electrical cable nipples.	Replace cracked or damaged electrical cable nipples ----
4.	Vacuum pump --	Start the tester, clip the vacuum hose and check to see if vacuum will reach its maximum on vacuum gage.
5.	Tester case and control panel.	Check for dents and exposed surfaces. Straighten dents, tighten loose screws, and paint exposed surfaces.

Troubleshooting

Malfunction	Probable cause	Corrective action
1. Distributor -----	a. Drive belt loose -----	a. Remove back from tester and tighten or replace belt
	b. Other causes -----	b. Refer other causes to field maintenance personnel.
2. Work lamp fails to light ----	a. Incandescent lamp burned out	a. Replace incandescent lamp
	b. Other causes -----	b. Refer other causes to field maintenance personnel.
3. Tester chatters or vibrates under speed.	a. Hold-down bolts loose -----	a. Check tester for looseness on the bench, tighten hold-down bolts.
	b. Other causes -----	b. Refer other causes to field maintenance personnel.
4. Vacuum pump fails to create desired vacuum control to distributor.	a. Pump piston or valve dry ----	a. Check lubrication record for dates of lubrication, apply oil in vacuum hose to lubricate pump parts.
	b. Other causes -----	b. Refer other causes to field maintenance personnel.
5. Speed meter, cam dwell meter, and vacuum meter do not register same when distributor is tested the second time.	-----	Refer malfunction to field maintenance personnel for correction.
6. Electrical clips do not make positive connection.	a. Electrical clips bent from rough usage.	a. Straighten electrical clips
	b. Electrical clips burned.	b. Clean electrical clips
	c. Electrical clips broken by rough usage.	c. Replace electrical clips
7. Electrical cable nipples do not insulate electrical clips properly.	a. Electrical cable nipples crushed or cut.	a. Replace electrical cable nipples
	b. Electrical cable nipples deteriorated.	b. Replace electrical cable nipples

Figure 9. Organizational responsibilities.

(10) Make sure test set fuel tank is empty or pipe plug is sealing fuel outlet at left rear of test set top.

(11) Place test set switch A in HI position and then in LO position. Test set fuel pump should operate when switch is in either position.

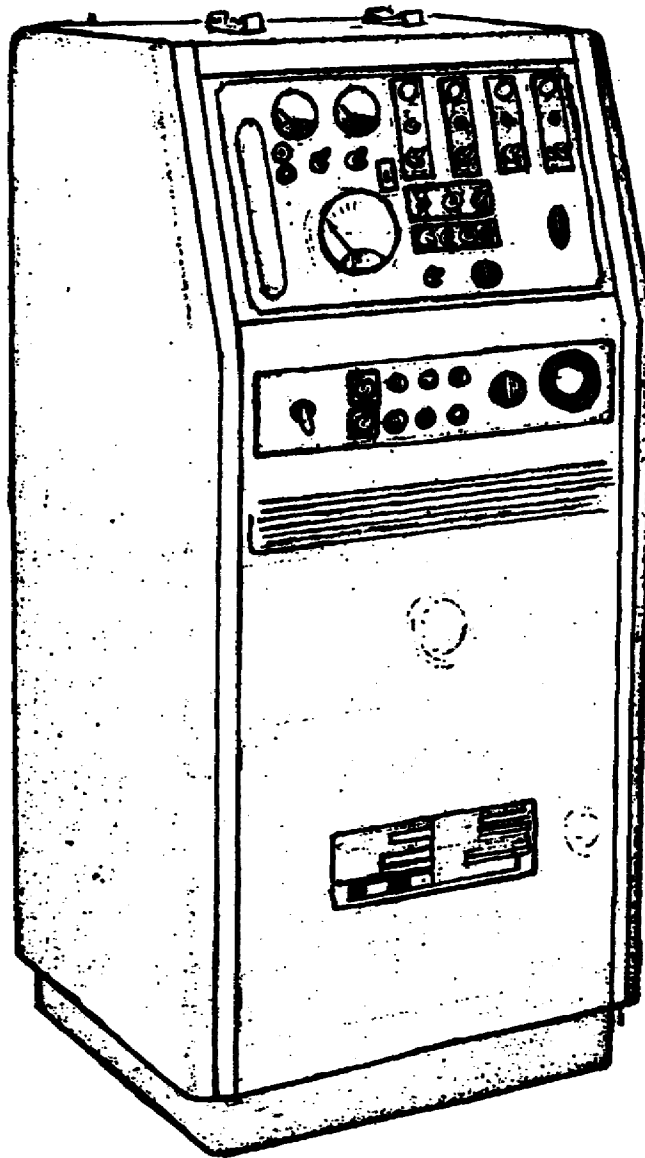


Figure 10. Model HT-1 heater test set.

(12) Connect a Jumper wire from pin C of receptacle A to pin A of receptacle A. Indicator light A should remain illuminated when switch A is in HI, LO, and OFF positions.

(13) Connect a Jumper wire from pin C of receptacle A to pin B of receptacle A. Indicator light A should illuminate only when switch A is in HI or LO position.

(14) Connect a Jumper wire from pin C of receptacle A to pin D of receptacle A. Indicator light A should illuminate only when switch A is in HI position.

(15) Place CIRCUIT SELECTOR switch in B position.

(16) Place test set switch B in RUN position. Fuel pump should operate only when switch is in this position.

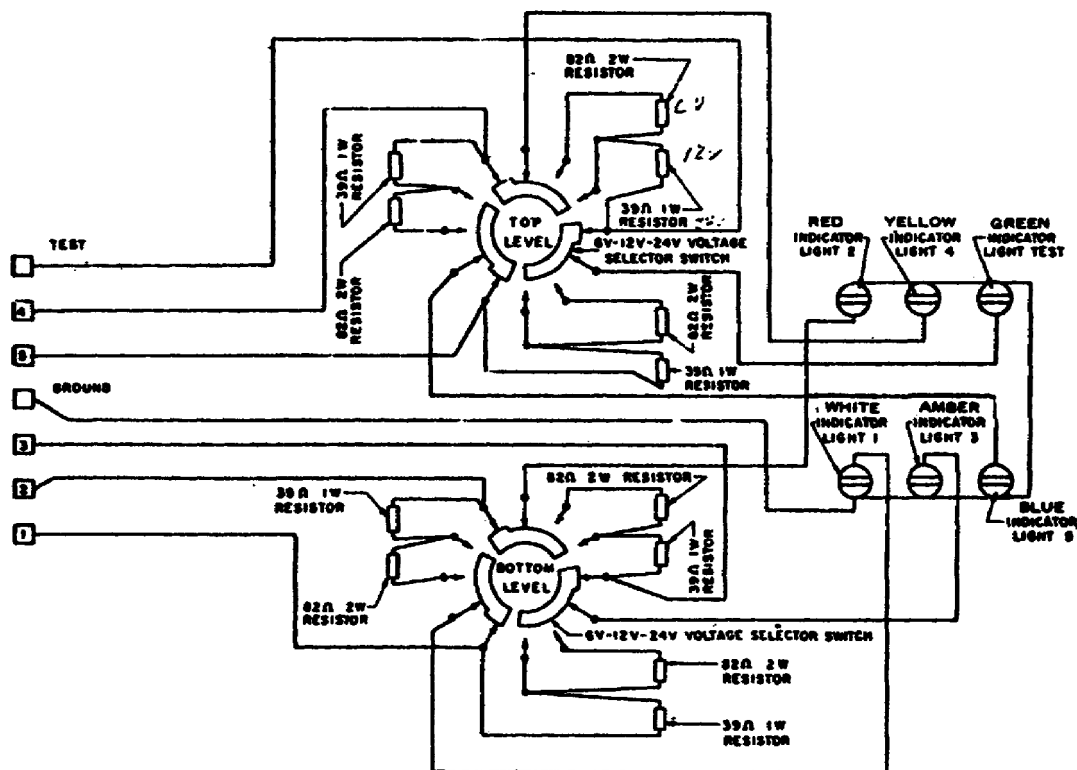


Figure 11. Circuit analyzer schematic wiring diagram.

(17) Connect a Jumper wire from pin C of receptacle A to pin A of receptacle B. Indicator light A should illuminate only when switch B is in RUN position.

(18) Connect a Jumper wire from pin C of receptacle A to pin C of receptacle B. Indicator light A should remain illuminated when switch B is in RUN, START, and OFF positions.

(19) Connect a Jumper wire from pin C of receptacle B to pin E of receptacle B. Test set fuel pump should operate.

(20) Place CIRCUIT SELECTOR switch in C position.

(21) Place test set switch C in HI position and then in LO position. Fuel pump should operate when switch is in either position.

(22) Connect a Jumper wire from pin C of receptacle C to pin A of receptacle C. Indicator light C should remain illuminated when switch C is in HI, LO, and OFF positions.

(23) Connect a Jumper wire from pin C of receptacle C to pin B of receptacle C. Indicator light C should illuminate only when switch C is in HI or LO position.

(24) Connect a Jumper wire from pin C of receptacle C to pin D of receptacle C. Indicator light C should illuminate only when switch C is in HI position.

Item to be inspected	Procedure
1. Exterior	Blow off accumulation of dust and dirt from exterior of test set with a jet of dry, low pressure air. Wash dial faces, indicator light lenses, and flowmeter tube with a soft cloth dampened in warm, soapy water. Dry with a clean, lint-free cloth.
2. Interior	Loosen dirt and dust in interior of test set by brushing with a non-metallic bristle brush. Blow out with a jet of dry, low pressure air and wipe all tubing with a cloth dampened with cleaning solvent.
3. Ducts and Lines	Examine exhaust duct and air pressure gage lines for breaks, restrictions and faulty connections.
4. Flowmeter	If the flowmeter leaks at the end(s) of the metering tube, uniformly tighten (approximately 1/2 turn) in rotation, the four packing compression screws located at each end of the flowmeter so that they protrude an equal length through the packing gland retainer. Exercise caution when tightening the packing compression screws to avoid breaking the tube. If, after tightening the screws, leakage continues, replace the flowmeter so that it may be repaired.
5. Fuel Filter	Remove bowl by unscrewing and clean inside of bowl. Clean filter element by washing in gasoline. When reassembling, be sure gasket is in place between bowl and filter body.
6. Fuel Connections	Check for leaks with fuel pressure applied.
7. Wiring Connections	Check for condition of insulation and firmness of connection.
Note. - Perform checkout procedure for the heater test set after completing the preventive maintenance checks and services listed above.	

Figure 12. Organizational preventive maintenance checks and services.

(25) Place CIRCUIT-SELECTOR switch in D position.

(26) Place test set RUN-OFF-START switch D in START position. Fuel pump should operate only when switch is in this position.

(27) Connect a Jumper wire from pin E of receptacle D to pin B of receptacle D. Indicator light D should illuminate only when RUN-OFF-START switch D is in START. or RUN position and HI-LO switch D is in HI position.

(28) Connect a Jumper wire from pin E of receptacle D to pin C of receptacle D. Indicator light should illuminate only when RUN-OFF-START switch is in START position.

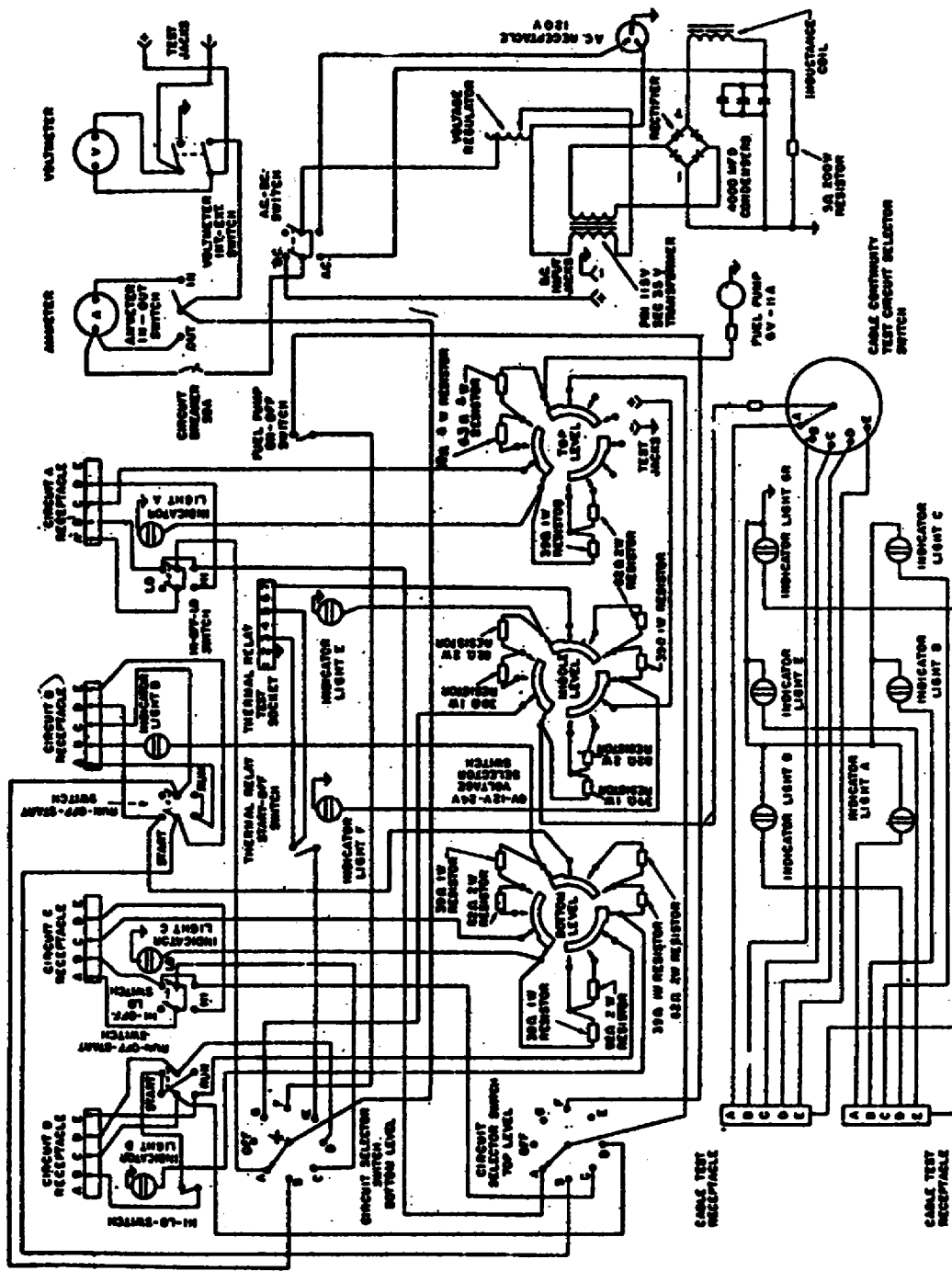


Figure 13. Test set schematic wiring diagram.

Trouble	Probable Cause	Remedy
Test set will not operate	1. No AC power supply 2. DC voltage control inoperative 3. Loose or broken wire lead(s) 4. Circuit breaker tripped to OFF 5. A.C.-OFF-D.C. switch improperly positioned or inoperative	1. Check power source; cable and connector. 2. Check power supply components; replace if defective. 3. Check continuity; tighten or replace defective lead(s). 4. Determine cause and reset circuit breaker to ON. 5. Place in proper position; check continuity and replace if defective.
Heater being tested will not operate or will not operate properly	1. Heater defective 2. Faulty test set receptacle, control switch, or interconnecting cable 3. Circuit selector switch improperly positioned or defective 4. Fuel pump inoperative 5. Fuel supply exhausted	1. Refer to heater manual. 2. Check continuity and replace if defective. 3. Place in A, B, C, or D position which is correct for heater being tested; replace if defective. 4. Check continuity and replace if defective. 5. Replenish.
Air pressure gage fails to indicate	1. Fresh air-exhaust valve improperly positioned 2. Exhaust valve not closed for exhaust reading	1. Place in FRESH AIR or EXHAUST position as appropriate for reading desired. 2. Rotate control knob on top of test set to close exhaust valve.
Indicator light(s) fail to illuminate	1. Defective lamp(s) 2. Loose or broken wire lead(s) 3. Voltage selector switch improperly positioned or defective	1. Replace lamp(s) (6V). 2. Check continuity; tighten or replace defective lead(s). 3. Place in proper position; replace if defective.
Voltmeter fails to indicate	1. Voltmeter switch in EXT. position or voltmeter or switch defective 2. Loose or broken wire lead(s)	1. Place in INT. position; replace if defective. 2. Check continuity; tighten or replace defective lead(s).
Ammeter fails to indicate	1. Ammeter switch in OUT position or ammeter or switch defective	1. Place in IN position; replace if defective.

Figure 14. Troubleshooting chart.

Trouble	Probable Cause	Remedy
Ammeter fails to indicate (Cont)	2. Loose or broken wire lead(s)	2. Check continuity; tighten or replace defective lead(s).
Flowmeter reading erratic	1. Air in fuel lines to heater 2. Flowmeter damaged	1. Bleed air from fuel lines. 2. Replace.
Circuit analyzer inoperative	1. Voltage selector switch defective 2. Loose or broken wire lead(s)	1. Use test prods of analyzer to check continuity by illumination of TEST indicator light. 2. Check continuity; tighten or replace defective lead(s).

Figure 14. Troubleshooting chart (cont).

(29) Connect a Jumper wire from pin E of receptacle D to pin D of receptacle D. Indicator light D should remain illuminated with D switches in any position.

(30) Place CIRCUIT SELECTOR switch in E position.

(31) Place switch E in START position. Connect a Jumper wire from pin 7 of tube socket in turn to pins 1 through 6. Indicator light E should illuminate only when pin 7 is connected to pin 3 or pin 5. Connect a jumper wire from pin 3 or pin 5 of tube socket to POS test Jack of F. Indicator light for circuit F should illuminate.

(32) Place CIRCUIT SELECTOR switch in F position.

(33) Place switch F in ON position. Fuel pump should operate.

(34) Place CIRCUIT SELECTOR switch in G position.

(35) Connect a Jumper wire from pin A of upper receptacle to pin A of lower receptacle.

(36) Place cable test circuit selector switch in A position. Indicator light A should illuminate.

(37) Connect a Jumper wire from pin A to upper receptacle ground and then to lower receptacle ground. Indicator light GR should illuminate in both instances.

(38) Repeat steps 35 and 36 for pins B and B, C and C, D and D, and E and E.

e. Repairs are normally confined to replacement of the various major assemblies and components of the test set. It is not recommended that any attempt be made to repair these assemblies or components. All components are readily accessible with the rear panels of the test set removed. Replacement of components consists mainly of removing attaching hardware and disconnecting fuel lines, pneumatic lines, or electrical connections. Tag wires when disconnecting them to facilitate proper connections when the replacement component has been installed.

8. MULTIMETER MAINTENANCE.

a. Multimeter TS-352 B/U (fig 15) is a multirange AC and DC volt-ohm-milliammeter using a single moving coil, 50-microampere meter of the D'Arsonval type, with appropriate scales marked to indicate AC and DC volts, DC current, and resistance in ohms. The voltmeter circuit is essentially a meter with series multiplier resistors. The multiplier resistors are the same for AC and DC measurements. However, since the meter is a DC milliammeter, the AC voltage input must be rectified before being applied to the meter.. Wafer switches are used in the switching circuits to control the functions and ranges of the multimeter. All meter shunt resistors and some multiplier resistors are selected by the positioning of the contacts in the switching circuits. The switching circuits also connect the battery, or batteries, and appropriate shunt and series resistors into the necessary circuit arrangements for resistance measurements in the different ohmmeter ranges.

b. The daily and weekly maintenance duties assigned to the operator are detailed in figure 16. Organizational preventive maintenance responsibilities are detailed in figure 17. No special tools or test equipment other than those issued with the equipment are required by the operators or organizational maintenance personnel to accomplish their duties.

c. When troubleshooting this equipment organizational maintenance personnel perform all functions of the multimeter operation. They proceed with the functions until an abnormal condition or result is observed. Noting the abnormal condition or result they refer to the troubleshooting chart (fig 18) and perform the checks and corrective actions indicated. When the corrective measures indicated do not result in correction of the trouble, a higher maintenance category repair is required.

9. LOW VOLTAGE CIRCUIT TESTER MAINTENANCE.

a. The LVCT test set (fig 19) is a self-contained, portable instrument, used for checking and analyzing low voltage direct current electrical circuits. The test set has four independent sections: voltmeter circuit, field rheostat circuit, 1/4-ohm load resistor circuit, and ammeter load bank circuit. Necessary test leads and a separate external shunt assembly come with the set and should be stowed in the compartment provided when not in use. Pertinent publications are stowed in a bracket provided in the cover.

b. Before and after-operation preventive maintenance services for the low voltage test set are listed in figure 20. Operators should note minor defects discovered during operation of the unit so that correction can be made as soon as possible. Some deficiencies require that operations be ceased to avoid equipment damage; therefore, all operators must be highly trained. Operators of the low voltage circuit tester have a limited troubleshooting responsibility. When a malfunction occurs immediate steps should be taken to locate and correct the problem. Figure 21 details the operator's troubleshooting responsibility.

c. Organizational maintenance is provided repair parts, common tools, and equipment necessary for replacement of those parts most likely to become worn, broken, or otherwise unserviceable. Weekly, monthly, and quarterly preventive maintenance responsibilities are listed in figure 22. Close adherence to the organizational maintenance troubleshooting procedures (fig 23) materially reduces the time required to locate the cause of malfunctions and restore the equipment to a serviceable condition.

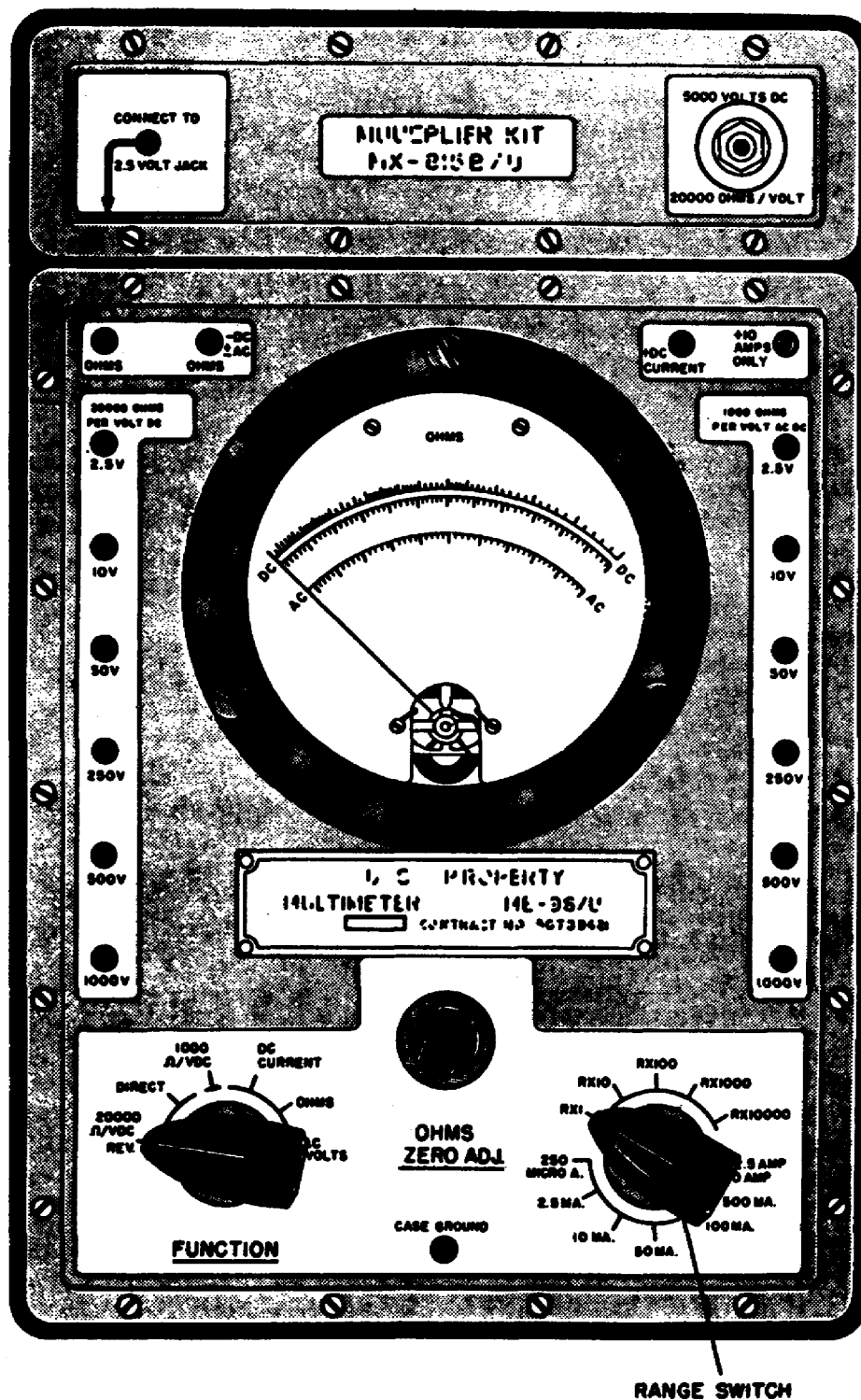


Figure 15. TS-352 B/U multimeter.

Operator's Daily Preventive Maintenance Checks and Services Chart

Sequence No.	Item to be inspected	Procedure
1	Multimeter set -----	Check equipment for completeness and general condition.
2	Exterior surfaces -----	Clean exterior surfaces of the equipment
3	External receptacles -----	Inspect external receptacles for breakage and for firm seating.
4	Meter glass -----	Inspect front panel glass window for damaged housing, broken glass, physical damage, dust, or moisture.
5	Knobs, controls, and switches.	During operation (item 6) check knobs, controls, and switches for proper mechanical action. Action must be positive, without backlash, binding, or scraping.
6	Operation -----	During operation, be alert for any abnormal indications.

Operator's Weekly Preventive Maintenance Checks and Services Chart

Sequence No.	Item to be inspected	Procedure
1	Cables -----	Inspect external cables for cuts, cracked or gouged jackets, fraying, or kinks.
2	Hardware -----	Inspect all exterior hardware for looseness, and damage. The multimeter set cover, carrying handle, hinges, and all bolts and screws must be tight and not damaged.
3	Preservation -----	Inspect the equipment to determine that it is free of bare spots, rust, and corrosion. If these conditions exist, refer to a higher maintenance category for repair.
4	Batteries -----	Inspect batteries for leakage, corrosion, and swelling.

Figure 16. Operator preventive maintenance.

10. SUMMARY. During this lesson you have learned the preventive maintenance and troubleshooting responsibilities the men under your supervision have with respect to eight items of equipment used to keep motor vehicles in operational conditions. By knowledgeable observation of their actions and the results of their work you can determine the readiness of your unit. Informed supervision which includes an adequate training program will enhance your unit's competence and efficiency. Application of the knowledge you have obtained will help you meet your supervisory responsibilities.

Organizational Monthly Preventive Maintenance Checks and Services Chart

Sequence No.	Item to be inspected	Procedure
1	Publications -----	Inspect the manual for completeness, and to see if it is in usable condition. Be sure that all changes to the manual are on hand.
2	Modification work orders --	Check to see that all URGENT MWO's have been applied and that all NORMAL MWO's have been scheduled.
3	Completeness -----	Check the equipment for completeness and general condition.
4	Cleanliness -----	Clean the exterior surfaces of the equipment.
5	Preservation -----	Inspect the equipment to determine that it is free of bare spots, rust, and corrosion.
6	External receptacles -----	Inspect the external receptacles for breakage and for firm seating.
7	Meter glass -----	Inspect the front panel glass window for damaged housing, broken glass, physical damage, dust, or moisture.
8	Cables -----	Inspect the external cables for cuts, cracked or gouged jackets, fraying, or kinks.
9	Hardware -----	Inspect all exterior hardware for looseness and damage. The multimeter set cover, carrying handle, hinges and all bolts and screws must be tight and not damaged.
10	Operation -----	During operation, be alert for any abnormal indications.

Figure 17. Organizational preventive maintenance.

Item No.	Trouble symptom	Probable trouble	Checks and corrective measures
1	Meter does not indicate	a. Open test leads ----- b. Corroded or dirty test lead prods. c. Defective meter -----	a. Repair, or replace test leads b. Clean test lead prods. c. Refer to a higher maintenance category.
2	Meter does not indicate within tolerance	a. Defective multiplier resistor, or resistors. b. Defective compensating network. c. Defective meter shunt -----	Refer to a higher maintenance category.
3	Meter does not indicate on AC ranges	Defective rectifier -----	Refer to a higher maintenance category.
4	Multimeter cannot be zero adjusted on RX1, RX10, RX100, and RX1000 ranges	Weak or defective Battery BA-30 (1.5 volt).	Replace battery
5	Multimeter cannot be zero adjusted on RX10000 range	Weak or defective Batteries BA-31 (4.5 volts each).	Replace batteries
6	Multimeter zero adjustment is erratic on all ranges, or a meter cannot be zero adjusted on any range	a. Defective OHMS ZERO ADJ. potentiometer. b. Defective test leads c. Defective batteries d. Poor connections on batteries.	a. Refer to a higher maintenance category. b. Replace test leads. c. Replace batteries d. Clean and tighten the battery connectors.

Figure 18. Troubleshooting.

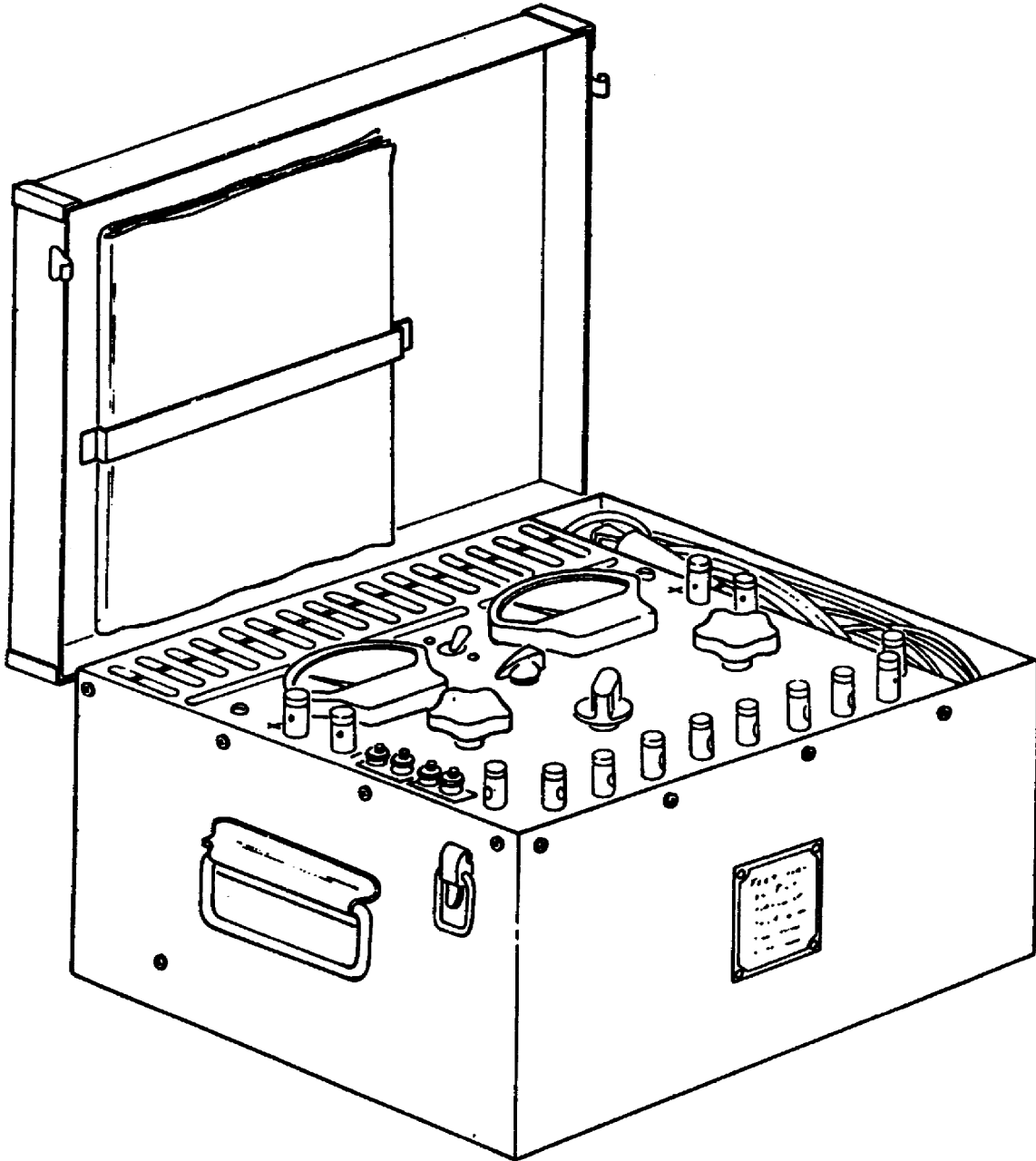


Figure 19. Low voltage circuit tester.

Item No	Procedures	Intervals	
		Before operation	After operation
1	Binding posts. Clean the binding posts by brushing dirt and other foreign matter from threaded posts and knurled screws.	X	X
2	Test leads and external shunt assembly.	X	
	a. Clean the test leads and external shunt assembly foreign material from them.		
	b. Roll the test leads neatly and see that the leads, other equipment and publications are properly stored to prevent deterioration and/or damage.		
3	Carrying case.		
	a. Inspect the air intake grilles on top and bottom of carrying case for obstructions. Clean dirt and other foreign material from the vents.	X	
	b. Remove all test leads and other equipment from the stowage compartment.	X	
4	Meters.		
	a. Clean meters by wiping dirt and other foreign material from the surface of the meter lens.	X	
	b. Adjust the pointer (needle) on each meter to zero.	X	

Figure 20. Operator's preventive maintenance services.

Malfuction	Probable cause	Corrective action
1. Ammeter or voltmeter pointer (needle) not centered on zero (under no load).	a. Pointer (needle) needs zero adjustment. b. Other causes.	a. Adjust pointer (needle) to zero b. Refer other causes to higher echelon maintenance personnel for correction.
2. Ammeter pointer (needle) swings counterclockwise.	Wrong polarity.	Reverse test leads on unit or circuit being tested.
3. Ammeter not operating.	a. Loose connections at unit or circuit being tested. b. Loose connections at binding posts. c. Too high a range chosen. d. Other causes.	a. Tighten connections at the unit or circuit. b. Tighten binding posts on test leads. c. Select a lower range d. Refer other causes to higher echelon maintenance personnel for correction.
4. Ammeter shows erratic reading.	.....	Refer malfunction to higher echelon maintenance personnel for correction.
5. No deflection of voltmeter pointer (needle).	a. Wrong polarity. b. Too high a range chosen. c. Loose connections. d. Other causes.	a. Reverse test lead on unit or circuit being tested. b. Select a lower range c. Tighten all connections. d. Refer other causes to higher echelon maintenance personnel for correction.
6. No resistance across 1/4-OHM resistor binding posts when in series with unit being tested.	a. Loose connections at binding posts or at the unit or circuit being tested. b. Other causes.	a. Tighten connections at binding posts on the unit or circuit being tested. b. Refer other causes to higher echelon maintenance personnel for correction.
7. Load bank switch not functioning.	.....	Refer malfunction to higher echelon maintenance personnel for correction.
8. Voltmeter range selector switch not functioning.	.....	Refer malfunction to higher echelon maintenance personnel for correction.
9. Field rheostat (70-OHM) not functioning.	a. Test leads loose at binding posts or circuit being tested. b. Other causes.	a. Tighten test leads at binding posts and/or circuit being tested. b. Refer other causes to higher echelon maintenance personnel for correction.
10. Load bank control not functioning.	a. Loose connections at binding posts or circuit being tested. b. Other causes.	a. Tighten connections at binding posts and/or circuit being tested. b. Refer other causes to higher echelon maintenance personnel for correction.

Figure 21. Operator troubleshooting.

Item No.	Procedures	Intervals			Quarterly
			Weekly	Monthly	
1	Binding posts.				
	a. Remove corrosion from all binding posts		...	X	...
	b. Inspect the transverse holes in the posts for burs or flat spots, and remove if necessary using a round file.		...	X	...
2	c. Apply a coating of automotive and artillery grease (MIL-G-10924) to the threaded parts of the posts to prevent further corrosion.		...	X	...
	Test leads and external shunt assembly.				
	a. Inspect test leads and external shunt assembly instrument for frayed, broken, cracked, or burned insulation.		X	...	...
3	b. Remove corrosion from the tip plugs and electrical clips on test leads and external shunt.		...	X	...
	c. Apply a coating of automotive and artillery grease (MIL-G-10924) to tip plugs and electrical clips to prevent further corrosion.		...	X	...
	d. Tape any frayed or cracked insulation.		...	X	...
4	Switches, rheostats, and knobs.				
	a. Inspect the knobs on switches and rheostats for being secure. Tighten setscrew in knob if loose fit is determined.		...	X	...
	b. Make sure that the rheostats functions smoothly and the switches have a positive action.		...	X	...
4	Carrying case.				
	a. Inspect the hinge pins and clasps on the carrying case for distorted or damaged condition. Straighten distorted pins and align fasteners with the catches on the cover of the case.		...	...	X
	b. Inspect the air intake grilles on the top and bottom of the carrying case for obstructions which may interfere with proper ventilation of the test set.		...	X	...

Figure 22. Organizational preventive maintenance.

Malfunction	Probable cause	Corrective action
1. Ammeter or voltmeter pointer (needle) not resting on zero (under no load). 2. Ammeter not functioning.	 a. Broken test lead(s). b. Corrosion on binding posts and/or terminals on test lead(s). c. Other causes.	Refer malfunction to higher echelon maintenance personnel for correction. a. Check continuity of test lead(s), using a test light or ohmmeter. Replace unserviceable test lead(s). b. Clean corrosion from binding posts and/or the terminals on test lead(s) c. Refer other causes to higher echelon maintenance personnel for correction.
3. Ammeter shows erratic reading.	a. Corrosion on binding posts and/or terminals on test lead(s). b. Broken or nearly broken test lead(s). c. Other causes.	a. Clean corrosion from binding posts and/or terminals on test lead(s) b. Check continuity of test lead(s), using a test light or ohmmeter. Replace unserviceable test lead(s). c. Refer other causes to higher echelon maintenance personnel for correction.
4. Voltmeter not functioning.	a. Broken test lead(s). b. Corrosion on binding posts and/or terminals on test lead(s). c. Other causes.	a. Check continuity of test lead(s), using a test light or ohmmeter. Replace unserviceable test lead(s). b. Clean corrosion from binding posts and/or terminals on test lead(s) c. Refer other causes to higher echelon maintenance personnel for correction.

Figure 23. Troubleshooting (organizational).

Corrective action	Malfunction	Probable cause
5. Voltmeter shows erratic reading.	a. Corrosion on binding posts and/or terminals on test lead(s). b. Broken or nearly broken test lead(s). c. Other causes.	a. Clean corrosion from binding posts and/or terminals on test lead(s). b. Check continuity of test lead(s), using a test light or ohmmeter. Replace unserviceable test lead(s). c. Refer other causes to higher echelon maintenance personnel for correction.
6. 1/4-OHM resistor circuit not functioning.	a. Corrosion on binding posts and/or terminals on test lead(s). b. Broken test lead(s). c. Other causes.	a. Clean corrosion from binding posts and/or terminals on test lead(s). b. Check continuity of test lead(s), using a test light or ohmmeter. Replace unserviceable test lead(s). c. Refer other causes to higher echelon maintenance personnel for correction.
7. Load bank switch not functioning.	.....	Refer malfunction to higher echelon maintenance personnel for correction.
8. Voltmeter range selector switch not functioning.	.....	Refer malfunction to higher echelon maintenance personnel for correction.
9. Field rheostat (70-OHM), not functioning.	.....	Refer malfunction to higher echelon maintenance personnel for correction.
10. Load bank control not functioning.	.....	Refer malfunction to higher echelon maintenance personnel for correction.

Figure 23. Continued.

EXERCISE

Note. - Refer to exercise instructions listed in lesson 1.

121. Which armature test set circuit consists of a primary coil and a portion of the iron of a transformer?
 - a. Growler
 - b. Ammeter
 - c. Test lamp
122. Who checks for possible MWO's applicable to the armature test set?
 - a. Operator/crew personnel
 - b. Organizational personnel
 - c. Administrative personnel
123. Which type of check is normally used when troubleshooting the ignition timing light?
 - a. Voltage
 - b. Amperage
 - c. Continuity
124. The battery of the magneto timing light should be replaced when a periodic check indicates its potential is less than
 - a. 3.9 volts.
 - b. 5.9 volts.
 - c. 11.9 volts.
125. When troubleshooting the magneto timing light, the battery, switch, and transformer primaries are found to be OK. Which item should be checked next?
 - a. Vibrator
 - b. Capacitor
 - c. Glow lamp
126. What speed (RPM) should be indicated when making a top speed check on the magneto test stand?
 - a. 120
 - b. 440
 - c. 4,200
127. When should the operator check the distributor tester switches for positive action?
 - a. Before operation
 - b. During operation
 - c. After operation
128. Which malfunction of the distributor tester may be corrected by the operator?
 - a. Work lamp fails to light
 - b. Tester chatters or vibrates under speed
 - c. Electrical cable nipples do not insulate electrical clips properly

129. How is the vacuum pump of the distributor tester lubricated?
- Through a Zerk fitting accessible from back of stand
 - Through the vacuum hose with pump running
 - Through oil filler pipe at side of test stand
130. What is a purpose of the circuit analyzer accessory of the heater test stand?
- To check the electrical circuits of the heater test stand
 - To check the vehicle's heater electrical system with the heater removed
 - To check heater electrical circuits with the heater installed in the vehicle or on the test stand
131. What type of indication does the operator observe when using the circuit analyzer?
- Light
 - Ammeter
 - Voltmeter
132. Which power source can be used to operate the heater test stand?
- 24VDC
 - 120 volts, 400 Hz, single phase
 - 220 volts, 60 Hz, three phase
133. How many functions can be selected by the TS-352 B/U multimeter function selector switch?
- 2
 - 4
 - 6
134. Which batteries need replacing when the TS 352- B/U multimeter cannot be zero adjusted on the RX 10,000 range?
- 1.5v
 - 4.5v
 - 6v
135. How many independent circuits are there in the low voltage circuit tester?
- 2
 - 3
 - 4

C O R R E S P O N D E N C E C O U R S E
o f t h e
U S A R M Y O R D N A N C E
C E N T E R A N D S C H O O L



LESSON ASSIGNMENT

<u>Ordnance Subcourse No 010</u>	Electrical System Component Repair
<u>Lesson 9</u>	Setup of Fuel and Electrical Shop Van
<u>Credit Hours</u>	One
<u>Lesson Objective</u>	After studying this lesson you will be able to: 1. Describe the field maintenance automotive fuel and electrical system shop sets. 2. Describe the differences between shop van configurations.
<u>Text</u>	Attached Memorandum
<u>Materials Required</u>	Response list and answer sheet
<u>Suggestion</u>	None

ATTACHED MEMORANDUM

SECTION I. INTRODUCTION

1. SHOP SETS. To keep the Army wheels moving shop sets were devised to be installed into mobile vans. The shop sets include the equipment and tools that you have been exposed to during this course of instruction. These tools and test equipment have been classified into three categories in order to be properly issued to a particular type of shop van. The categories are the basic set, No 1 supplemental, and No 2 supplemental.

a. A complete fuel and electrical support shop requires the use of the basic set and a supplemental set. The shop may be set up in semitrailer M146 or in two shop vans (M109 or M220). The No 1 supplemental set and basic set are used in the semitrailer; when two vans are used, the basic set is installed in one and the No 2 supplemental set in the other.

b. The equipment or components that make up the shop sets are alphabetically listed in supply catalogs (CL). These catalogs are intended as requisitioning and reference documents for use by using troops, depots, and supply organizations. For a complete index of DA supply catalogs and supply manuals, see DA Pam 310-4 and DA Pam 310-6.

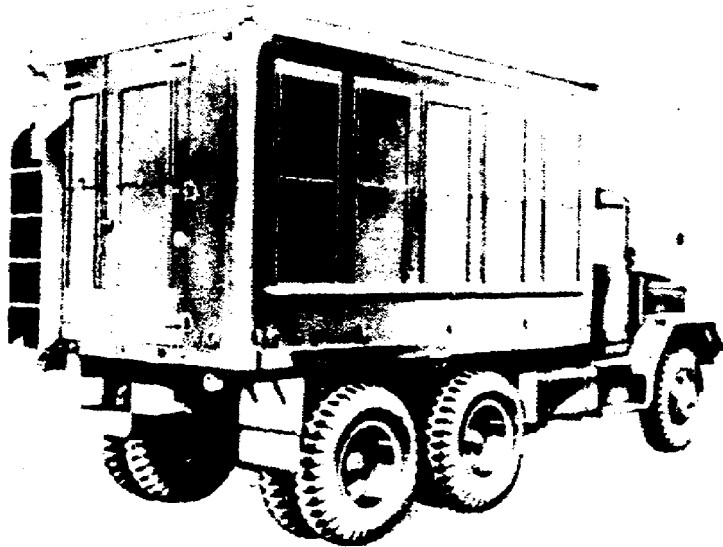
c. SC 4910-95-CL-A01 contains the items in the basic shop set; SC 4910-95-CL-A65 contains the items in the No 2 supplemental set that are installed in an M109 or M220 shop van; and SC 4910-95-CL-A64 contains the items in the No 1 supplemental set that is installed in semitrailer M146 shop van along with the basic shop set.

d. Within each supply catalog the publications necessary for installation are listed along with equipment items. These publications are called technical bulletins (TB). They prescribe the instructions necessary for installation into the shop vans and, because of the minor variations existing in the construction of equipment and vehicles of different manufacturers, they can be used only as guides for installation.

e. The TB's of interest to the fuel and electric maintenance shop are TB 9-4910-337-30/1, TB ORD 44-18, and TB ORD 444-22. TB 9-4910-337-30/1 and TB ORD 444-18 cover instructions pertaining to the M109 or M220 shop vans. TB ORD 444-22 covers the installation into the semitrailer M146.

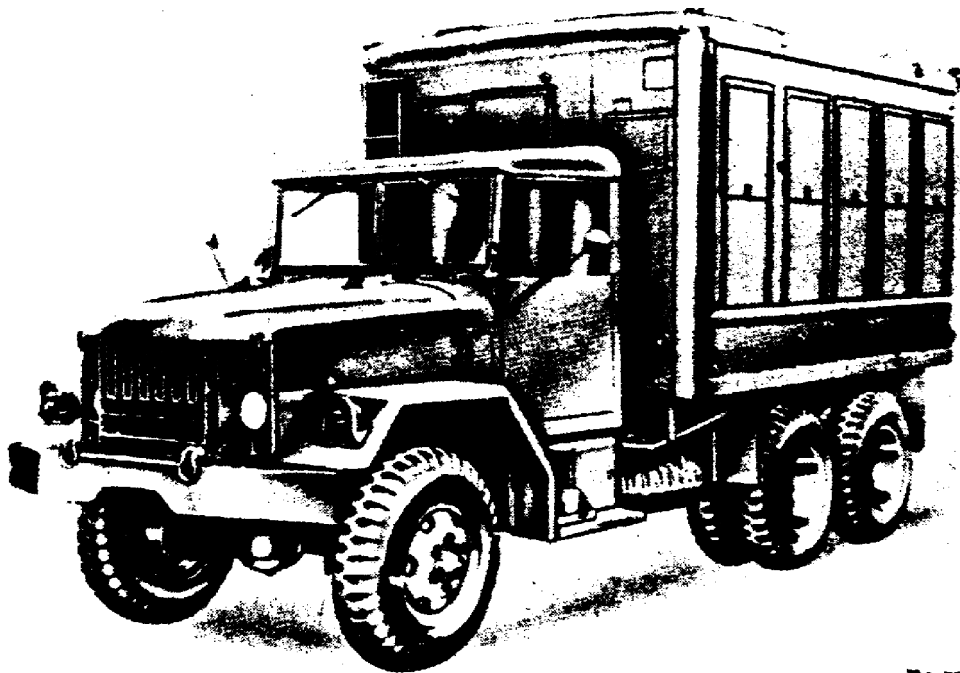
SECTION II. VAN AND TRAILER LAYOUTS

2. M109 VAN. The shop van truck M109 (fig 1 and 2) is basically equipped to serve as a mobile shop. The body is insulated against heat and cold through double panel construction with insulating material between panels. The windows (fig 3) are double glazed and equipped with blackout panels. Side sash insect screens are provided for all side window openings. These windows can be opened with blackout panels in place to act as a sunshade or with them in the stored position to allow maximum daylight inside. The front or rear door windows cannot be opened.



RA FD 361901

Figure 1. 2-1/2-ton, 6x6, shop van truck M109 - right rear view.



RA PD 361900

Figure 2. 2-1/2-ton, 6x6, shop van truck M109 - left front view.

a. The shop van body is provided with necessary electrical components to permit the use of 24-volt DC power or 115-volt AC power to operate the dome lights and exhaust blower. Power is brought in from the entrance receptacle (fig 4) which is located behind the folding ladder on the right front end of the van body.

(1) Located on the right side of the front panel on the inside of the van are the power controls (fig 5). The power switch selects either the 24-volt DC battery system or the 115-volt AC system. With the switch in the UP position it selects 115-volt AC; in the DOWN position it selects the 24-volt DC.

(2) The circuit breaker (CB) No 1, upper left-hand, controls 115 volts AC to the molding receptacle above the right panel windows; CB No 2, upper right-hand, controls AC to the molding receptacle on the left side; CB No 3, lower left-hand, controls AC to the converter; and CB No 4, lower right-hand, controls AC to the dome light switch. The breakers provide overload protection. When a circuit is overloaded the breaker trips to the OFF position. After removal of the overload cause the CB must be manually reset to the ON position.

(3) The dome light switch is a three-position switch. The center position is OFF; lower ON position supplies 115 volts AC to the dome lights; and upper ON position supplies 115 volts AC to the normal dome lights and blackout lights. The normal lights are in series with the 115-volt rear door blackout switch, so when the door is open only the blackout lights remain on.

(4) Located in the rear on the inside above the door are two toggle switches. These switches control the 24-volt dome lights. When the blackout switch is ON, as the door opens the normal lights go out leaving only the black lamps glowing. When the blackout switch is OFF, the other switch controls the interior lighting (fig 6A).

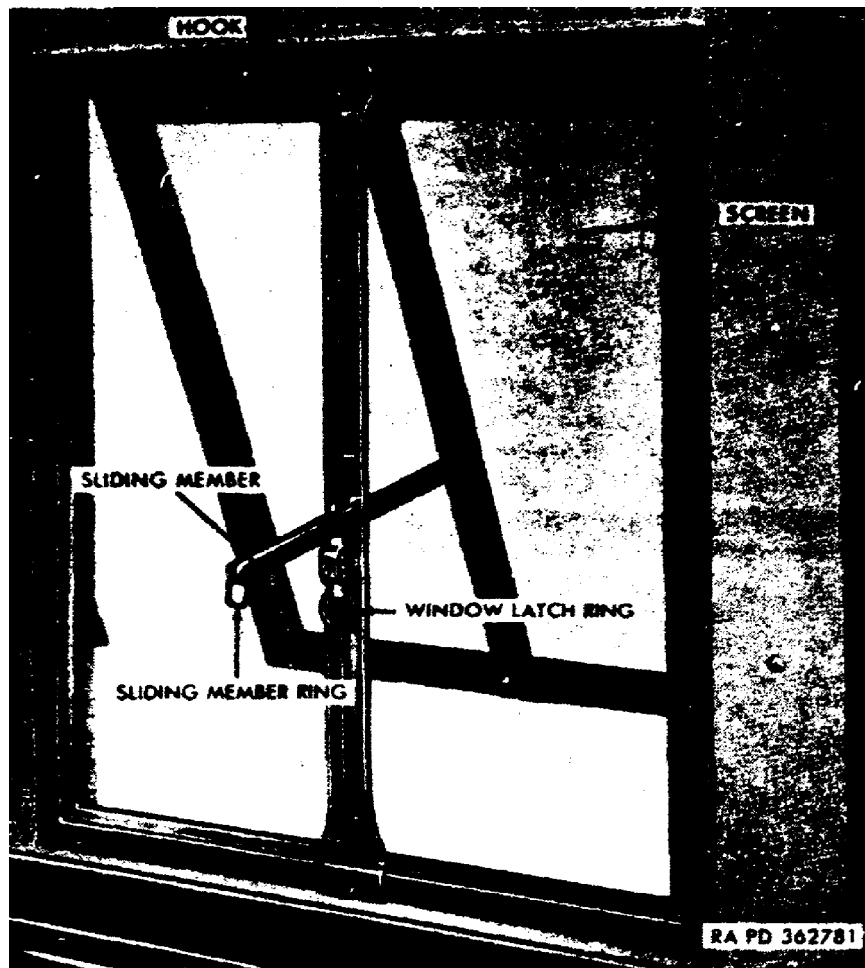


Figure 3. M109 shop van windows,

(5) The AC to DC converter changes the 115 volts AC to 24 volts DC to operate the exhaust blower. The switch on the panel controls the selection of vehicle battery power or the external AC power. Also, the HI-LO position controls the speed of the exhaust blower motor.

b. Foldout 1 shows the interior of the M109 shop van and covers the installation of the basic set. The figure shows the four workbenches and mounted equipment.

c. Foldout 2 shows the interior of the M109 shop van, with the No 2 supplemental set installed in accordance with TB ORD 444-18. Note the single worktable, generator test stand, and ignition magneto test stand on the storage cabinet.

3. M146 SEMITRAILER. The 6-ton, 2 wheeled, shop van semitrailer M146 (fig 6B) is designed to provide quarters for the field shop equipment. It is intended for use on highways or cross country with a 2-1/2-ton, 6x6, M48 truck tractor or equivalent as the towing vehicle.



Figure 4. Entrance receptacle, 24-volt DC and 115-volt AC.

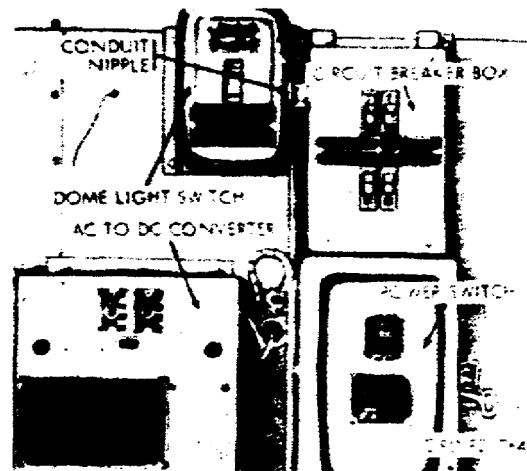


Figure 5. AC to DC converter, dome light switch, power switch, and circuit breaker box.

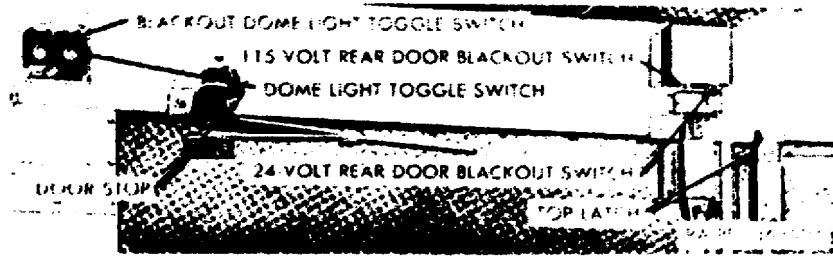


Figure 6A. Shop van body rear interior panel.

a. The semitrailer has provisions for 24 volts DC and 115 volts AC power. The receptacles are located on the center front and right front, respectively, of the trailer. The van contains both 24-volt and 115-volt lighting systems with blackout capabilities.

b. The M146 has a curbside personnel door and two rear entrance doors. The windows are of the same construction as the M109 van with blackout shades.

c. Foldout 3 shows the interior of the M146 semitrailer shop van, with the basic set and No 1 supplemental set installed in accordance with TB ORD 444-22.

4. GENERATOR TRAILERS. Each shop van requires 115 volts to operate; however, the total power requirement of each shop set is different. Therefore these generator trailer configurations are used.

a. The basic set installed into the M109, as required by TB 9-4910-337-30/1, utilizes one 1-1/2-ton, 2-wheeled, cargo trailer. Figure 7 shows the equipment that is installed on the trailer. There are two generators: a 10KW to supply 115 volts AC and a 2KW to supply 12 volts DC-for charging batteries. There is also a mixing tank for making electrolyte for batteries.

b. The No 2 supplemental set installed into the M109, as required by TB ORD 444-18, utilizes the 3-1/2-ton, M353, trailer chassis. This trailer carries the 60KW generator to supply 3-phase voltage for operation of the generator test stand and other components.

c. The No 1 supplemental and basic sets installed into the M146 semitrailer shop van, as required by TB ORD 444-22, utilizes a 2-1/2-ton, 2-wheeled generator trailer chassis M200A1. Figure 8 shows the 60KW 3-phase generator mounted on the trailer chassis. The 2KW, 12-volt DC generator is mounted on the floor on the left side at the rear of the semitrailer (foldout 3).

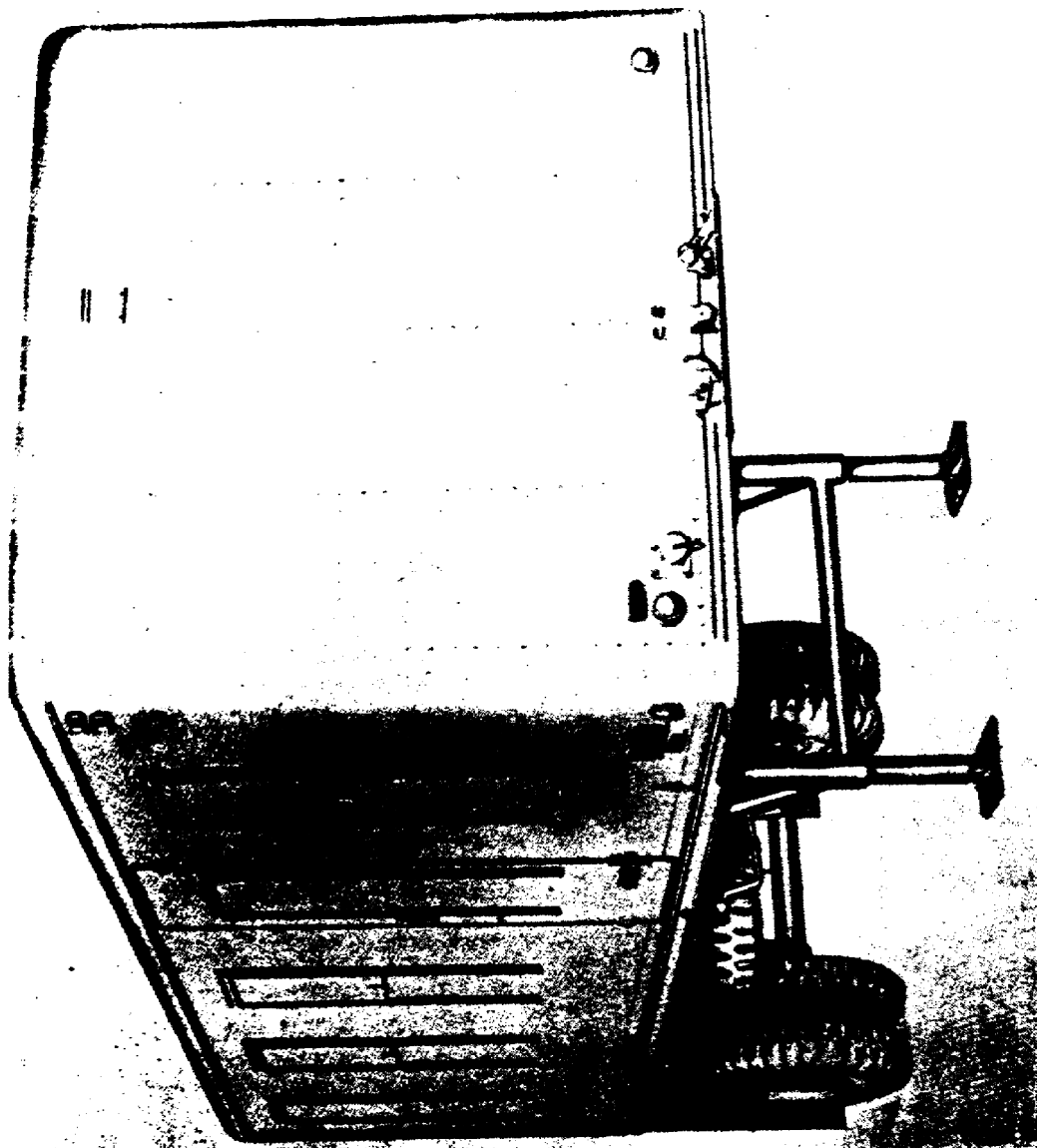


Figure 6B. M146 semitrailer shop van, 6-ton, 2-wheeled, M146-right front view.

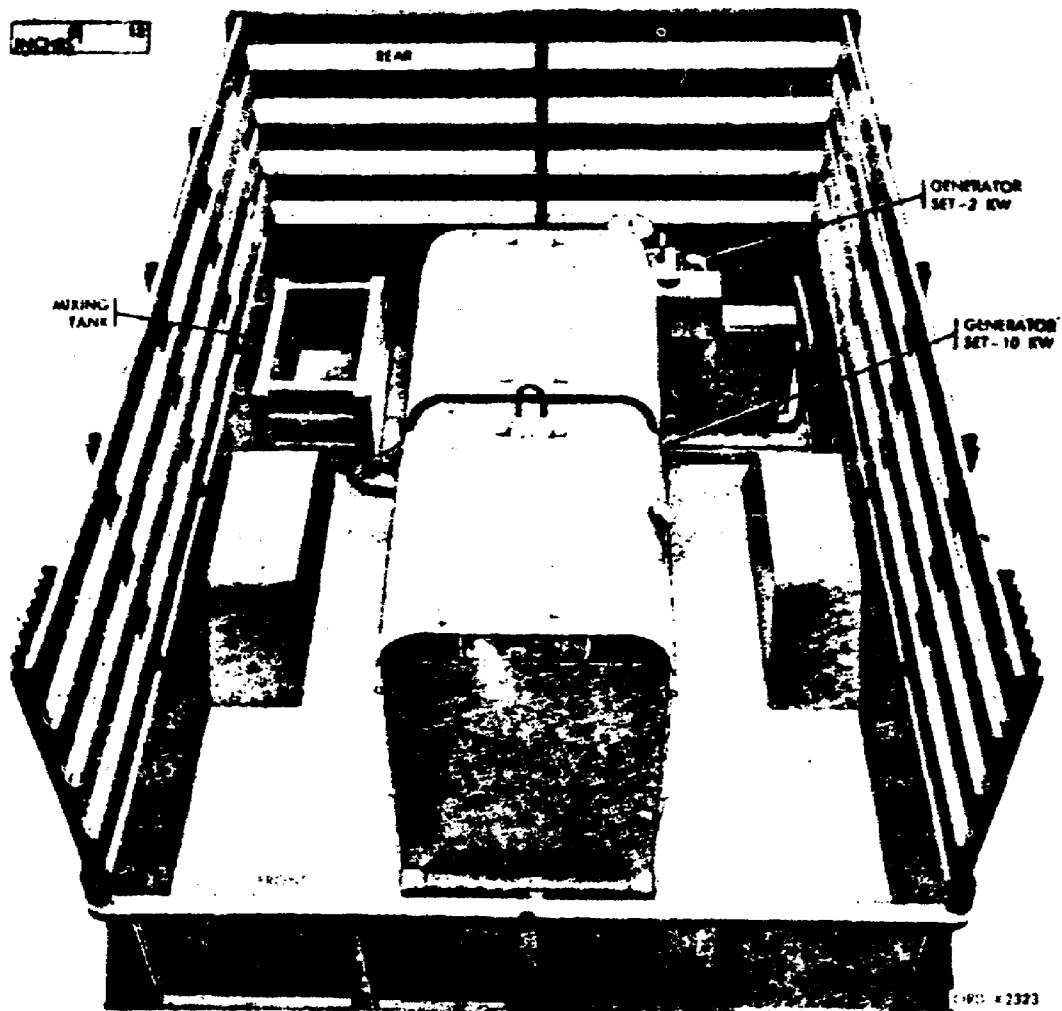


Figure 7. Trailer basic set - equipment installed in trailer.

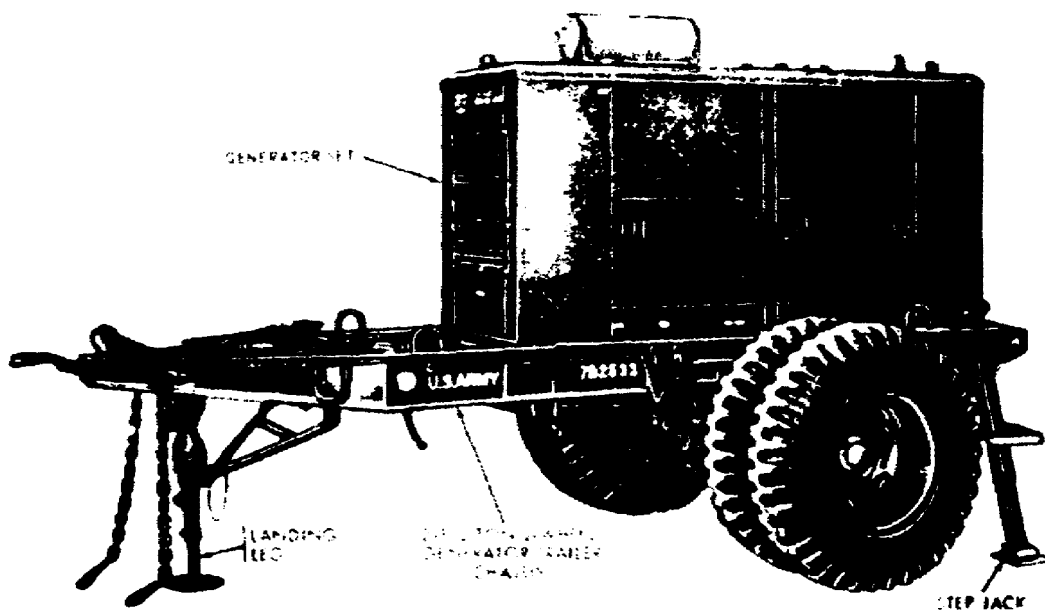


Figure 8. Generator set mounted on trailer chassis.

SECTION III. CONCLUSION

5. SUMMARY. In this lesson we covered the basic set, supplemental sets No 1 and No 2, and general layout configurations within the shop vans. This information will be important to you in your supervisory capacity, especially when you are required to set up a fuel and electrical section.

a. You have learned what supply catalogs are applicable to your mission as a fuel and electric supervisor.

b. You have learned that these supply catalogs are valuable tools for requisitioning purposes and reference documents. They list the technical bulletins necessary for shop van installation.

c. You have learned the main differences between the basic set and supplemental sets No 1 and No 2. Also presented were the differences in trailers and generators as required by the various configurations.

EXERCISE

Note. - Refer to the exercise directions in lesson 1.

136. What DA Pamphlet lists a complete index of DA supply catalogs?

- a. 310-3
- b. 310-4
- c. 310-5

137. Which is a semitrailer shop van?

- a. M109
- b. M220
- c. M146

138. What shop set requires the 10KW, 115-volt, AC generator?

- a. Basic set
- b. No 1 supplemental
- c. No 2 supplemental

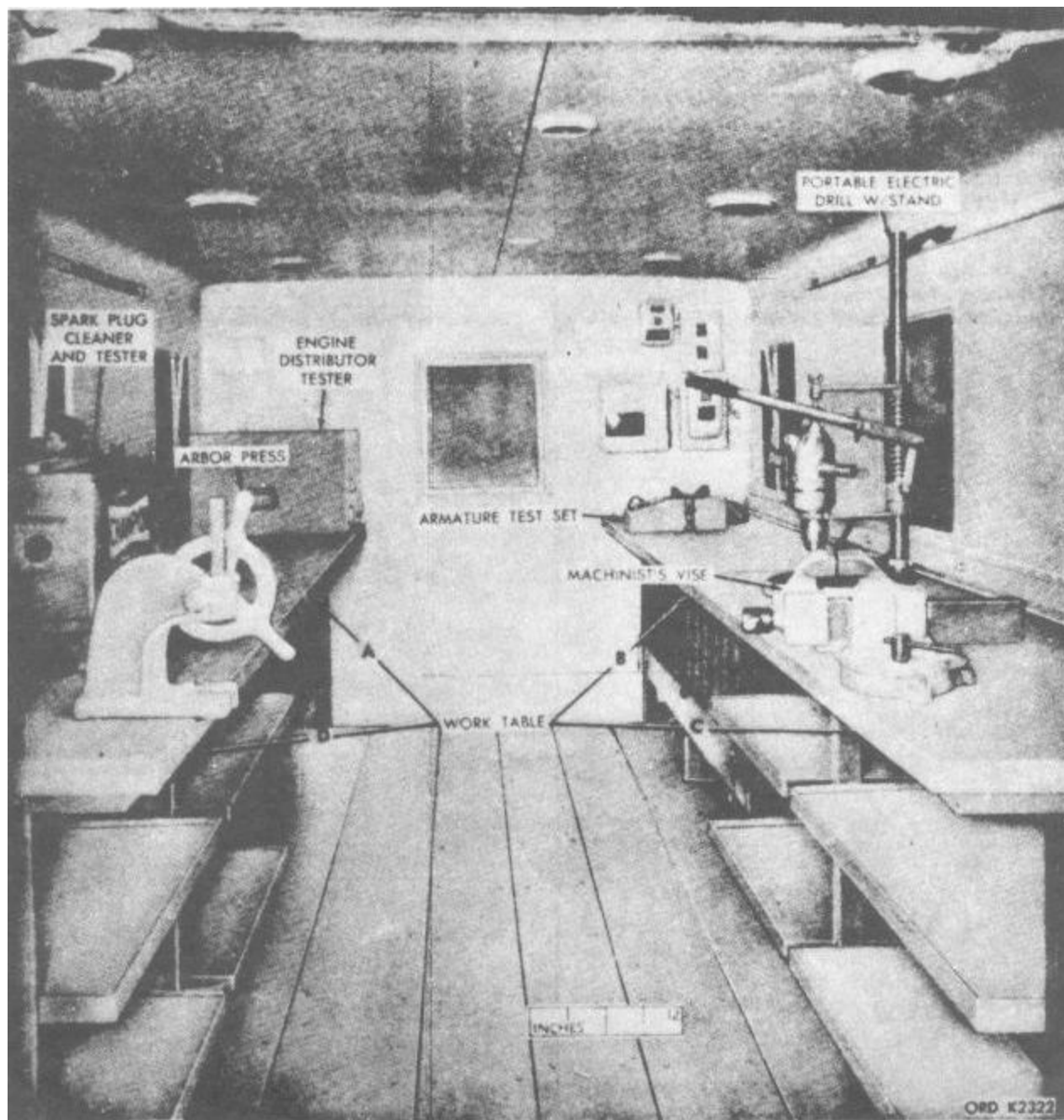
139. What is contained in the M146 semitrailer?

- a. No 1 and No 2 supplemental sets
- b. No 1 supplemental and basic sets
- c. No 2 supplemental and basic sets

140. What technical bulletin covers the installation of tool sets into the M146 semitrailer?

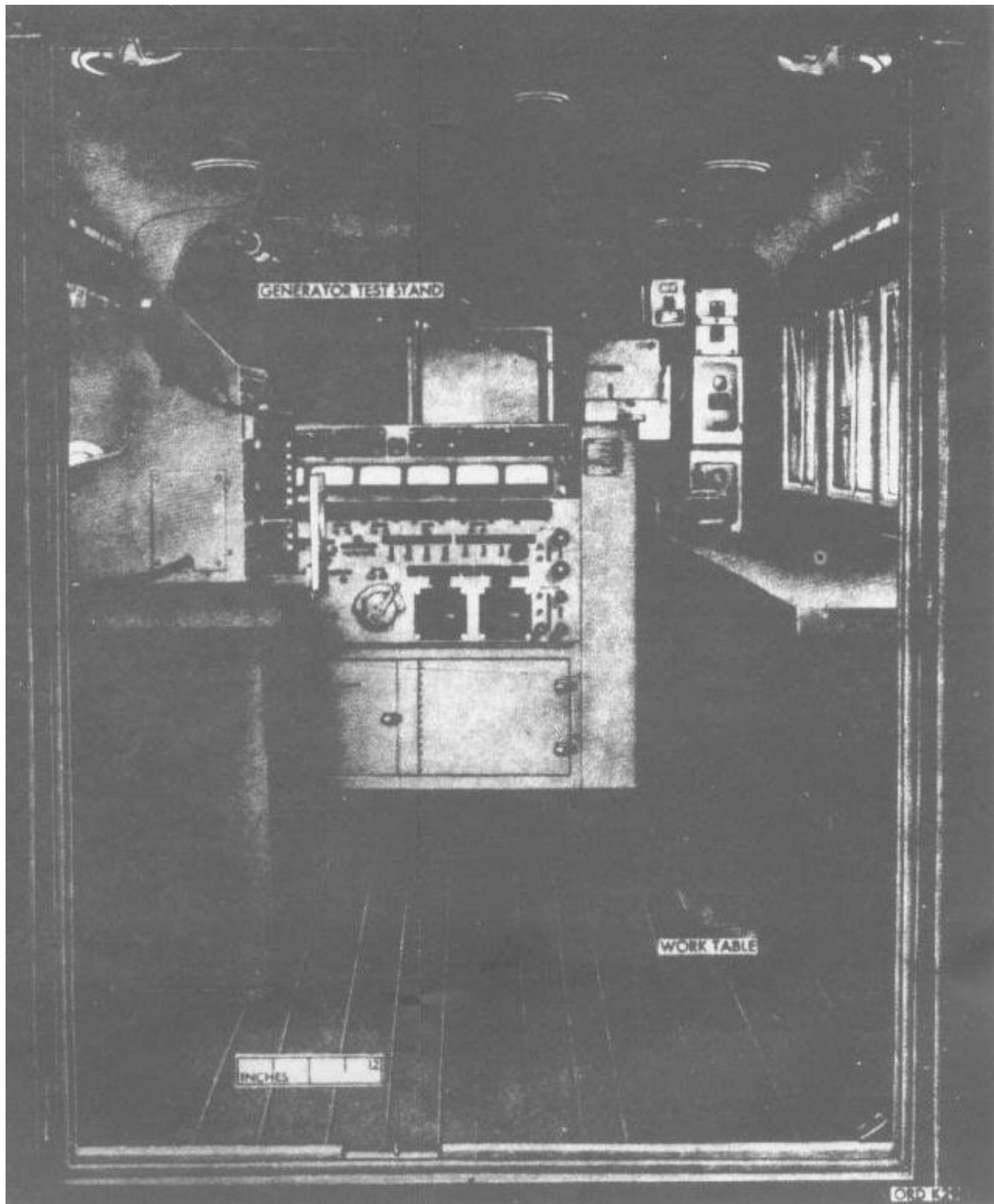
- a. TB 9-4910-337-30/1
- b. TB ORD 44-18
- c. TB ORD 444-22

141. Under blackout conditions what happens when the rear door is opened?
- a. Blackout lights come on
 - b. Dome lights go out
 - c. All lights go out
142. The 115-volt, AC, power receptacle on the M146 semitrailer shop van is located on the
- a. left front of the trailer.
 - b. right front of the trailer.
 - c. center front of the trailer.
143. The 1-1/2-ton, 2-wheeled cargo trailer is utilized with what shop set?
- a. Basic set
 - b. No 1 supplemental
 - c. No 2 supplemental
144. The 3-1/2-ton, M353, trailer chassis is utilized with what shop set?
- a. Basic set
 - b. No 1 supplemental
 - c. No 2 supplemental
145. The 2-1/2-ton, 2-wheeled, generator trailer chassis is utilized with what shop set?
- a. Basic
 - b. No 1 supplemental
 - c. No 2 supplemental



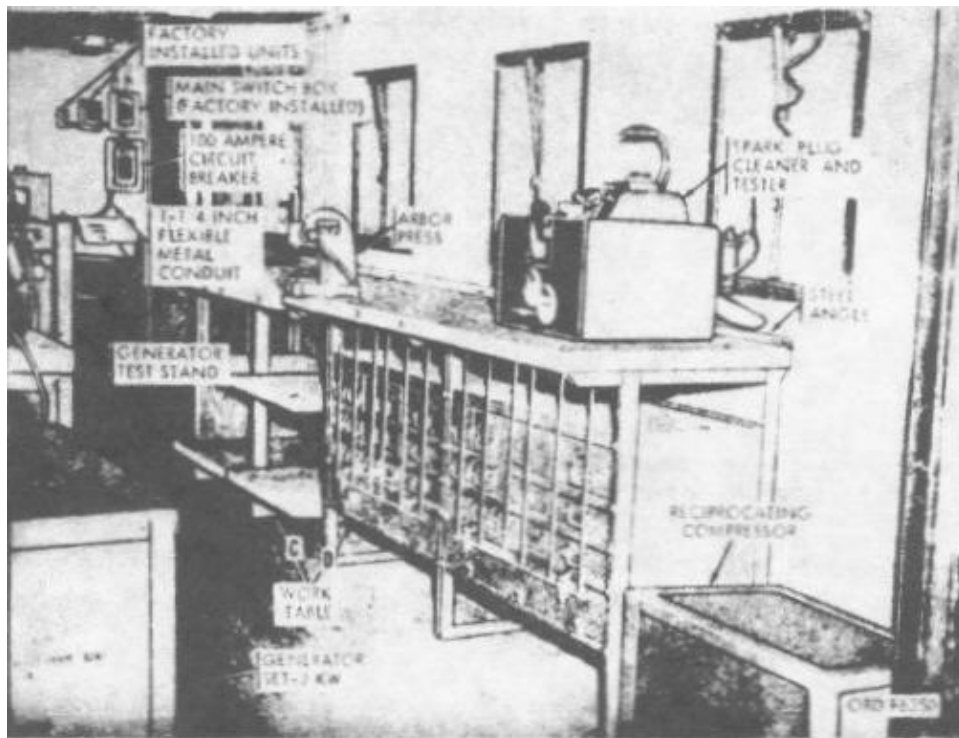
Equipment installed in shop-van.

Foldout 1.

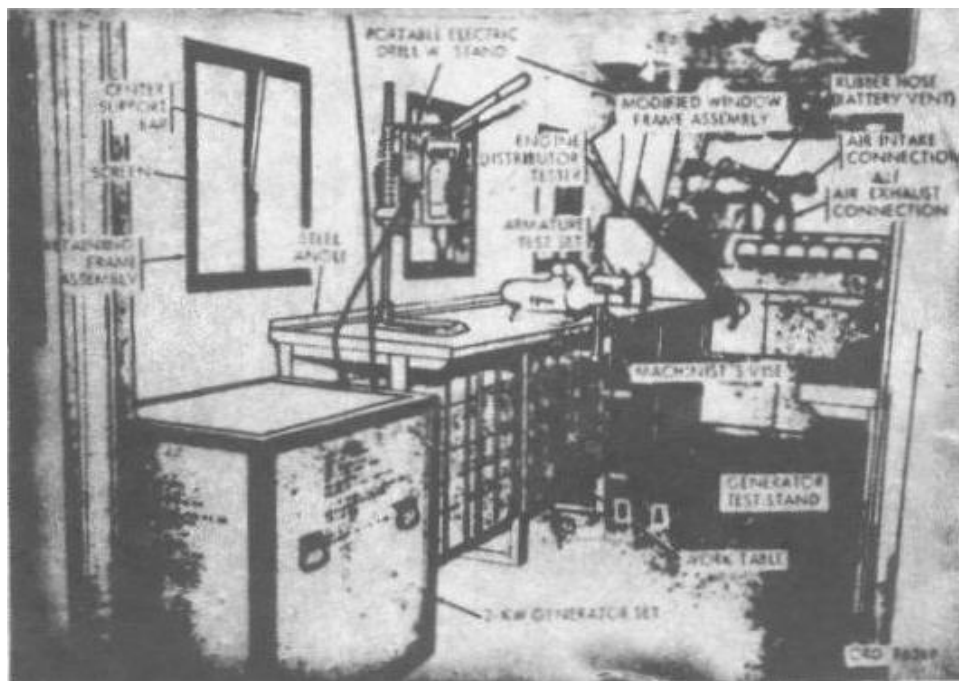


Installation of work table.

Foldout 2.



Equipment installed in shop-van semitrailer - front and right side view.



Equipment installed in shop-van semitrailer - front and left side view.

Foldout 3.

EXERCISE RESPONSE LIST

ORDNANCE SUBCOURSE 010 ELECTRICAL SYSTEM COMPONENT REPAIR

FEBRUARY 1975

**DEPARTMENT OF ARMY WIDE TRAINING SUPPORT
US ARMY ORDNANCE CENTER AND SCHOOL**

ANSWER SHEET

	a	b	c		a	b	c		a	b	c		a	b	c		a	b	c
1.	104	501	536	41.	437	523	333	81.	245	405	460	121.	625	346	515	161.	428	613	114
2.	223	657	596	42.	349	639	274	82.	360	440	624	122.	484	255	399	162.	201	552	443
3.	421	309	243	43.	277	394	647	83.	600	365	122	123.	217	698	436	163.	509	373	660
4.	241	483	527	44.	539	496	699	84.	233	526	339	124.	334	503	139	164.	180	481	230
5.	375	166	612	45.	113	408	392	85.	565	282	271	125.	593	388	291	165.	357	272	554
6.	690	110	427	46.	522	397	299	86.	175	684	488	126.	111	650	331	166.	586	386	174
7.	562	290	420	47.	191	642	412	87.	434	150	575	127.	633	252	479	167.	343	151	686
8.	630	197	463	48.	358	662	253	88.	651	363	154	128.	216	438	528	168.	120	519	495
9.	679	143	661	49.	500	379	416	89.	225	474	672	129.	411	196	671	169.	626	246	314
10.	547	685	342	50.	116	493	204	90.	400	136	352	130.	568	169	398	170.	487	652	203
11.	289	578	231	51.	164	415	533	91.	371	536	202	131.	368	697	275	171.	285	433	540
12.	635	409	236	52.	629	195	520	92.	513	266	446	132.	144	467	656	172.	618	155	361
13.	429	396	636	53.	311	505	498	93.	106	654	543	133.	476	502	123	173.	473	658	249
14.	103	112	529	54.	167	239	323	94.	644	262	454	134.	602	258	450	174.	211	566	489
15.	119	336	178	55.	304	442	227	95.	387	518	181	135.	229	303	598	175.	182	351	681
16.	510	276	452	56.	631	350	590	96.	159	374	605	136.	168	441	305	176.	308	466	588
17.	236	382	524	57.	677	206	425	97.	557	127	332	137.	472	680	125	177.	538	265	105
18.	101	490	362	58.	389	402	147	98.	410	619	212	138.	359	157	576	178.	445	187	646
19.	521	391	369	59.	316	638	403	99.	247	451	587	139.	534	380	244	179.	153	542	312
20.	628	378	426	60.	194	553	268	100.	328	551	186	140.	675	221	401	180.	234	655	458
21.	486	124	582	61.	393	570	477	101.	199	301	614	141.	287	589	606	181.	670	283	550
22.	541	492	242	62.	284	367	109	102.	693	131	459	142.	354	695	189	182.	302	430	148
23.	326	133	597	63.	207	545	648	103.	431	607	250	143.	641	297	499	183.	574	317	240
24.	293	485	637	64.	422	138	508	104.	281	480	512	144.	163	598	386	184.	165	345	564
25.	246	330	288	65.	615	504	417	105.	561	286	318	145.	564	322	257	185.	325	663	261
26.	152	295	423	66.	145	407	218	106.	115	507	238	146.	226	449	514	186.	622	176	456
27.	296	591	643	67.	580	205	376	107.	601	222	419	147.	418	130	609	187.	592	269	616
28.	573	390	432	68.	621	177	603	108.	414	190	669	148.	506	395	196	188.	208	517	327
29.	537	213	256	69.	468	669	320	109.	356	611	172	149.	294	604	406	189.	585	413	107
30.	192	264	117	70.	134	497	694	110.	687	439	329	150.	424	158	353	190.	377	673	132
31.	581	471	341	71.	385	448	170	111.	140	381	569	151.	646	219	548	191.	135	319	461
32.	279	617	324	72.	200	555	307	112.	384	667	193	152.	128	583	254	192.	683	185	370
33.	691	577	292	73.	674	184	516	113.	610	118	556	153.	321	453	676	193.	494	251	525
34.	259	679	298	74.	567	260	682	114.	149	447	209	154.	171	364	620	194.	544	469	232
35.	347	572	129	75.	228	608	161	115.	462	335	623	155.	653	237	464	195.	267	530	649
36.	156	594	278	76.	372	141	696	116.	338	666	404	156.	435	692	146	196.	668	263	455
37.	179	563	491	77.	549	665	210	117.	108	224	300	157.	560	102	337	197.	315	160	632
38.	465	564	188	78.	444	220	313	118.	599	664	142	158.	310	532	270	198.	137	511	340
39.	215	634	482	79.	688	559	173	119.	306	121	640	159.	214	475	571	199.	568	383	280
40.	457	627	356	80.	100	344	531	120.	183	470	273	160.	678	162	348	200.	478	689	126

RESPONSE
NUMBER

RESPONSE*

100	Para 4d
101	Para 3d
102	Para 3c(1)
103	Para 10d
104	Figure 33, 34, and 36
106	Para 6c
108	CORRECT. Remember Ohm s law and you can easily figure out DC meter circuits.
109	Para 5a(4) (a)
110	CORRECT. The resistance of a reversed biased diode approaches an open circuit.
111	Para 5b
112	Para 10d
113	Figure 15
115	Figure 1
116	Para 3c
117	Para 18h(2)
118	CORRECT. This action will put all new grease in the system.
119	Para 10d(4)
121	Para 7f
122	CORRECT. When bench tested all external components to the regulator circuit board have been checked. If under operating conditions it does not regulate, then the regulator circuit board has to be bad.
123	CORRECT. The function selector switch adapts the meter circuits to several types of measurement.
124	CORRECT. A low ohm reading between a slipring and the shaft indicates a grounded field winding.
125	CORRECT. The M146 is a semitrailer shop van.
127	Para 8e(1)
129	Para 2f

*If your response is not listed CORRECT, refer to the indicated paragraph or figure for the right answer.

131 Para 11a(1)

133 CORRECT. Due to the low resistance of the stator winding a check
can be done, but it will have no practical value since all the coils
are connected in series.

134 Para 6d(5)

136 CORRECT. The drive assembly is located on the armature splined end.

138 CORRECT. The rectifiers may be damaged if the output voltage
exceeds 32 volts.

139 Para 4d

140 CORRECT. The last operator of the test stand should have checked
the gearcase oil level. He may be in the process of correcting
the situation; if not, he has ignored the preventive maintenance
task.

141 CORRECT. The reverse current relay disconnects the battery circuit.

142 CORRECT. The total resistance of 50,000 ohms will allow a current
flow of 50 microamperes when 2.5VDC is applied.

143 CORRECT. The three-phase AC generator has phase voltages that are
1200 apart in time.

144 CORRECT. DC power or 120 volts, 60 Hz, single-phase power may be
used.

145 Para 5b(3)

147 CORRECT. If the diameter of the generator pulley is the same as the
drive pulley, then the RPM of the test stand will be the RPM of the
generator.

149 Restudy figure 5, the lubrication chart.

150 CORRECT. Most starter motors are series wound.

152 Para 13

154 Para 4d(2)

156 Para 2h

157 Para 4a

159 CORRECT. Brushes are only cleaned with a dry cloth.

161 Para 2c

163 Para 4b

164 Para 3c(2)

166 Para 3c

167 CORRECT. The spline adapter mates the coupling shaft to the
generator.

168 Para 1b
169 Para 7b
170 CORRECT. The purpose of a regulator is to limit the generator
voltage to a safe value.
172 CORRECT. The other components are in the high voltage compartment
and the main circuit breaker must be turned OFF when working in that
area.
173 Para 3e
175 Para 2d
177 Para 6c(1)
178 Para 10d(4)
179 CORRECT. Higher temperatures cause expansion of the electrolyte
and will therefore lower the hydrometer reading.
181 Para 6d
183 Para 8d
184 CORRECT. If the generator speed increases the output voltage
will also; so, to reduce the voltage, the field voltage which
controls the field current must be reduced to protect the
generator.
186 Para 9b
188 Para 2a
189 Para 3a
190 Figure 1
191 Para 2a
192 Para 18h(2)
193 CORRECT. This will release grease pressure on the bearings.
194 Para 4c(3) (b) 4
195 Para 4c(1) (a)
197 Para 5f
198 CORRECT. All other moving parts are lifetime lubricated.
199 Para 11
200 Para 2
202 Para 5b
204 CORRECT. For the varidrive unit to remain operating, there must
be airflow to actuate the flow sensing switch.
205 Para 6a

206 Para 4c(3) (a) 5
207 Para 5a(5)
209 CORRECT. The oil is changed annually.
210 Para 3a
212 Para 8e(2)
213 Para 17f
215 Para 4b
216 Figure 8
217 Para 3c
218 CORRECT. With the regulator in the system the output voltage
should remain constant
220 Para 3a(1)
221 Para 1e
222 CORRECT. This is one of the weekly preventive maintenance
checks.
223 Para 2b
224 Para 7c
225 Para 4c
227 Para 4c(3) (a)
228 CORRECT. The first type of regulator was a voltage sensitive
relay.
229 Para 9a
231 Para 9a
233 CORRECT. This is another check of the load relay or line switch.
J1 is the positive lead of the variable power supply.
235 CORRECT. The exciter magnetic field is controlled by the
regulator.
236 Para 1b
238 Figure 1
239 Para 4c(2) (a)
241 Para 2f
242 Para 4a
243 Para 2g
244 Para 1a
245 Para 4c

247 Para 8e(4)
248 Para 6
250 CORRECT. The parameters measured during the STALL TORQUE test
are the torque and current.
252 Take another look at figure 7.
253 CORRECT. To preclude damage the switches and controls have preset
positions.
255 CORRECT. This check should be made monthly.
256 Para 17f
257 Para 4c
258 CORRECT. Those batteries provide the potential for ohms
measurement on the R X 10,000 scale.
259 Para 2e
260 Para 2b(3)
262 Para 6c(1)
264 CORRECT. With a tension of 10 ounces the spring's length should
be 1 inch.
266 CORRECT. The pinion housing assembly is the first to be removed
during disassembly.
268 Para 4c(3) (b) 4
271 CORRECT. If the regulator is operational the output voltage should
remain stable no matter what load is applied; otherwise it is not
operational.
273 Para 8d
274 Para 7e
275 Take another look at figure 11
276 Para 1a(4)
277 Para 9b
278 Para 2h
279 CORRECT. They must be connected in series to provide 6V, 12V,
and 24V outputs.
281 Para 11a(2) (b)
282 Para 5d(2) (b)
284 Para 5a(4) (a)
286 CORRECT. During assembly the brushes and their holder are installed
in the frame assembly first.
287 Para 2a(3)

288 CORRECT. The serviceable diode will indicate a low resistance
reading when forward biased and a high resistance reading when
reversed biased.

289 CORRECT. The exciter coil is located in the rotor.

290 Para 8d

291 Para 4e

292 Refer to the tabulated data in figure 4.

293 Para 5

295 Para 13

296 Para 16b

297 Para 4a

298 CORRECT. The DC voltmeter circuit selector is a four-position
switch.

299 CORRECT. In preparation for any tests using meters their
mechanical zeros should always be checked.

300 Para 7c

301 CORRECT. The minimum time between cranking cycles is 2 minutes.

303 Para 9a

304 Para 4c(3) (a)

305 Para 1b

306 Para 7f

307 Para 2

309 Para 2g

311 Para 4c(1) (d)

313 Para 3a(1)

316 CORRECT. The equation is $\text{RPM UUT} = (6,000 \times 4) \div D$; accordingly,
 $8,000 \text{ RPM} = (6,000 \times 4) \div 3$.

318 Para 10f

320 Para 7f

322 CORRECT. The 2-1/2-ton, 2-wheeled, generator trailer carries the
generator for the No 1 supplemental set.

323 Para 4c(2) (a)

324 Study figure 3 to determine the correct answer.

326 Para 5

328 CORRECT. Score marks and nicks on the spline are repaired using
a fine stone.

329 Figure 1
330 Para 6
331 CORRECT. Top speed decreases as the drive belt wears.
332 CORRECT. Continuity between the core and commutator riser bar
is checked for armature grounds.
333 CORRECT. These circuits are used when checking vibrator-type
regulators and to check the carbon pile of generator (alternator)
regulators.
334 CORRECT. Replacement will prevent a failure during normal use.
335 CORRECT. Regular cleaning and service prolongs battery life.
336 CORRECT. The zener is a reversed biased diode. When the sensing
voltage exceeds 12 volts then maximum current will flow and turn
the transistor ON.
338 CORRECT. This identifies the change of electrolytic solution.
339 Para 5d(3)
341 Take another look at figures 1 and 2.
342 Para 9b(4)
344 Para 4d
346 Para 2b
347 Para 2f
349 Para 7e
350 Para 4c(3) (a) 2
352 Para 5a(2)
354 Para 3a
355 Figure 2
356 Para 4i
358 Para 2c
359 CORRECT. The basic set requires the 10KW AC generator.
360 Para 5a
362 CORRECT. An ammeter is always connected in series with the load.
363 Para 4d(2)

365 Para 5c(2)

367 CORRECT. The field current is reduced first if the load is
decreased, for decreasing the load has a tendency to increase
the. voltage.

368 CORRECT. Red, yellow, green, white, amber, and blue indicators
are used.

369 Para 3c(2)

371 CORRECT. The solenoid relay makes control possible from a remote
point.

372 Para 2d(2)

374 Para 7c

375 CORRECT. The zener diode is designed to operate at the reverse
breakdown voltage. This enables it to provide a constant voltage
drop over a wide current range.

376 CORRECT. The 100-ampere alternator is a three-phase generator.

378 Para 3e

379 CORRECT. If the power lamp is LIT an interlock switch has to be
open.

380 CORRECT. The M146 semitrailer houses the No 1 supplemental and
basic sets.

381 Para 3a and 3b and fig 1

382 CORRECT. The rectifiers, sliprings, and brushes are exposed when the
drive end housing is removed.

384 Consult figure 5, the lubrication chart.

385 Para 1b

386 CORRECT. The 3-1/2-ton, M353, trailer chassis carries the generator
for the No 2 supplemental set.

387 Para 6d

388 Para 4e

389 Para 4c(3) (b) 3

390 Para 17f

391 Para 3c

392 CORRECT. The DC ammeter load and start selector should be set at
500A and the DC ammeter field and battery selector should be set at
15A.

393 Para 5a

394 Para 9b

396 Para 10C and fig 39

397 Para 2a
398 CORRECT. The analyzer is adaptable for use with 6V, 12V, and 24V
units.
399 Para 2g
400 Para 5a(2)
401 CORRECT. TB ORD 444-22 covers the installation of the No 1
supplemental set into the M146 semitrailer.
402 Para 4c(3) (b) 3
403 Para 4c(3) (b) 3
404 Para 6f
405 CORRECT. The reverse polarity diode prevents the line switch relay
from closing when the wrong polarity is applied.
407 Para 5b(3)
408 Fig 15
409 Para 10b
410 CORRECT. To inspect the armature for shorts a growler and steel
strip are used.
411 Para 6c
412 Para 2a
414 Fig 1
415 CORRECT. The START button should not be held down more than 30
seconds.
416 Para 3b
417 Para 5b(3)
419 Fig 1
420 CORRECT. The voltage (E) across a load resistance (R) is equal to
the current (I) multiplied by the resistance (R) or $E = IR$. The
amount of current to the load is controlled by the rectifying diode,
so a voltage will be developed across the load only when the diode is
forward biased and maximum current is allowed to flow.
421 CORRECT. The current (I) is equal to the voltage (E) divided by the
resistance (R). $I = E/R$, so $I = 1 \text{ volt}/1000 = .001 \text{ ampere}$ or
1 milliampere.
422 Para 5a(4) (a)
423 CORRECT. To avoid bearing damage force should be applied to the
outer race.
425 Para 4c(3) (a) 5

426 CORRECT. The battery is the load in the generator system, so to
increase the amount of load the variable load is connected in
parallel.

427 Para 8c

429 CORRECT. If the transistor is forward biased it is said to be ON,
thus exhibiting a resistance approaching a short circuit. No
voltage can be developed across a short circuit.

431 Para 11a(2)(i)

432 CORRECT. Then clean with compressed air.

434 Para 2i

436 CORRECT. This is the most efficient means of troubleshooting the
ignition timing light.

437 Para 4k

438 CORRECT. This can be corrected by loosening the distributor
clamp and centering the distributor shaft.

439 Fig 1

440 CORRECT. You are checking the reverse polarity diode.

441 CORRECT. DA Pam 310-4 lists a complete index of DA supply catalogs.

442 CORRECT. The pulley output shaft couples between the driving head and
pulley.

444 CORRECT. The contact screw adjusts the pressure against the pile,
thereby setting the minimum resistance of the carbon pile.

446 Para 6a

447 Restudy figure 5, the lubrication chart.

448 Para 1b

450 Fig 18

451 Para 8e(4)

452 CORRECT. The internal regulator voltage adjustment is under the pipe
plug on the front housing.

454 CORRECT. To free the yoke cover the yoke pin in the pivot Joint
must be removed.

457 CORRECT. This is one of three field switches.

459 Para 11a(1)

460 Para 4c

462 Para 6a(1)

463 CORRECT. A stator assembly is loops of wire in a frame surrounding
the rotor.

465 CORRECT. To assure the accuracy of the monitors they are compared
with certified standards.

467 Para 7a and fig 13

468 Para 7f

470 CORRECT. Rotating the control clockwise increases the charging
potential applied to the batteries.

471 CORRECT. The power service entrance is located at the lower left
front of the test stand.

472 Para 1a

474 CORRECT. The shifter lever is a part of the over-running clutch
drive system.

476 Fig 15

477 CORRECT. The Jumper wires complete the field circuit in the rotor.

479 Take another look at figure 7.

480 CORRECT. To prevent body injury, the yoke shifting lever is blocked
in the operating position during STALL TORQUE tests.

482 CORRECT. The relay lamp switch. is a three-position toggle switch
selects the proper circuit for the relay closure indicator lamp.

483 CORRECT. $E = IR = 2 \text{ amperes} \times 6 \text{ ohms} = 12 \text{ volts}$.

484 Para 2g

485 Para 5

486 Para 4b

488 CORRECT. The current flowing through a wire creates a magnetic field
around it and will cause a force on the wire if the wire itself is in
a magnetic field.

490 Para 3c

491 Consult figure 22 to determine the effects of temperature on specific
gravity.

492 Para 4a

493 Para 3c

496 CORRECT. This circuit looks very compact on the electrical wiring
diagram, but remember the meter and generator are widely separated
on the test stand.

497 Para 6d(5)

498 CORRECT. The mounting flange adapter connects between the pivot
arm and generator.

499 Para 4a

500 Para 3b

501 CORRECT. The multioutput AC charging system has a full wave
rectified DC output.

502 Fig 15

503 Para 4d

504 Para 5b(3)

505 Para 4c(1) (d)

507 CORRECT. This is one of the DURING OPERATION preventive maintenance
checks.

508 Para 5a(4) (a)

510 Para 1a(4)

512 Para 11a(2) (b)

513 Para 6a

515 Para 2b

516 Para 2a

518 CORRECT. During disassembly the intermediate housing is removed
before the armature is freed.

520 Para 4c(1) (a)

521 CORRECT. Voltmeters offer a very high resistance; normally,
around 20,000 ohms per volt.

522 Para 2a

523 Para 4k

524 Para 1b

526 Para 5d(3)

527 Para 2f

528 Fig 8

529 CORRECT. If the transistor is reverse biased it is said to be OFF,
thus exhibiting a resistance approaching an open circuit and allowing
maximum voltage to be developed across it. The voltage causes
current to flow in the SCR gate circuit turning it ON and allowing
maximum current to flow in the field coil.

531 CORRECT. When the ignition is turned OFF the line switch relay
deenergizes. The inductance of the relay coil generates a high
voltage transient due to the collapse of the magnetic field. This
voltage is bypassed by the diode.

533 Para 3c(2)

534 Para 1a

535 Para 5b

536 Fig 33, 34, and 36
537 CORRECT. After polishing the sliprings they are cleaned with
compressed air.
539 Take another look at figure 14
541 CORRECT. A high resistance between the sliprings indicates an open
field winding.
543 CORRECT. The yoke cover contains the pivot Joint for the shift lever.
545 Para 5a(5)
546 Para 4c
547 Para 9b(4)
549 Para 3a
551 Para 9b
553 CORRECT. Once the RPM has been determined the tachometer is switched
to the CAL PULLEY position so the adjustment can be made.
555 CORRECT. The field voltage is the best way to control the generator
voltage output.
556 This would be a waste of lubricant. Consult figure 5, the
lubrication chart.
557 Para 8e(1)
558 Para 7b
559 CORRECT. The capacitor assembly is for suppressing radio
interference generated by the ignition system.
561 Para 10f
562 Para 8d
563 Consult figure 22 to determine the effects of temperature on
specific gravity
565 Para 5d(2) (b)
567 CORRECT. The basic regulator principle is a switching action.
569 Para 3a and 3b and fig 1
570 Para 5a
572 CORRECT. The tachometer reads drive head speed directly when in the
direct position, but it must be calibrated according to formula when
a pulley driven generator is being tested.
573 Para 17f
575 Para 2i
576 Para 4a

577 CORRECT. The running speed of the varidrive motor is a constant
1,800 RPM.

578 Para 9a

579 Para 7a

580 Para 6a

581 Fig 1 and 2

582 Para 4b

584 Para 2a

587 CORRECT. Concentricity is a check of roundness and is measured with
a lathe and dial indicator.

589 CORRECT. Under blackout conditions the dome lights go out when the
door is opened.

590 CORRECT. The chain vise is powerful and should never be clamped
over thin shell housing.

591 CORRECT. The special tool is used to protect the intermediate seal.

593 CORRECT. An audio tone will indicate when this item is operational.

594 CORRECT. When not in use the AC voltmeter circuit selector should
be set to the OFF position.

595 CORRECT. The electric current is measured in amperes.

596 Para 4b

597 Para 5

598 CORRECT. There are four independent sections: voltmeter circuit,
field rheostat circuit, 1/4-ohm load resistor circuit, and load bank
circuit.

599 Para 7d

600 Para 5c(2)

601 Fig 1

602 Fig 18

603 Para 6c(1)

604 Para 6c(1)

605 Para 7c

606 Para 2a(3)

607 Para 11a(2) (i)

608 Para 2c

610 Consult figure 5, the lubrication chart.

611 Figure 2
612 Para 3c
614 Para 11
615 CORRECT. In the 60-ampere system the field current should not exceed
1 ampere of current.
617 Study figure 3 to determine the correct answer.
619 Para 8e(2)
621 CORRECT. The 100-ampere regulator is a solid-state device.
623 Para 6a(1)
624 Para 5a
625 CORRECT. Positioning the armature under test completes this magnetic
circuit.
627 Para 4i
628 Para 3e
629 CORRECT. The pivot arm and mounting brackets are left mounted to the
test stand after a test.
630 Para 5f
631 Para 4c(3) (a) 2
633 CORRECT. Meter, cables, and leads are also checked at this time.
634 Para 4b
635 Para 10b
636 Para 10c and fig 39
637 CORRECT. Since the WYE ("Y") configuration makes one common
connection between the stator coils, it can be checked for an open
circuit.
638 Para 4c(3) (b) 3
639 CORRECT. This switch is used when checking alternator dropoff
voltage.
640 CORRECT. The meter shunt keeps most of the current to be
measured from flowing through the meter movement.
641 CORRECT. The 1-1/2-ton, 2-wheeled, cargo trailer carries the generator
for the basic set.
642 CORRECT. The zero adjustment is located below the lens in the middle
of the meter.
643 Para 16b

644 Para 6c(1)

647 CORRECT. The V-belt assumes a smaller diameter on the driven shaft
as a larger diameter is assumed on the drive shaft.

648 CORRECT. With no output voltage or current the rotor field circuit
is most likely open.

650 Para 5b

651 CORRECT. The over-running clutch drive pinion is activated before
the armature rotates.

654 Para 6c

656 Para 7a and fig 13

657 Para 2b

659 CORRECT. The gearcase level should be checked before and after
test stand operation.

661 Para 7a

662 Para 2c

664 Para 7d

665 CORRECT. The pile is made of strips of carbon placed on top of
each other; the greater the pressure - the closer they are together,
thereby having less resistance.

666 Para 6f

667 Consult figure 5, the lubrication chart.

669 CORRECT. The LOAD RELAY test is done with the variable DC power
supply on the test stand.

671 Para 6c

672 Para 4c

674 Para 2a

675 Para 1e

677 CORRECT. To regulate the belt tension, the mounting bracket
is adjusted.

679 Para 2e

680 Para 1a

682 Para 2b(3)

684 Para 2d

685 CORRECT. The number of north and south poles on the rotor determines
the frequency. By dividing the total number of poles by two we find
the effective number of bar magnets, which will be the actual number
of cycles developed during a single revolution.

687 CORRECT. The operator in his before-operation preventive maintenance
checks will usually be the one to discover the problem and is
authorized to replace the antistatic coating.

688 Para 3e

690 Para 8c

691 Fig 4

693 CORRECT. The parameters measured during the NO LOAD test are
the RPM and current.

694 CORRECT. The proper field current for the 100-ampere system is
between 9 and 12 amperes.

695 CORRECT. The AC power receptacle on the M146 van is located on the
right front of the trailer.

696 Para 2d(2)

697 Fig 11

698 Para 3c

699 Fig 14