SERVICE DEPARTMENT

EMD GM

Electro-Motive Division
Of General Motors
La Grange, Illinois 60525

Maintenance Instruction

AR6-D14 TRACTION GENERATOR

AR6-D14 traction generator maintenance and overhaul instructions are presented in six sections, each under separate cover. General maintenance instructions are included for the AR6-D14 combination. In addition, detailed instructions to completely disassemble, inspect, recondition, assemble, and test the AR6 traction generator are included. Performance of a specific procedure may require, as a prerequisite, the completion of a procedure contained in another section. In each case this procedure will be referenced.

SECTION 5

RECTIFIER BANK ASSEMBLIES AND SUPPRESSION CIRCUITS

CAUTION

Do not perform high potential tests on diodes, either individually or collectively.

If a high potential test is to be performed on the locomotive or generator, all positive and negative generator buses must be shorted together, and the brushes at the slip rings connected together to prevent high potential from being applied to the controlled rectifier assembly SCR.

Operation of the AR6 generator without load is not recommended, and should be restricted to an absolute minimum; but under no circumstances allow no-load voltage to exceed 800 V DC, and never operate the generator with the inspection doors open or panels removed.

INTRODUCTION

The AR6 traction generator is a 3-phase alternator, the rotor of which makes up a 10 pole DC excited field. Two sets of "Y"-connected windings make up the alternator stator. The arrangement results in two separate sources of 3-phase AC output, each independently rectified by an assembly of heat-sink mounted silicon diodes. The rectifier assembly frame is shown in Fig. 1.

Fuses are provided to isolate diodes that may become shorted, and the operating coil of a protective relay is connected across the neutral points of the stator windings to detect a single phase condition. The relay coil is also connected through resistance to ground to detect generator or locomotive grounds.

At the slip ring end of the machine, one rectifier bank assembly is to the left and the other to the right of the slip rings. Each assembly consists of:

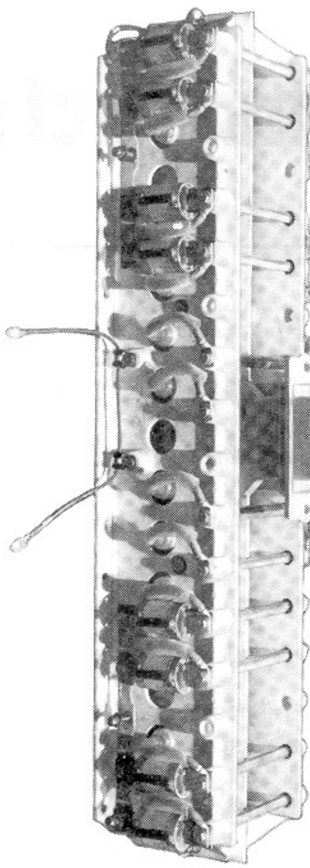

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Fig. 1 – Molded Type Rectifier Assembly

1. A positive and a negative heat sink and bus bar assembly.

2. A mounting frame.

3. An equal number of positive base diodes and negative base diodes.

4. Interrupting fuses.

Capacitors and resistors for suppression of transient voltage spikes are located within the generator airbox, on the airbox wall, Fig. 2.

The AR6 main generator is equipped with current transformers mounted on the generator end plate. There are three transformers, one for phase "A," one for phase "B," and one for phase "C" at the AC side of the rectifier banks. AC current as sensed by the transformers is proportional to DC current at the main generator busses. As such, it provides a signal that is proportional to DC current output from the main generator. When the locomotive control system is equipped with a performance control panel PCP or a performance control module, the generator mounted transformers, along with a cabinet mounted potential

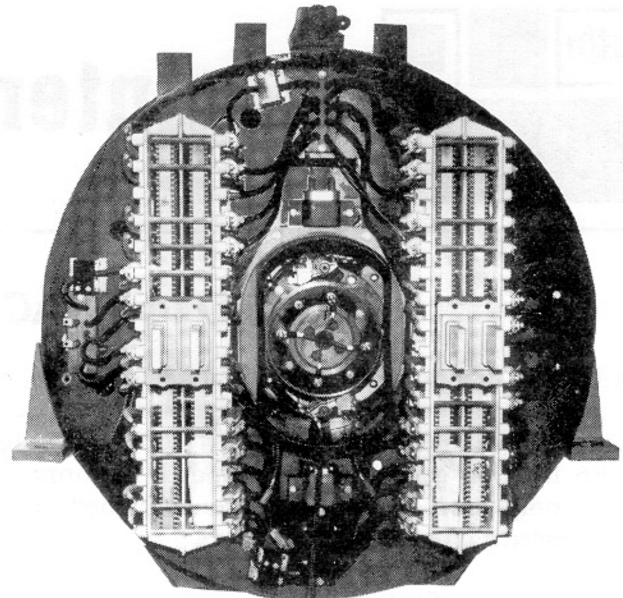

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Fig. 2 – Generator Air Box (Cover Removed)

transformer, provide signals for control of generator excitation and power output.

CLEANING RECTIFIER BANK ASSEMBLY

The following procedure is recommended for cleaning the AR6 rectifier assemblies. The cleaning should be performed at the intervals stated in the scheduled maintenance program.

1. Remove the heat sink assemblies from the generator.

2. Remove all fuses from the assemblies. Do not remove the diodes, and do not remove the sleeves from the diodes.

WARNING: Water or cleaning solution allowed to contaminate the arc quenching sand inside the fuse body can cause the fuse to explode when it is required to isolate a shorted diode.

3. In a suitable tank, mix "Turco Steam Fas" cleaner in a ratio of 3 ounces per gallon of water. Maintain solution temperature at about 71° C (160° F). Do not allow the solution to boil.

4. Place the suction pipe from a steam gun into the solution, and open valves to obtain a 71° C (160° F) mix with steam at the gun discharge nozzle.

CAUTION: Do not use live steam alone to clean the assemblies, and do not soak the assemblies in a caustic solution. If diodes are removed from the heat sink, the contact surfaces of the diodes and heat sink assemblies must not be cleaned with an abrasive material or wire brush. Such cleaning will destroy the finish and reduce heat rejection capability.

5. Clean all parts of the heat sink assembly, keeping the gun nozzle 100 to 150 mm (4 to 6 inches) from the work.
6. Thoroughly rinse the assembly with a low pressure stream of clean water to remove all residue.
7. Blow off remaining clean water with dry air.
8. Test all diodes and fuses with an ohmmeter.
9. Reinstall fuses and reinstall the diode assembly after the generator airbox and end plate have been cleaned.

DIODE CLASSIFICATION

For service purposes the following classifications of AR6 diodes are significant.

1. Polarity with respect to the diode base (threaded stud). A color code is used to assist in identification.
2. Type with respect to forward voltage drop. Identification is assisted by color code and by type number impressed into the base.
3. Voltage class in respect to repetitive and non-repetitive peak inverse voltage rating. Identification is assisted by color code.

DIODE POLARITY

The direction in which conventional electrical current flows through a diode determines its polarity. The graphical arrow symbol, Fig. 3, is oriented to indicated diode polarity.

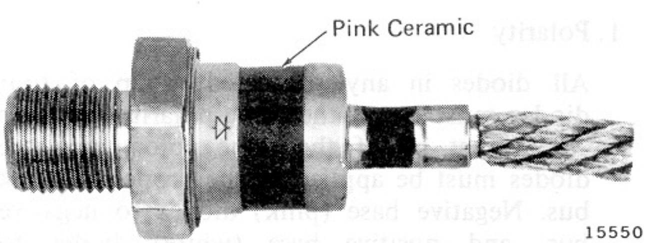


Fig. 3 – Rectifier Polarity Symbol - Negative Base Diode Shown

To provide a permanent method of identification, the cermaic cases of the diodes are permanently colored as follows:

DIODE POLARITY	
Positive Base Diode	White Ceramic
Negative Base Diode	Pink Ceramic

For the diode to conduct, a positive voltage must be applied coincident with the tail of the arrow, and a negative voltage applied coincident with the point of the arrow. If the voltages are reversed, the diode will block, and only a small leakage current will pass through the diode.

Negative base diodes require a positive voltage on the stud, and a negative voltage on the flexible lead in order to conduct.

Positive base diodes require a positive voltage on the flexible lead, and a negative voltage on the stud.

DIODE TYPES

Because of the high DC current requirements for locomotive tractive power, diodes must be connected in parallel conducting paths. When parallel operation of silicon diodes is undertaken, means must be provided to ensure a reasonable degree of current sharing. Each diode in a parallel group must share the load to prevent overloading of diodes in parallel with it.

Current sharing of AR6 diodes is accomplished by paralleling only diodes whose forward characteristic (forward voltage drops) are a near match.

At the time of manufacture, diodes are segregated under specific test conditions according to their forward characteristics and are assigned a type number that is permanently impressed in the metal at the flat end of the threaded stud. In addition, a color code band is applied where the flexible lead is crimped to the diode body. Fig. 4.

DIODE TYPES	
Diode Type Number	Body Crimp Color Band
2	Red
3	Black

▨ Not used on AR6.

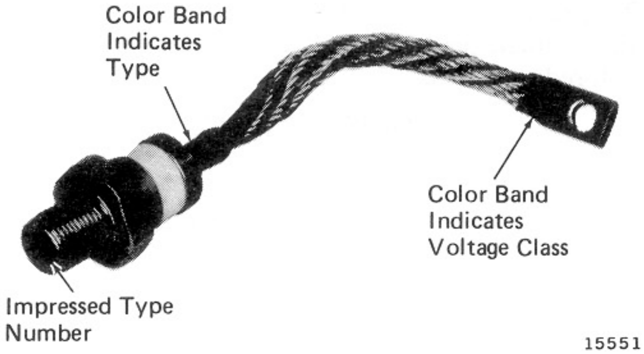


Fig. 4 - Impressed Type Number And Color Bands Indicating Type And Voltage Class

DIODE VOLTAGE CLASSES

Four voltage classes of diodes have been manufactured, but only the 2400 volt diodes are used by EMD in the AR6 generator. The class identification is indicative of repetitive and non-repetitive peak inverse voltage capabilities under specific test conditions. A color band around the barrel at the lug end of the flexible lead indicates the diode voltage class.

DIODE VOLTAGE CLASSES	
Color Band At Lug Barrel	Voltage Class
None	1600/2000
Green	2000/2400
Brown	2200/2600
Blue	2200/2800

▨ Not used on AR6.

MANUFACTURER'S QUALIFICATION MARKS

Various phases of diode qualification testing have occurred in the past and will continue to occur in the future. A variety of qualification marks (see Fig. 5) have been placed upon diodes by the manufacturer. For example; small color dots on the diode body, large color spots (not bands) on the diode body or lug, color marks at the edge of the lug, and numbers stamped onto the diode body. These marks are for manufacturer's identification only.

The only significant marks for service purposes are:

1. The color band 360 degrees around the lug barrel at the end of the flexible lead.
2. The color band 360 degrees around the crimp at the flexible lead and diode body.
3. The service part number printed on the cap of the diode body.
4. The color of the ceramic insulator.
5. The diode type number stamped into the flat end of the treaded stud.

PROTECTIVE FUSES

Current limiting fuses, Fig. 6, are provided to isolate shorted diodes. The fuses are a bolted lug type, with the lugs affixed to end blocks. Fast acting silver alloy fusible links attached to the end block are surrounded with silicon sand that acts to absorb arc energy during fault clearing. The body of the fuse is made of reinforced melamine.

A small indicating fuse is affixed to the main fuse body and is connected in parallel with the main fuse elements. When the main elements burn open, the element of the indicator also burns open. A spring in the indicator drives an indicating pin to protrude about 5 mm (3/16") from the end of the indicator.

Note that the internal-hex screw on one end of the fuse is provided only for insertion of sand by the manufacturer. The screw is staked to prevent its removal. The fusible elements cannot be renewed, and a blown fuse cannot be repaired.

DIODE MATCHING

Fig. 7 shows the AR6 rectifier assembly with the air box removed. The illustration shows how diodes and fuses are paralleled in groups of four by use of paralleling bars.

Diodes used in the AR6 generator must be matched as follows:

1. Polarity

   All diodes in any paralleled group of four diodes must be of the same polarity (ceramic cases must be of the same color), and the diodes must be applied to the proper heatsink bus. Negative base (pink) diodes to negative bus, and positive base (white) diodes to positive bus. Bus polarity is stamped into the end of the bus.

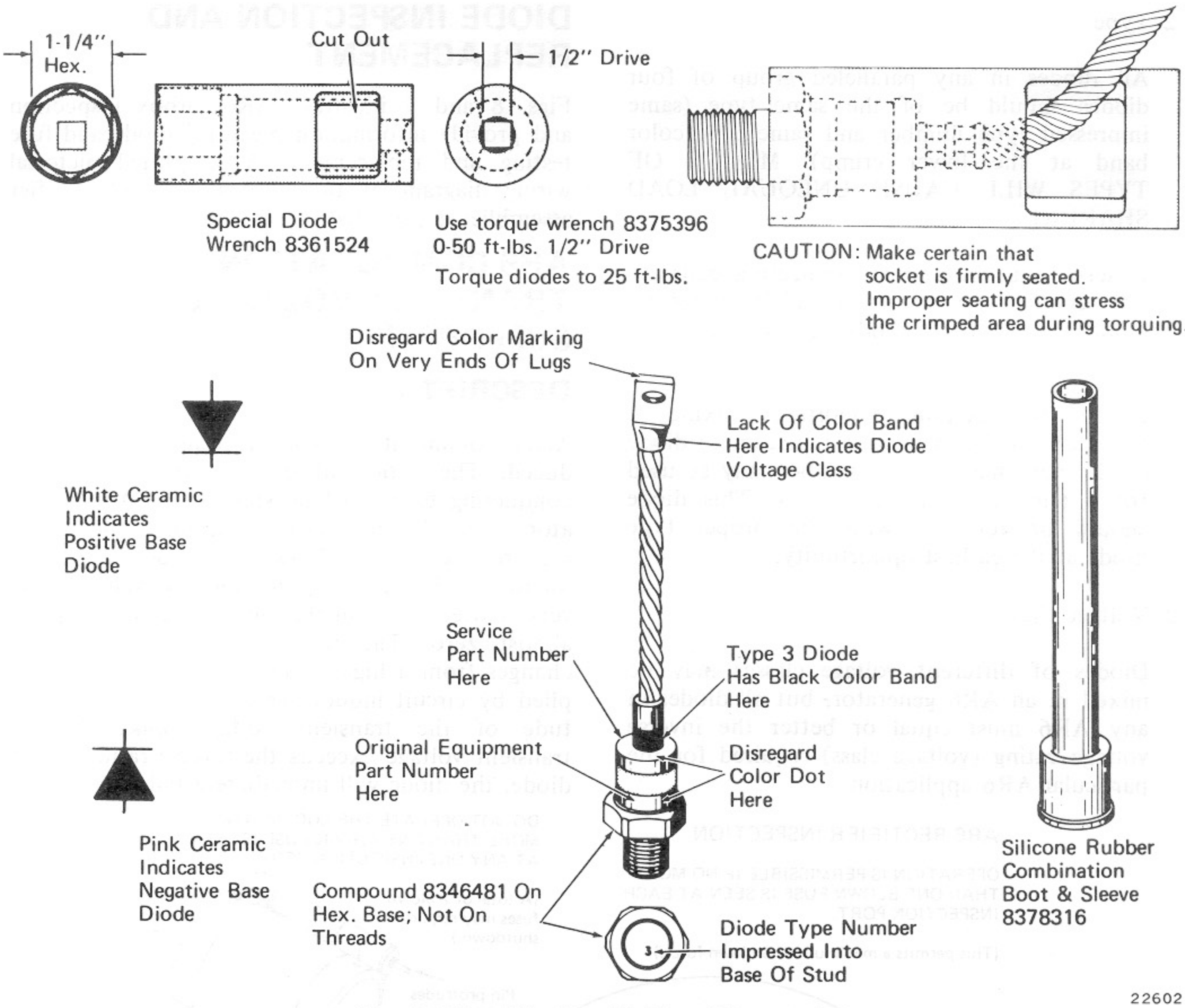


Fig. 5 – Identification Markings Illustrated

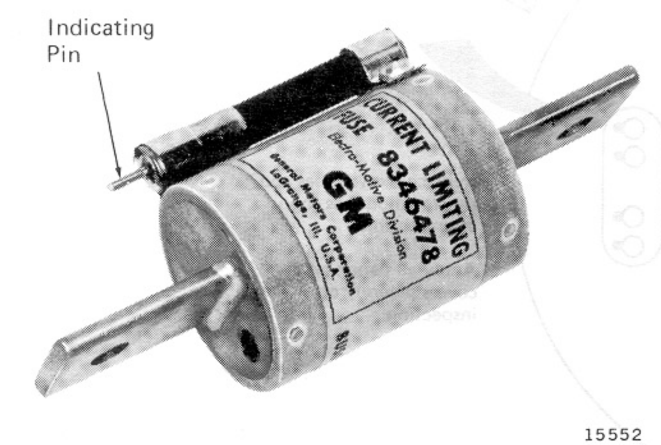


Fig. 6 – Current Limiting Fuse

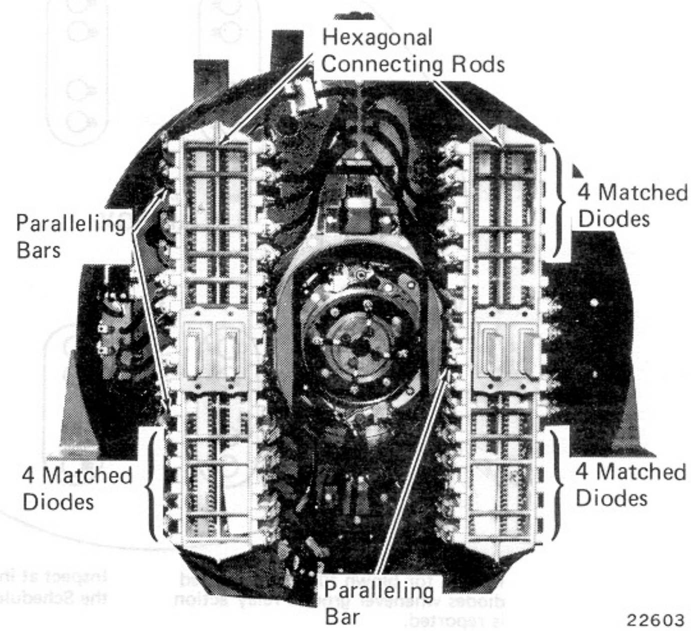


Fig. 7 – Diode Matching Within Groups

2. Type

All diodes in any paralleled group of four diodes should be of the same type (same impressed type number and same type color band at the lower crimp). MIXING OF TYPES WILL CAUSE UNEQUAL LOAD SHARING.

Observe that hexagonal connecting rods do not connect diodes in parallel; therefore, diodes connected by rods do not necessarily match by type.

If due to operating conditions mixing of types cannot be avoided, a replacement diode of the next higher type number may be used for a temporary emergency fix. This diode should be replaced with the proper type diode at the earliest opportunity.

3. Voltage Class

Diodes of different voltage classes may be mixed in an AR6 generator, but all diodes in any AR6 must equal or better the inverse voltage rating (voltage class) required for the particular AR6 application.

DIODE INSPECTION AND REPLACEMENT

Figs. 8 and 9 illustrate AR6 airbox inspection and provide information regarding diode and fuse testing and replacement. A simplified pictorial wiring diagram of the AR6 stator and rectifier assemblies is provided in Fig. 10.

AR6 COMMUTATION TRANSIENT VOLTAGE SUPPRESSION

DESCRIPTION

After commutation, voltage transients are produced. The action of diodes switching from a conducting to a blocking state in the AR6 generator is called commutation. During commutation high reverse current flows in the diodes for a few microseconds, after which time the value of reverse current flow in the diode suddenly drops to almost zero. The rate at which current flow changes from a high value to almost zero, multiplied by circuit inductance determines the magnitude of the transient voltage spike. If this transient voltage exceeds the reverse rating of the diode, the diode will immediately fail.

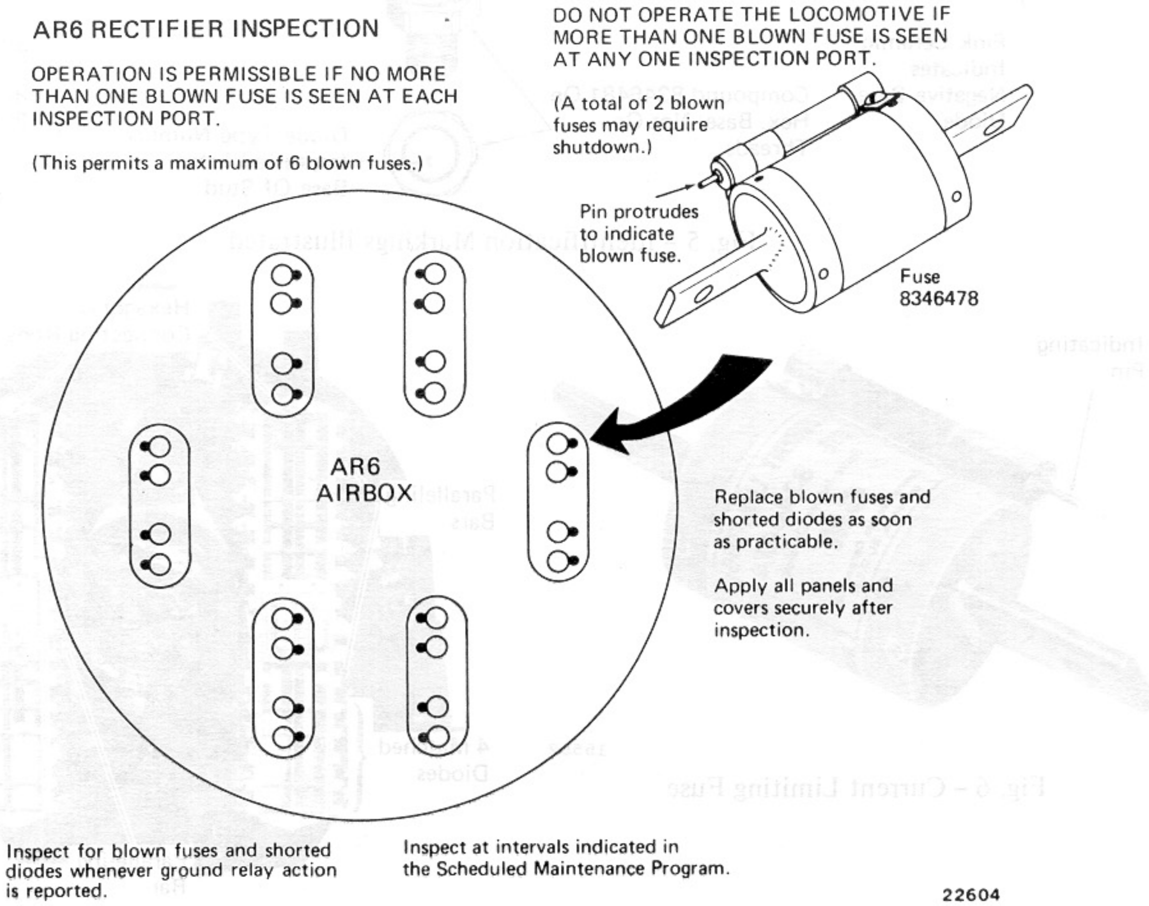
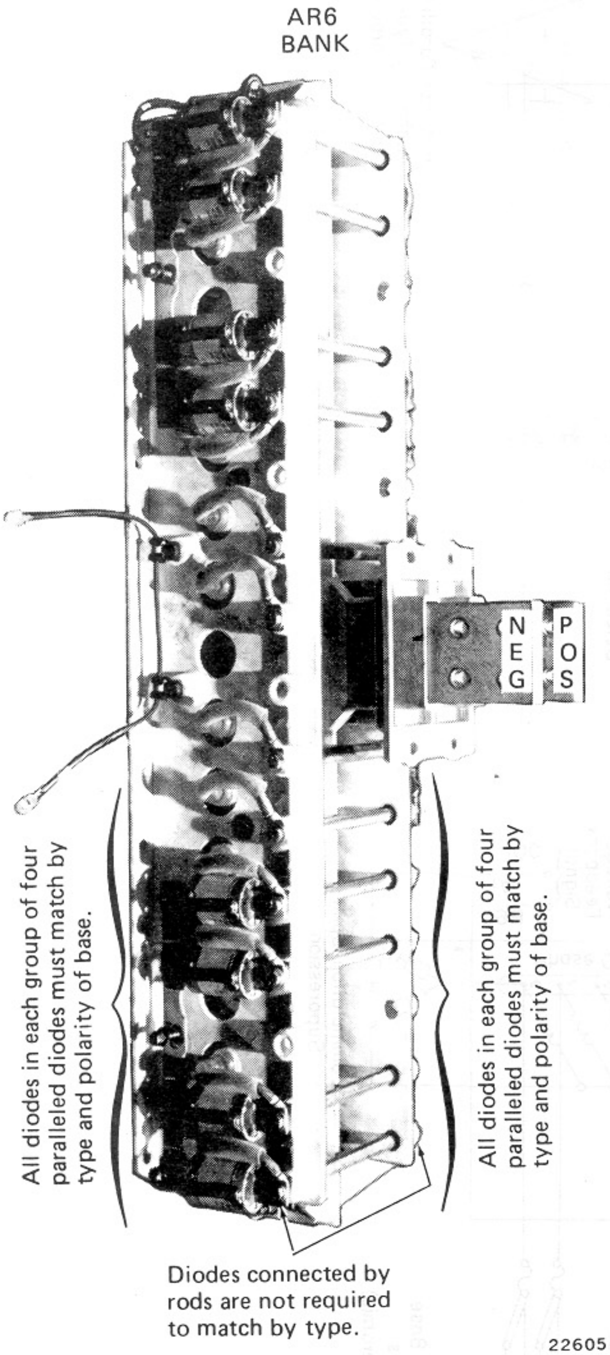


Fig. 8 – AR6 Rectifier Inspection



DIODE INSPECTION AND REPLACEMENT

1. Indicating pin protrudes.
2. Remove nut and unfasten diode lead. Check fuse continuity.

NOTE: If multiple failures have occurred in a single group of 4 diodes, or if repeated failures have been observed in a single group of 4 diodes, isolate and check all diodes in the group.

3. Place continuity tester across negative bus and connecting rod, then switch the tester leads. This checks one of the diodes protected by the fuse.

   If diode is good, the meter registers 10 to 20 ohms in one direction and above 30,000 ohms when leads are reversed.
4. Place continuity tester across positive bus and diode lead, then switch the tester leads. This checks the other diode protected by the fuse.
5. Replace blown fuse with a good fuse.
6. Remove faulty diodes, using special diode wrench 8361524.
7. Clean the mounting surface of the heat sink bus.
8. Replace shorted diodes with good diodes of identical type, polarity, and voltage class (or higher voltage class). Apply compound 8346481 to the base of the diode hex in sufficient quanity to cover the surface. Do not apply on threads.
9. With special diode wrench and 0-50 ft-lbs torque wrench 8375396, torque diodes to 25 ft-lbs. Make certain that the wrench is properly seated when torquing.
10. Replace and securely fasten all airbox panels and inspection covers.

Fig. 9 – Diode Inspection And Replacement

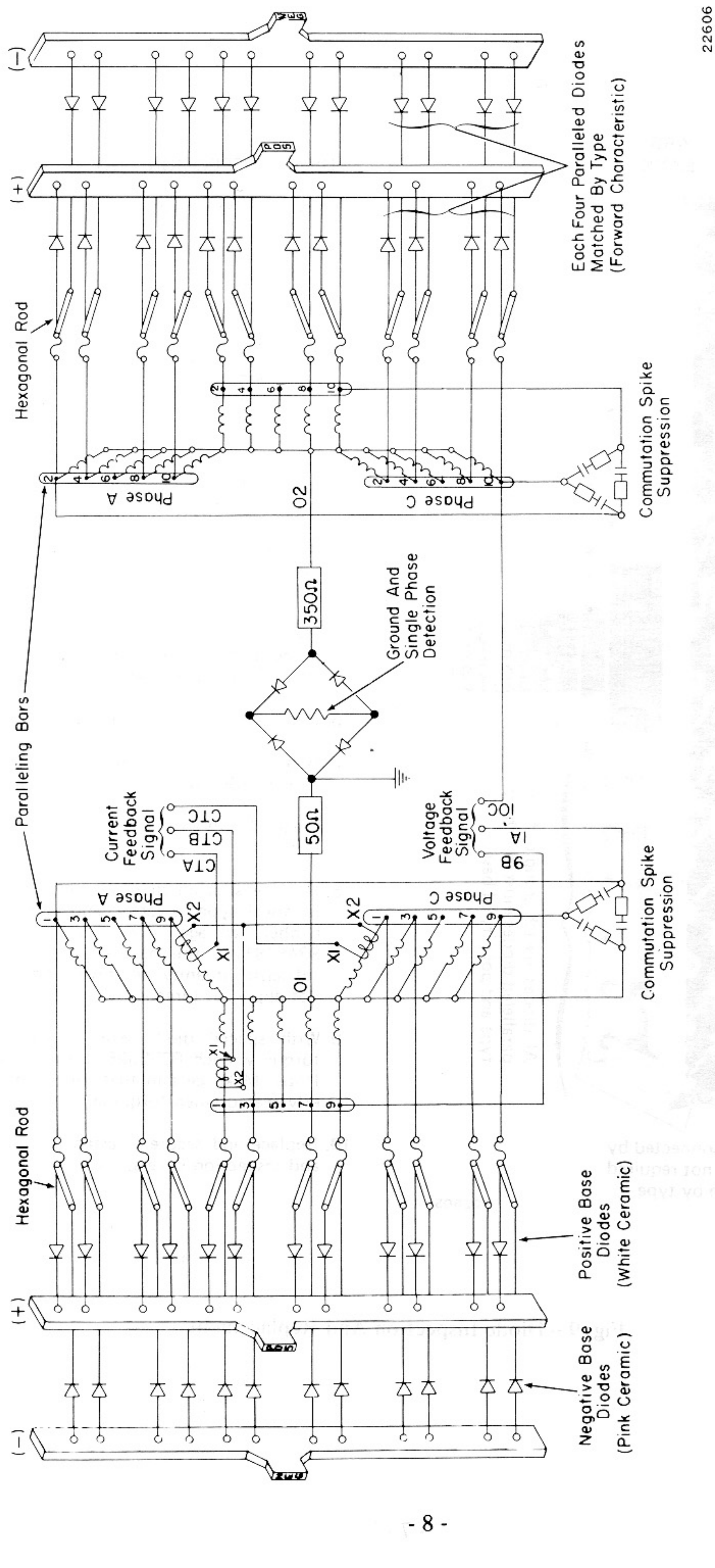


Fig. 10 – Simplified AR6 Pictorial Wiring Diagram

The AR6 generator is provided with a system for capacitive storage of energy from circuit inductance during commutation. The system is called the commutation transient voltage suppression system. It utilizes a total of six 2 microfarad capacitors and six 5 ohm resistors. The resistors and capacitors are connected in delta fashion, Fig. 11, between the "A," "B," and "C" phase paralleling bars on both the left and right banks of the generator.

INSPECTION OF THE SUPPRESSION SYSTEM

An inspection of the commutation transient voltage suppression system should be made every time a faulty or failed diode is detected and replaced. The required inspection is basically visual. The following checks should be made.

1. Check that all connections are tight and are electrically correct. See Fig. 12 for wiring diagram.

2. Examine all resistors for evidence of overheating and open turns.

3. Examine all capacitors for oil leaks or deformation of the container. (The container top may be badly pushed out.)

TEST AND CORRECTIVE MEASURES

LOOSE OR IMPROPER CONNECTIONS

Tighten any loose connections in accordance with the applicable wiring diagram.

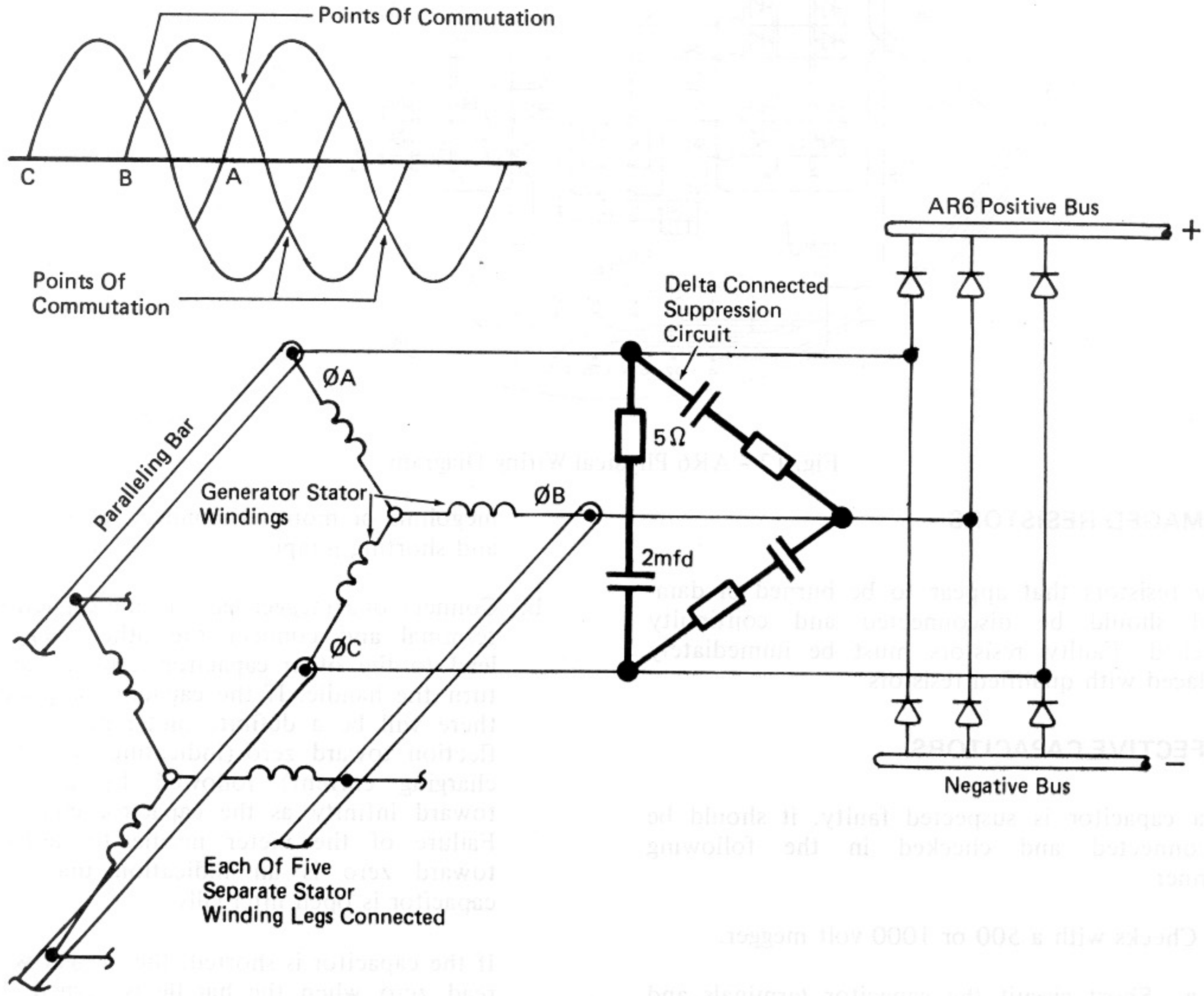


Fig. 11 – Delta Connected Suppression Circuit - Simplified Diagram

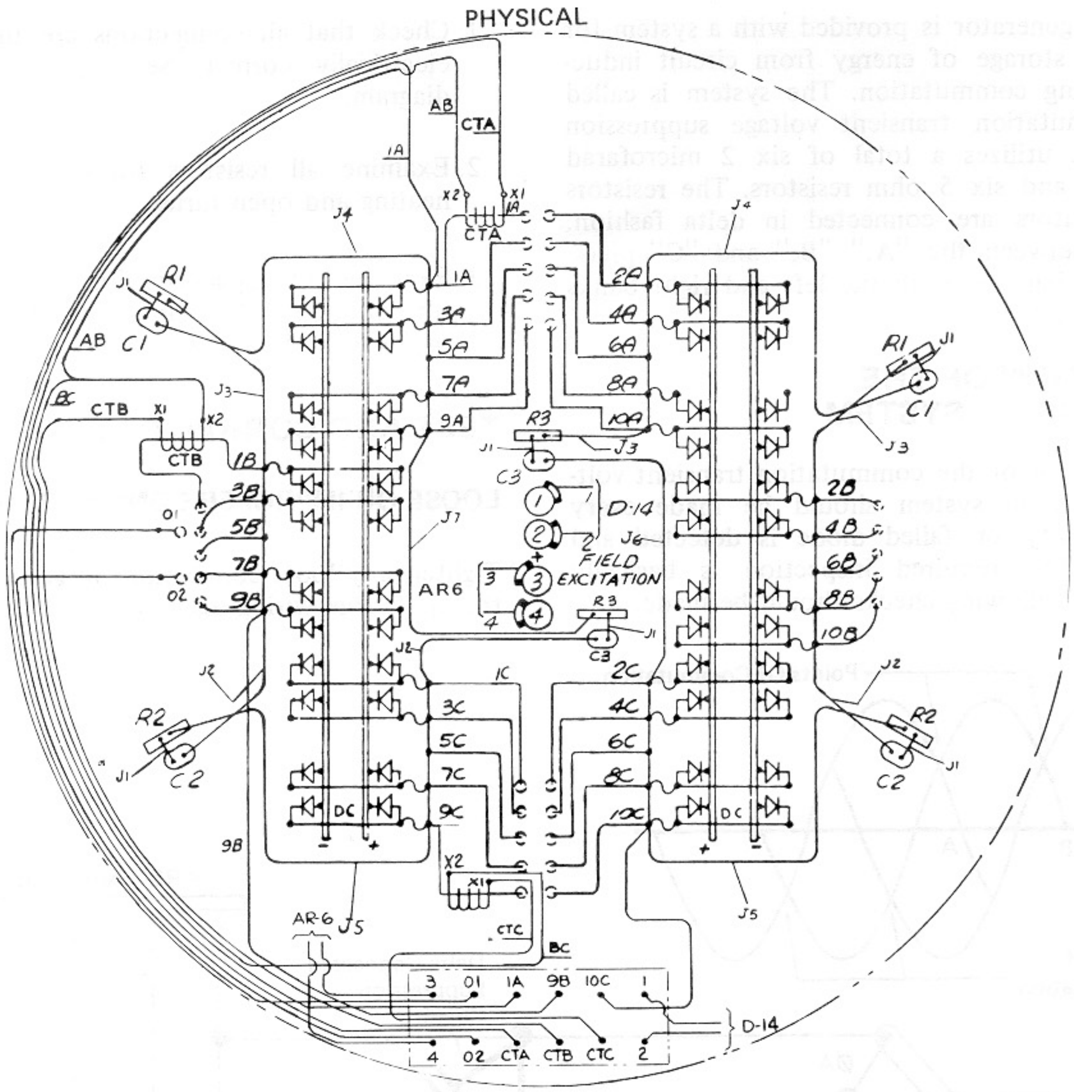


Fig. 12 – AR6 Physical Wiring Diagram

DAMAGED RESISTORS

Any resistors that appear to be burned or damaged should be disconnected and continuity checked. Faulty resistors must be immediately replaced with qualified resistors.

DEFECTIVE CAPACITORS

If a capacitor is suspected faulty, it should be disconnected and checked in the following manner.

1. Checks with a 500 or 1000 volt megger.

   a. Short circuit the capacitor terminals and connect the positive lead from the megger to the terminals. Connect the megger negative lead to the capacitor case, and turn the megger. The reading should be 25 megohms or more. Disconnect the megger and shorting jumper.

   b. Connect one megger lead to one capacitor terminal and connect the other megger lead to the other capacitor terminal, and turn the handle. If the capacitor is good, there will be a definite meter needle deflection toward zero (indicating capacitor charging current) followed by a drift toward infinity as the capacitor charges. Failure of the meter needle to deflect toward zero is an indication that the capacitor is open internally.

   If the capacitor is shorted, the megger will read zero when the handle is turned. If the capacitor is open, it will read infinity immediately upon turning the handle, and the reading will drop to zero when the turning stops.

CAUTION: Carefully discharge the capacitor after the check by using an insulated handled screwdriver to short across the capacitor terminals.

2. If only a 500 volt megger is available, and megger checks indicate a good capacitor but the condition of the capacitor is still suspect (burn spots appear on resistors associated with the capacitor), use a 64 V DC input, 1200 V DC output MG set as a high potential tester to induce possible flashover within the capacitor.

   a. Connect the positive output lead from the MG set to one terminal of the capacitor. Connect the negative output lead from the MG set to the other capacitor terminal. Connect a 0-1500 V DC meter to read MG set output voltage. Connect MG set input to a 64 or 74 V DC source.

   b. Advance MG set output voltage. The meter needle will advance as the MG set handle is turned. If a flashover is induced in the capacitor, the meter will dip toward zero, indicating a bad capacitor. Immediately reduce voltage to zero, then turn off the MG set.

      If the capacitor is good, voltage will remain at the high output value from the MG set. Reduce MG set voltage to zero, then turn off the set.

CAUTION: Carefully discharge the capacitor after the check by using an insulated handled screwdriver to short across the capacitor terminals.

SERVICE DATA

SPECIFICATIONS

Weight Of Rectifier Bank Assembly . . . . 41 kg (90 lbs)

EQUIPMENT LIST

Special Diode Socket Wrench	8361524
Torque Wrench 0-50 Ft-Lbs -- 1/2" Drive	8375396
Compound -- Joint (Apply to diode hex contact area prior to mounting. Do not apply to threads.)	8346481
Multimeter	8276478
500 V DC Megohmmeter (Megger)	8174880
Dynamotor (MG Set) 1200 V DC Output -- 64 V DC Input	8233558