MAINTENANCE INSTRUCTION
M.I. 3317-2
Revision E

Service Department
ELECTRO-MOTIVE DIVISION
GENERAL MOTORS CORPORATION
October, 2001

AR10, AR12, AR15, AR16, AR17, TA12, TA17, TA20 and TA22
Traction Generator Rectifier Bank Assemblies and Suppression Circuits

SAFETY PRECAUTIONS

Please refer to the EMD Safety Precautions in Appendix to the Locomotive Service Manual whenever routine service or maintenance work is to be performed on any AC traction-equipped locomotive.

The maintenance procedure as outlined in this instruction is specific to AR and TA-Type Main Generators and is offered for planning purposes only. As written, this document reflects current EMD product design and service experience for this design. The content of this Maintenance Instruction reflects maintenance requirements based on time from delivery or miles in service. This recommendation is consistent with present fleet performance and remains within the EMD experience envelope.

This Maintenance Instruction is intended to serve as a guide when establishing maintenance schedules to meet the particular requirements of individual operations and planned economic life of the AR and TA-type main generators. It provides average recommendations, which should ensure satisfactory locomotive operation, and economical maintenance costs where average load factors and climatic conditions are encountered.

The scheduled inspection and maintenance items defined herein are specific to the AR and TA-type main generators. Component renewal provisions are consistent with traditional overhaul procedures.

For planning purposes, EMD has established the following overhaul interval recommendations for the main generators. These overhaul interval recommendations are based on whichever event occurs first: time or miles.

AR and TA Series Main Generators:
High Speed Service: 16 years / 2,500,000 miles /4,000,000 Kilometers
Heavy Haul Service: 16 years / 2,000,000 miles / 3,200,000 Kilometers

NOTE

Mileage values referenced above are defined by Microprocessor Archive Data when the locomotive is equipped with a locomotive control computer system.

As usual, when specific operating conditions severely impact locomotive performance and/or reliability, maintenance schedules must be adjusted accordingly.

TABLE OF CONTENTS

1.0 AR10, AR12, AR15, AR16, AR17, TA12, TA17, TA20 and TA22 Traction Generator 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 collector rings connected together to prevent high potential from being applied to the controlled rectifier assembly (SCR). Always refer to the applicable Locomotive Service Manual to perform a high potential test on a locomotive.

Operation of the 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 VDC, and never operate the generator with the inspection doors open or panels removed.

1.1 INTRODUCTION

NOTE

The AR8, AR11, AR11A, and AR20 Traction Generator Rectifier Bank Assemblies and Suppression Circuits are covered in Maintenance Instruction MI 3317-3. MI 3318 is dedicated to AR5, and AR6 Main Generator is covered under MI 3323. Main Generator assemblies equipped with a Head End Generator are covered under MI 3319.

The traction generator is a three-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 three-phase AC output, each independently rectified by an assembly of heat-sink mounted silicon diodes. Two types of rectifier assembly frames are now being used. The fabricated-type frame is shown in Figure 1. The molded-type frame is shown in Figure 2.

Fuses are provided to isolate diodes that may become shorted. On the AR-type Main Generator discussed in this Maintenance Instruction, the operating coil of a protective relay (GR), is connected across the neutral points of the stator windings to detect a single phase or imbalance condition. On all the TA-type Main Generators, a ground relay transductor (GRT) and a transformer (T2) are used in conjunction with the ground relay to detect an open phase or imbalance condition. The ground relay coil is also connected through resistance to ground to detect High Voltage Grounds (Generator / Traction Motors [AC and DC] / Inverters or locomotive grounds).

At the collector 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:

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 voltage spikes of a transient nature are located within the generator airbox, either on the airbox wall or on the generator end housing. Refer to Figure 3 and Figure 4.

NOTE

TA 20 and TA 22 Main Generators do not have a suppression circuit.

Most models of Main Generators are equipped with current transformers mounted on the generator end plate. On TA12, TA17 and all AR-type Main Generators (when equipped) there are three transformers, one per phase ("A", "B", and "C"), installed on one of the stator winding set at the AC side of a rectifier bank. AC current as sensed by the transformers is proportional to DC current at the main generator buses. As such, it provides a signal that is proportional to DC current output from the main generator.

Models TA20 and TA22 Main Generators are dual output generators, meaning that each of the two stator winding outputs is connected directly to a different inverter. The two stator winding sets are <u>not</u> paralleled, and therefore 6 current transformers are being used on these Main Generators (Three per winding set).

When the locomotive control system is equipped with a performance control panel (PCP), or a performance control module (Dash-2 control system), the generator- mounted current transformers, along with cabinet-mounted potential transformer(s), provide signals for control of generator excitation and power output.

On those AR10 generators that are not equipped with current transformers (CT's), a cabinet-mounted main generator field current transductor provides the necessary signals for control of generator output. The use of field current to provide a signal related to output is possible because the characteristics of the generator are such that for much of the generator operating range generator output increases directly as field current increases.

When a locomotive is equipped with a locomotive control computer (LCC), the signals from the CT's are used, along with other feedback devices, to control Main Generator field excitation, as well as to monitor Main Generator output current.

CAUTION

Some generators may be equipped with current transformers that are not used. The secondary winding of these unused current transformers must be shorted together to prevent high voltage damage to the generator.

Model AR16 generators have one larger current transformer mounted on the generator end plate. The single transformer monitors all of the AC current from phase "A" of one rectifier bank. Refer to Figure 5 to Figure 12 for a simplified pictorial wiring diagram of the AR and TA- type main generators discussed in this maintenance instruction.

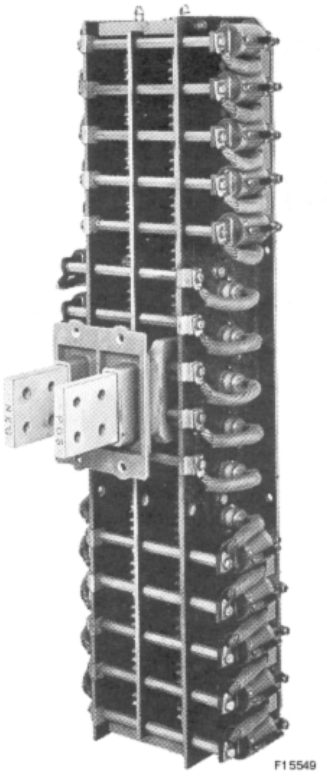


Figure 1 Fabricated-Type Rectifier Bank Assembly

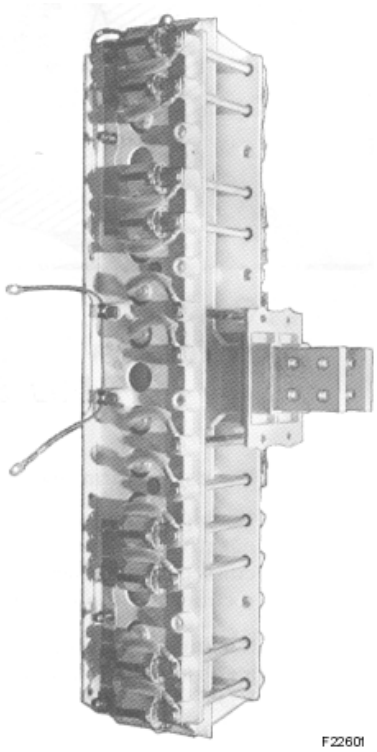


Figure 2 Molded-Type Rectifier Bank Assembly

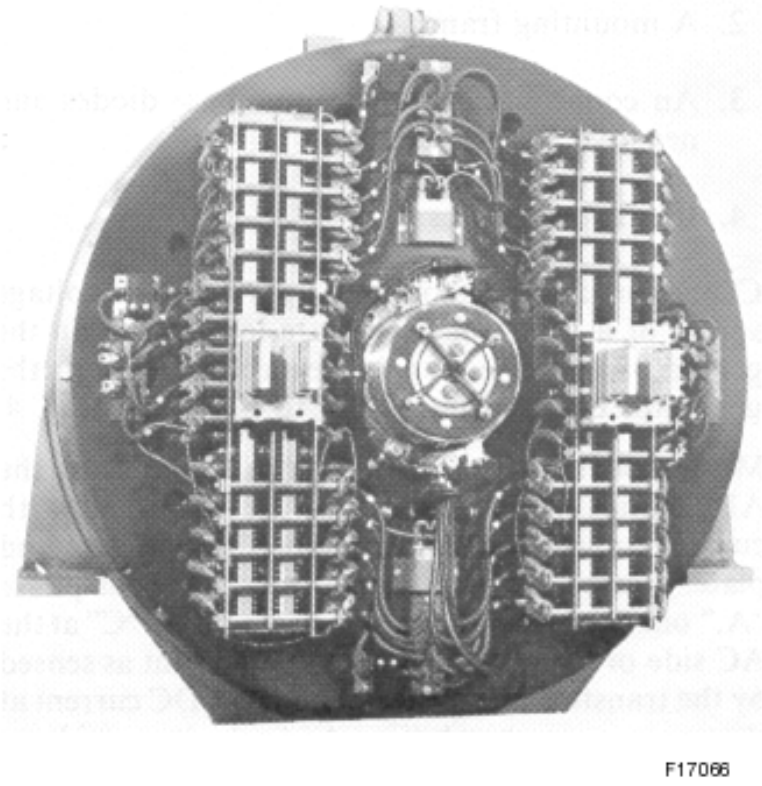


Figure 3 Fabricated-Type Rectifier Assembly in Place

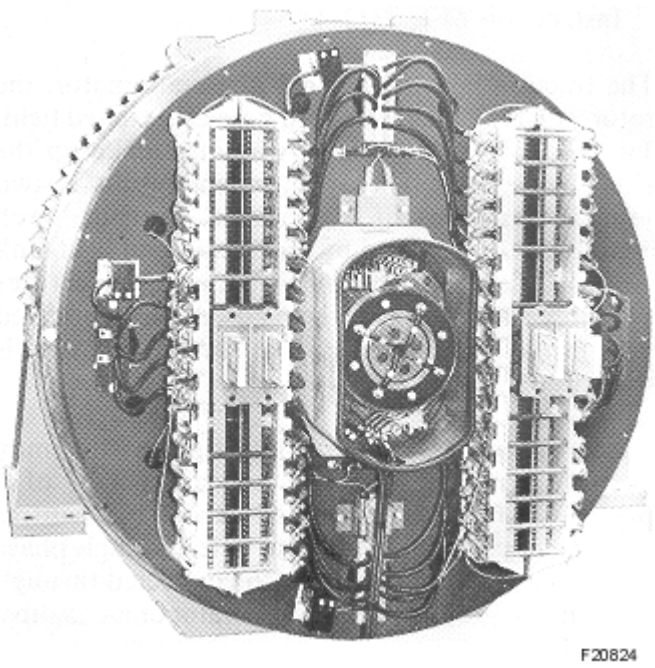


Figure 4 Molded-Type Rectifier Assembly in Place

1.2 RECTIFIER INSPECTION

The rectifier assembly should be inspected at intervals indicated in the Scheduled Maintenance Program. Refer to Figure 13 to inspect the rectifier assembly.

IMPORTANT NOTICE

It is recommended that the fuses and diodes in any given model generator be replaced after 10 years of service due to thermal/mechanical degradation

SAFETY PRECAUTIONS

Please refer to the EMD Safety Precautions in Appendix to the Locomotive Service Manual whenever routine service or maintenance work is to be performed on any AC traction-equipped locomotive.

1.2.1 CLEANING RECTIFIER BANK ASSEMBLY

The following procedure is recommended for cleaning the 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. Ensure all cables and wires are labeled before disconnecting.
2. Remove all fuses from rectifier banks to prevent damage to fuses during cleaning operation. If there is no visible damage to diodes, diodes should remain in heat sinks. If there is reason to remove diodes before cleaning, inserts such as discarded diodes should be placed in diode holes to protect diode contact surface on the heat sinks. Use special diode wrench to remove diodes. Refer to Service Data for diode-wrench part number.

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. Mix a steam cleaner such as Dober Chemical Corporation Cleaner 6006, or Turco Chemical Company Steamfas in a suitable container. Use an 85-g per 3.79-liter (3 oz. per gal.) mixture of cleaner and water and maintain a tank temperature of approximately 60°C to 71°C (140°F to 160°F).

WARNING

Protect skin and clothing while steam cleaning. Operator should always wear rubber apron, boots, gloves, and a plastic face shield.

4. Place steam gun suction-pipe into the cleaning solution and regulate the gun to obtain a good soapy solution.

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”) from the work.

6. Thoroughly rinse the assembly with a low-pressure stream of clean water to remove all residues.

7. Blow off remaining clean water with dry air.

8. After cleaning, the assembly should be checked for flash damage, or damage caused by shorting to ground. If damage has occurred, dismantle the assembly and replace any defective parts with new parts. (Always refer to parts catalogue to disassemble or reassemble a rectifier bank assembly.) If no damage is found, the assembly will not need to be dismantled.

1.2.2 DIODE AND FUSE QUALIFICATION

Check all diodes using the following procedure:

1. Connect one of the ohmmeter leads on the negative bus, and with the other lead check every diode connected to the bus. Then switch the tester leads and check every diode again. This checks all the negative base diodes. If diode is good, the meter registers 10 to 20 ohms in one direction, and above 30,000 ohms when leads are reversed.
2. Connect one of the ohmmeter leads on the positive bus and with the other lead check every diode connected to the bus. Then switch the tester leads and check every diode again. This checks all the positive base diodes. If diode is good, the meter registers 10 to 20 ohms in one direction and above 30,000 ohms when leads are reversed.
3. Remove any defective diodes, using special diode socket (See Service Data for socket number)
4. Wipe the diode-mounting surface of the heat sink bus. Do not use abrasive material.
5. Replace defective diodes with good diodes of identical polarity, and voltage class (or higher voltage class). Apply a thin coating of compound 8346481 to the base of the diode hex to cover the surface. Do not apply on threads.
6. With special diode socket and 0 – 50 ft.-lbs. Torque wrench, torque diodes to 45 to 47 Nm (33 to 35 ft.-lbs.). Make certain that the wrench is properly seated when torquing.
7. Check all fuses with continuity tester. Clean the electrical contact surfaces of the fuses as required, and reapply.
8. Torque diode terminal lug bolts to between 15 to 18 Nm (11 to 13 ft.-lbs).

Figure 5 through Figure 12 illustrate simplified drawings of the wiring schematic typical for AR and TA style generators.

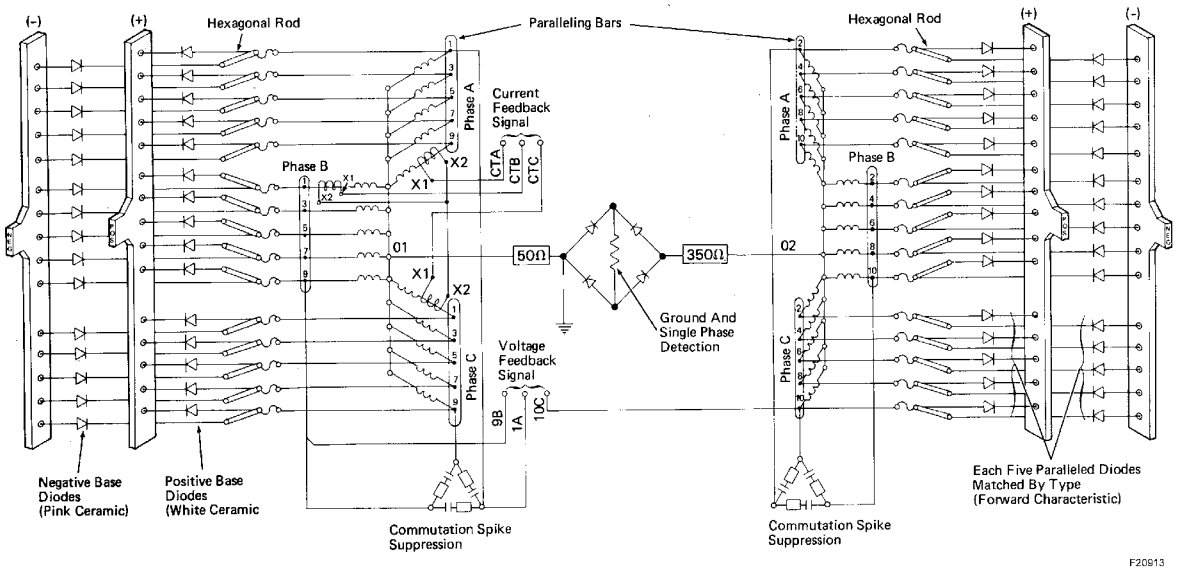


Figure 5 Simplified AR10, AR12, and AR15 Pictorial Diagram

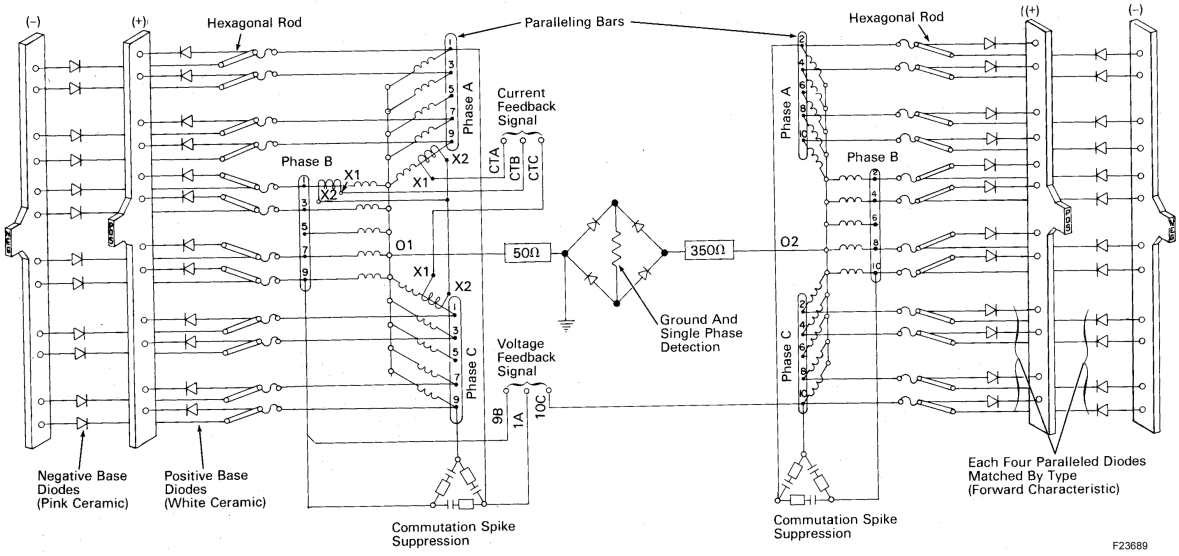


Figure 6 Simplified AR10E2 Pictorial Diagram

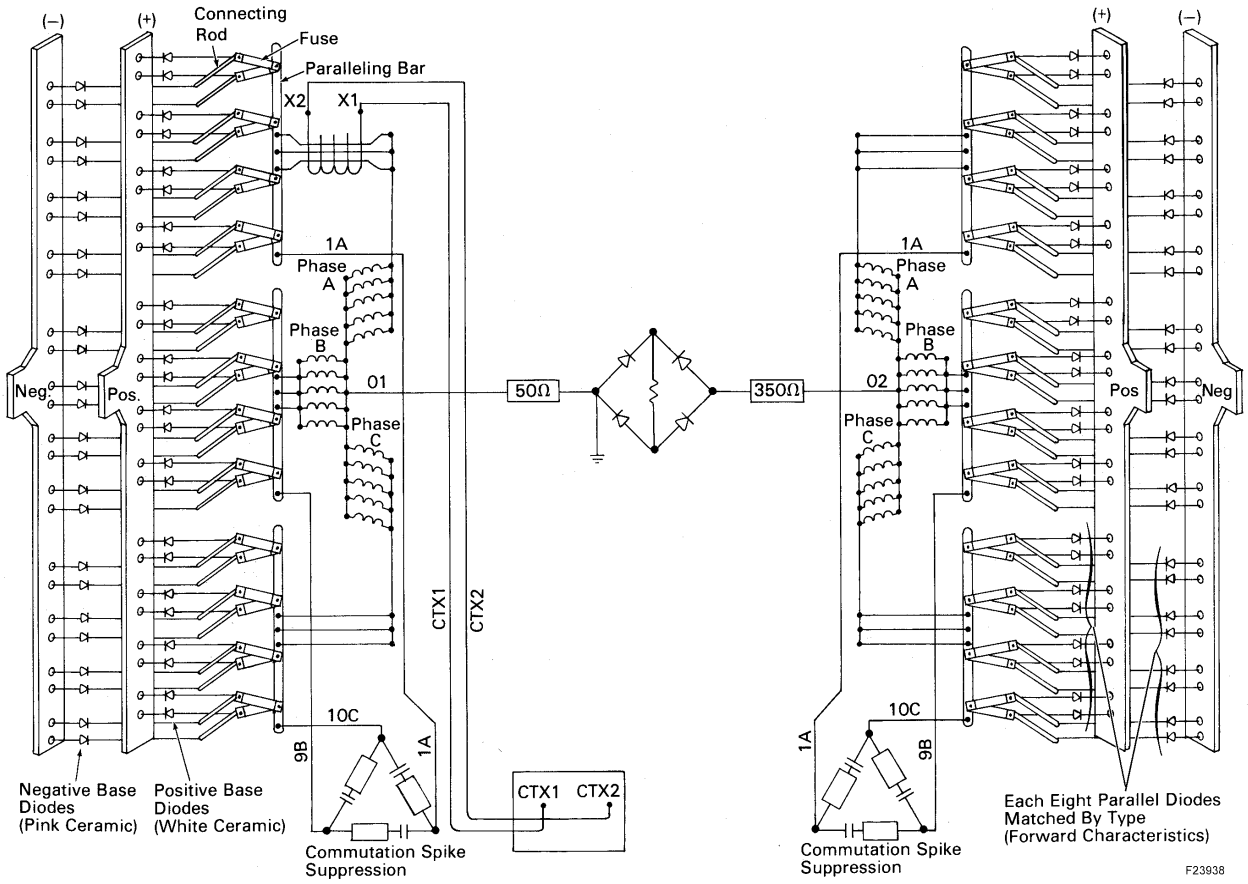


Figure 7 Simplified AR16 Pictorial Diagram

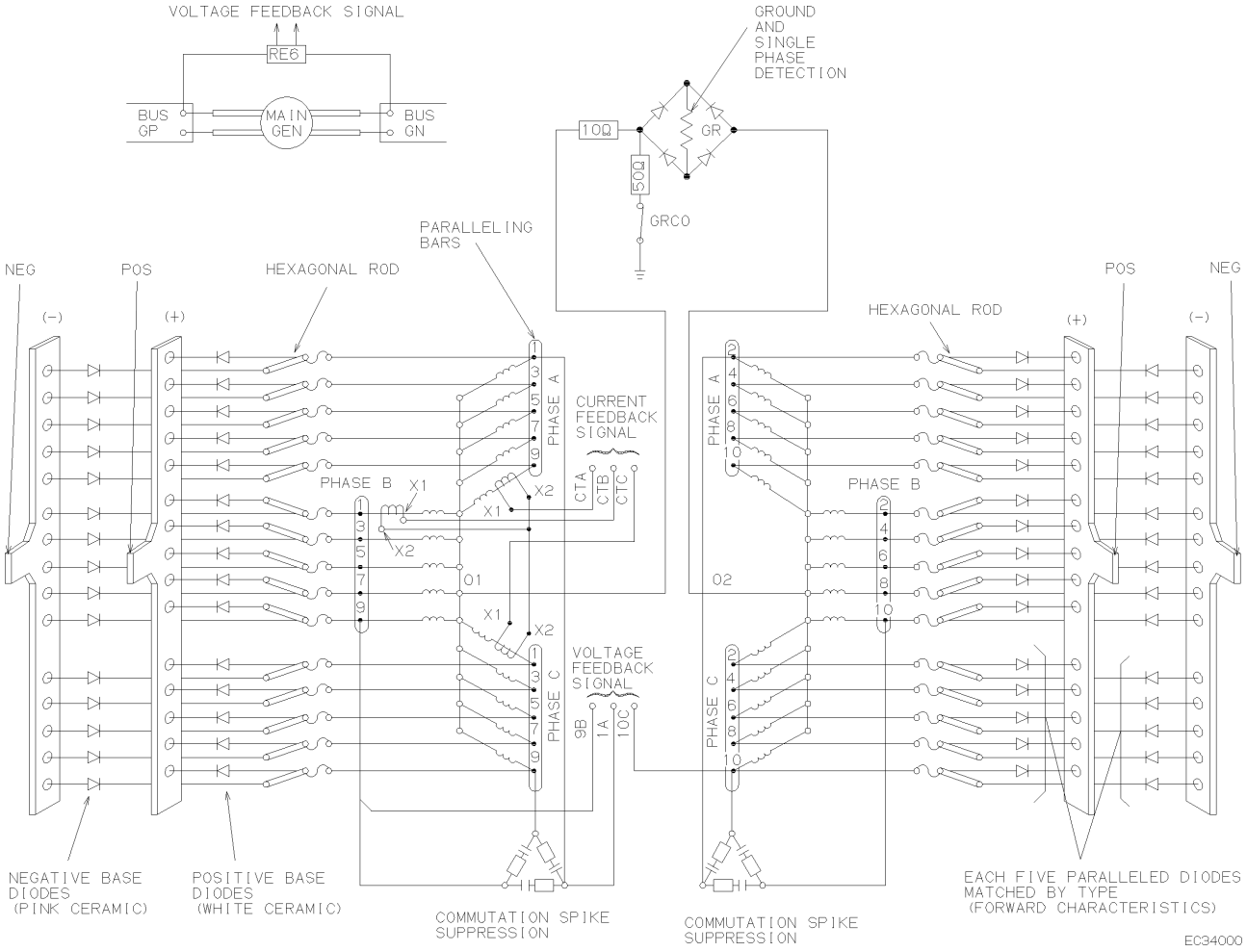


Figure 8 Simplified AR17 Pictorial Diagram

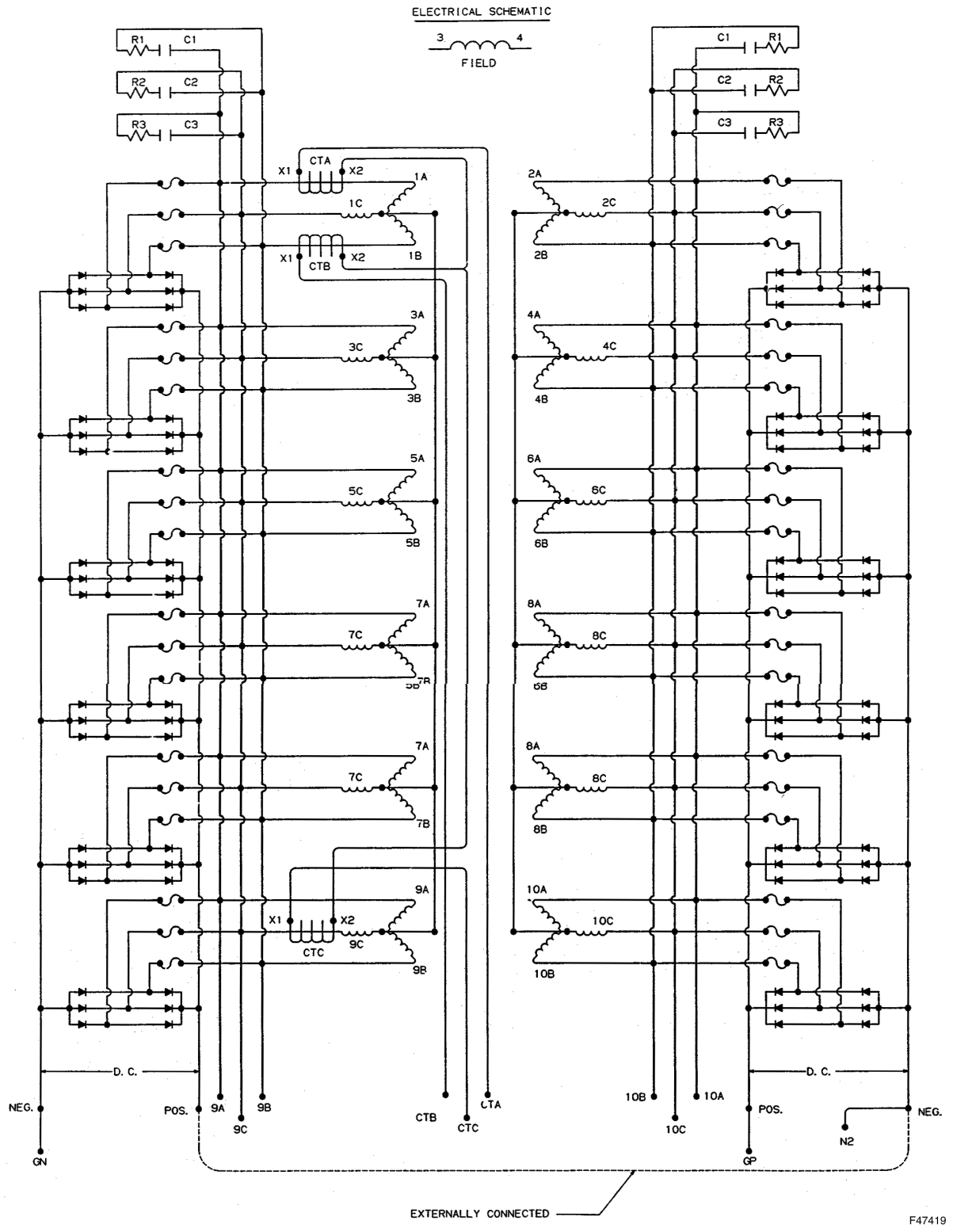


Figure 9 Simplified TA12 Pictorial Diagram

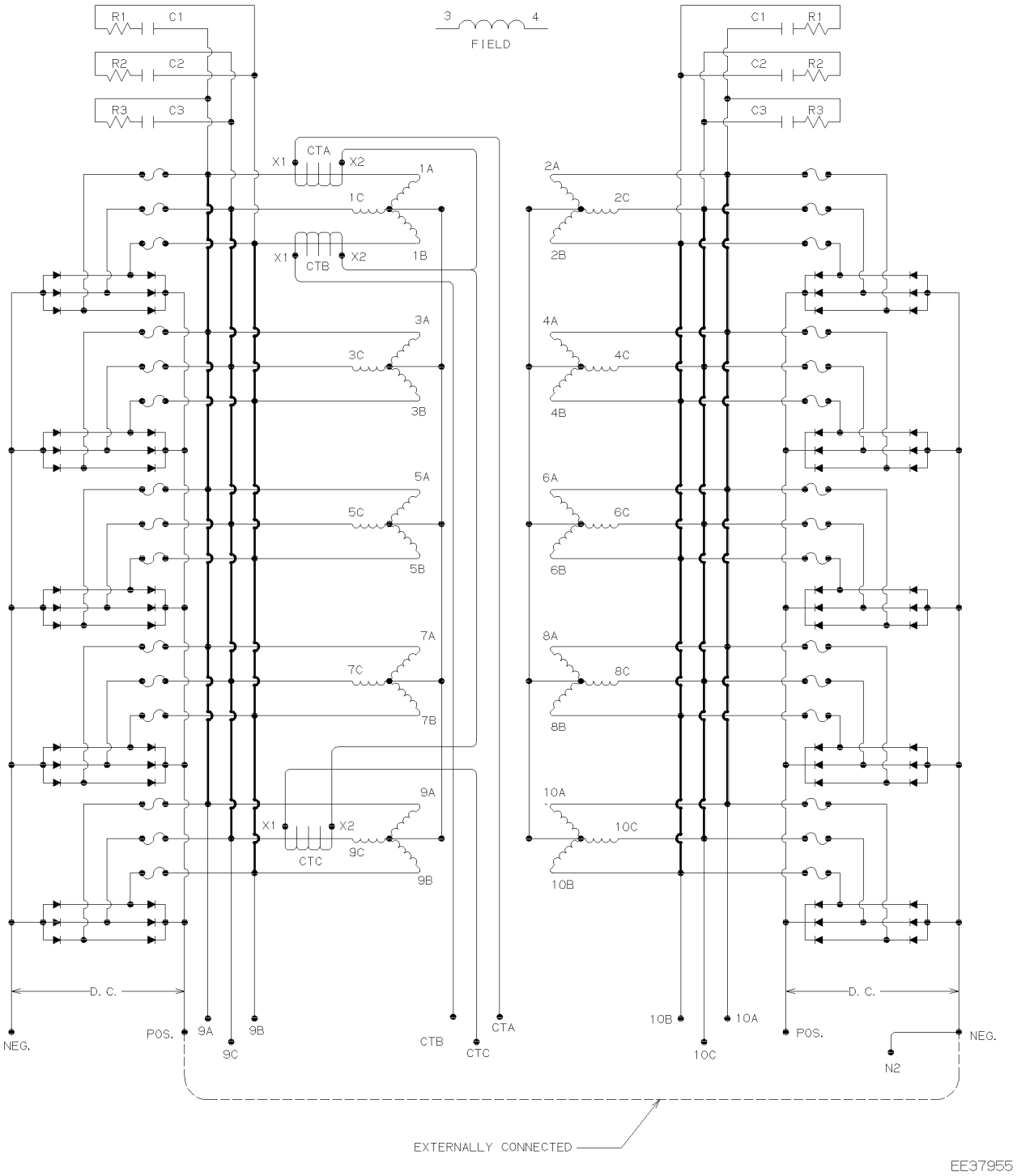


Figure 10 Simplified TA17 Pictorial Diagram

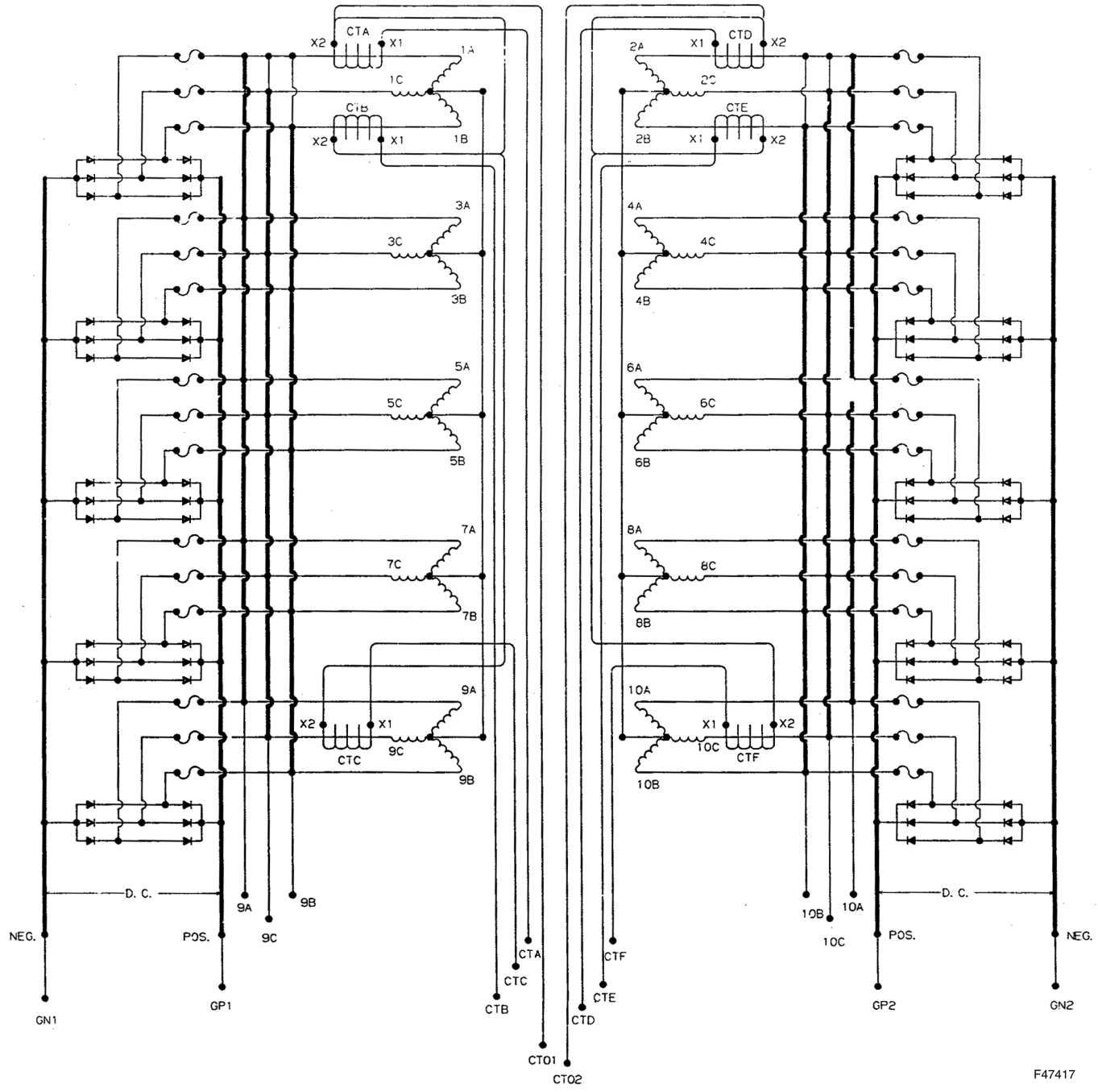


Figure 11 Simplified TA20 Pictorial Diagram

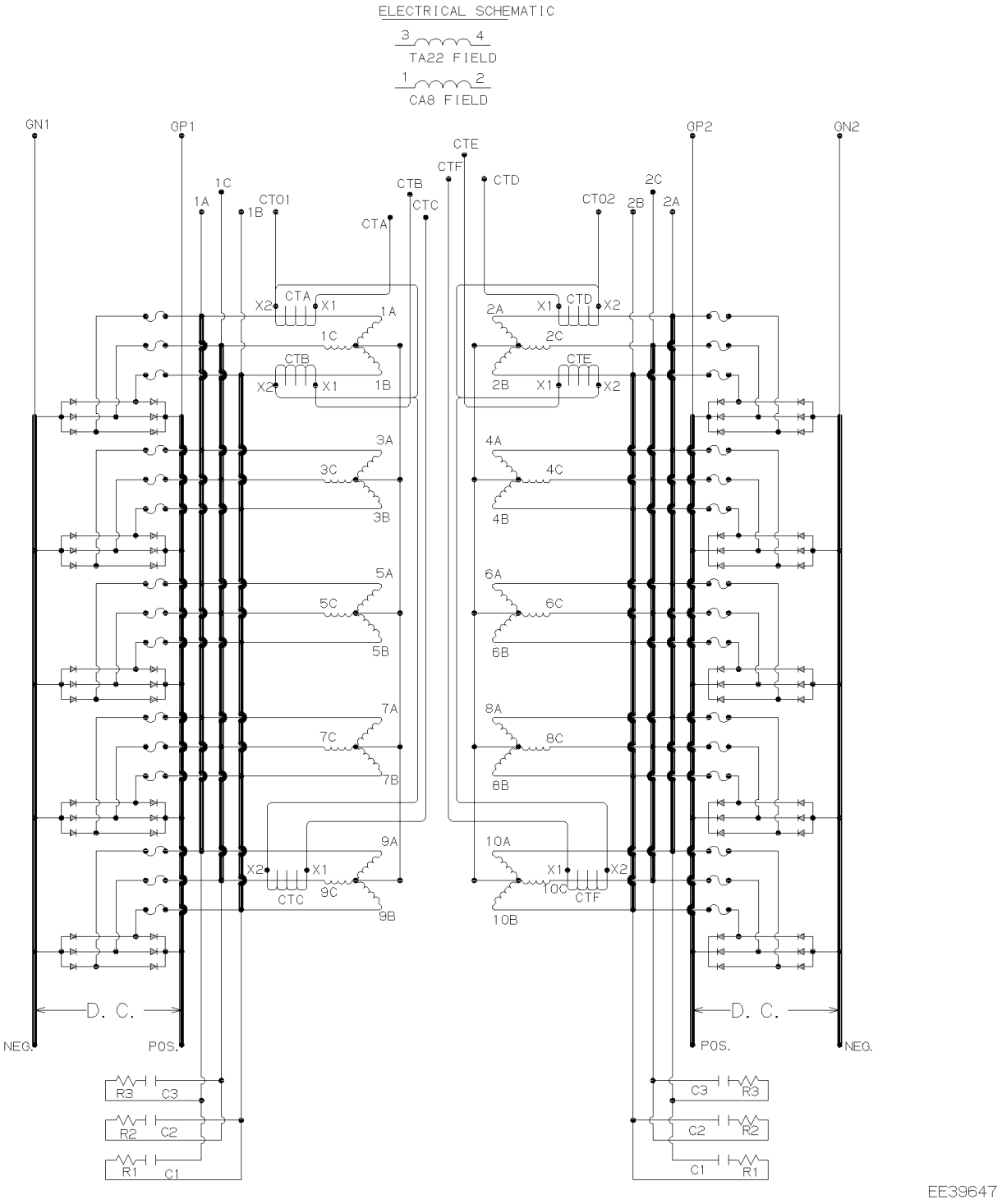


Figure 12 Simplified TA22 Pictorial Diagram

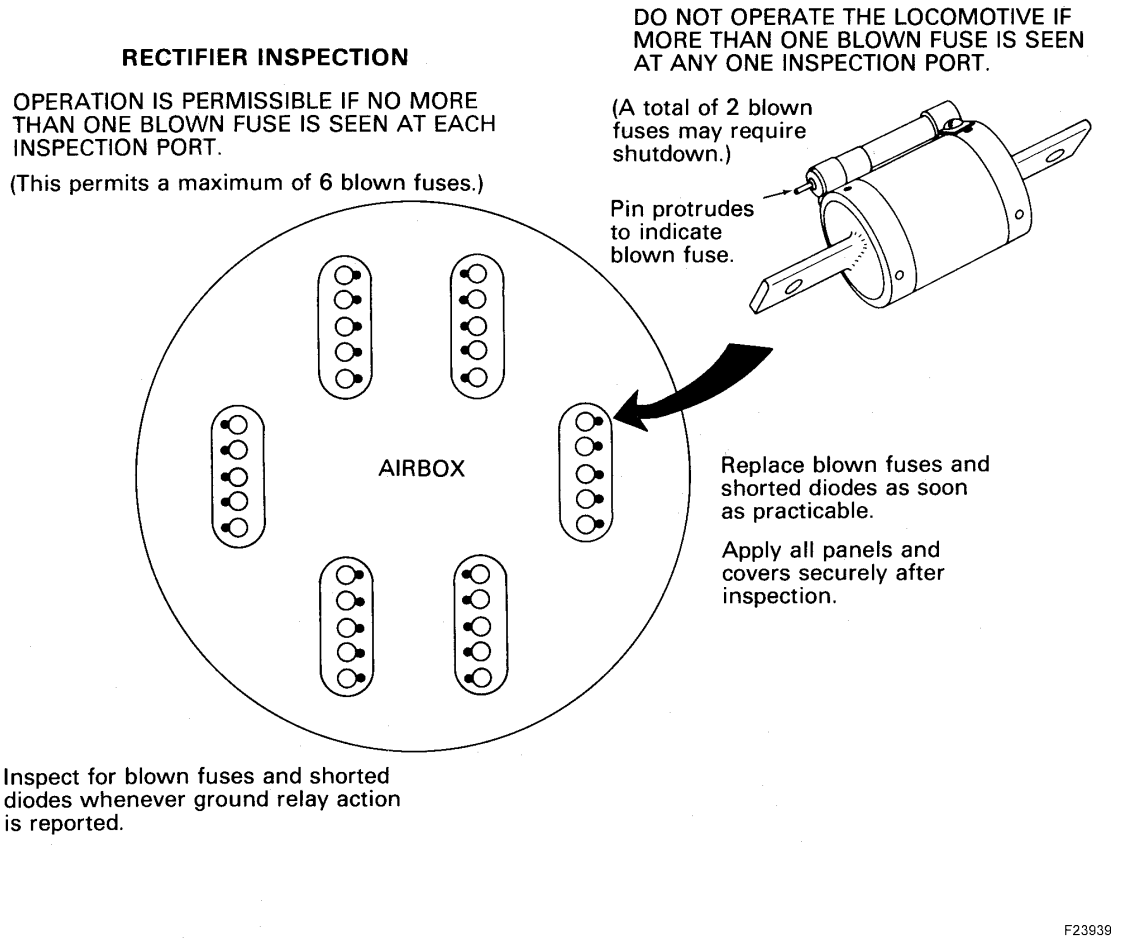


Figure 13 Rectifier Inspection

NOTE
Models AR10E2 and TA20 have 24 fuses (4 at each port). Model AR16 has 48 fuses (8 fuses at each port). All the other models covered by this maintenance instruction have 30 fuses (5 at each inspection port).

Figure 14 Current Limiting Fuse- Round Type

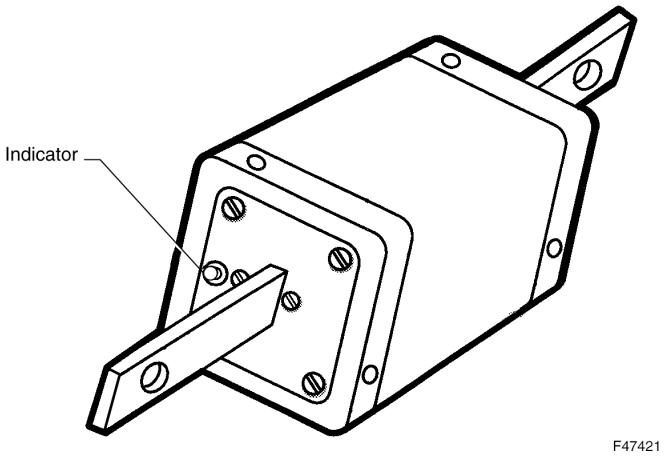


Figure 15 Current Limiting Fuse- Square Type (applied to TA20 and TA22)

2.0 PROTECTIVE FUSES

Current limiting fuses, Figure 14 and Figure 15, 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.

On the round-type fuse, 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. The operating principle remains the same for the square type, except that the indicator pin is part of the fuse main body.

NOTE

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.

2.1 FUSE RATING AND TEST VALUES

PART #	CURRENT RATING	GENERATOR MODEL	NOTES
8346478	350 Amps	AR6, AR7, AR10, AR 12	Original Equipment
8407729	400 Amps	AR15, AR17, TA12, TA17	Original Equipment
40054000	315 Amps	TA20, TA22	Original Equipment
40080476	600 Amps	AR6, AR7, AR10, AR12 AR15, AR17, TA12, TA17	Replaces Fuses 8346478 and 8407729

Table 1 Table Current Limiting Fuses and Rating

PART #	CURRENT RATING	GENERATOR MODEL	RESISTANCE VALUES
8346478	350 Amps	AR6, AR7, AR10, AR 12	.000195 + - .000010
8407729	400 Amps	AR15, AR17, TA12, TA17	.000195 + - .000010
40054000	315 Amps	TA20, TA22	.000368 + - .000010
40080476	600 Amps	AR6, AR7, AR10, AR12 AR15, AR17, TA12, TA17	.000195 + - .000010

Table 2 Fuse Resistance Values

2.1.1 FUSE TESTING

Thermal and mechanical loads could subsequently break the fusible links inside the fuse body. There are normally 6 links per fuse that will equate to the resistance value provided in table 2. If any of the fuse links should break and or burn open, it will change the resistance value, which will warrant replacement of the fuse. If not detected, a whole phase group of fuses could fail and result in an imbalance condition. This will result in pick-up of the ground relay and a reduction of load to the locomotive.

The resistance check must be performed with the use of a low resistance ohmeter, capable of taking readings as low as 1.999 milliohms. (Reference Service Data for part number of tester). Due to the use of silver links in these fuses verses copper, it is very important that the correct temperature of the fuse be determined, or the fuse could fall outside the limits and a good fuse may show it is defective. As a rule of thumb, if at least one link is open, the resistance value will increase by at least 25 %.

NOTE

The values listed in table 2 are taken at 75 degrees F, 23 degrees C. Important to test the fuses at this temperature range to achieve an accurate value.

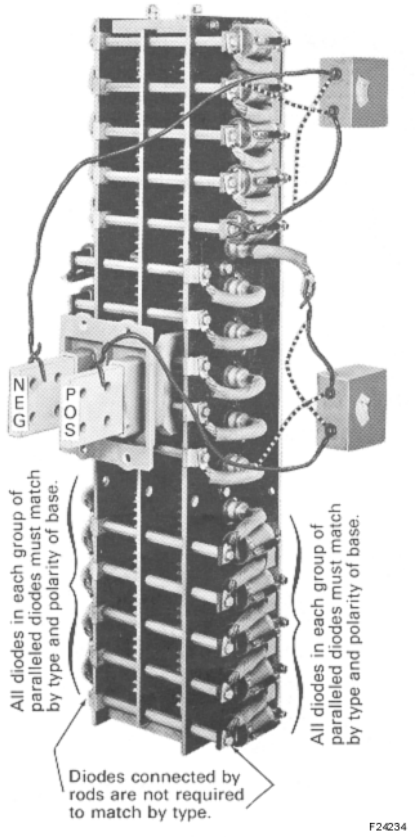


Figure 16 Diode Inspection and Replacement (Diodes must be matched if universal type diodes are not used)

2.2 DIODE INSPECTION AND REPLACEMENT

Refer to 1.2 for information regarding diode testing and replacement. Use the following procedures for testing and replacement of diodes.

2.2.1 MIXING OF DIODES

This is with respect to the release of the universal diodes P/N 40029132 (Pos) and 40029131 (Neg). These diodes will not permit desired sharing of load current when paralleled with any other previous used (Typed Diodes). In order to insure proper current sharing, a "5-for-5," 4-for-4," or "8-for-8" replacement per phase group, (dependant on Alternator model) should be done for the polarity diodes involved. It is not necessary to replace both polarities, or both sides of a phase group, as long as no failures need changeout. Those devices removed, and found to be still functional, may be retained and used as spare parts.

When an alternator is equipped with the black band universal diode and a failure of one or more occurs, it is **NOT** necessary to change the entire group of diodes. Only change the failed diode(s) and associated fuses in that particular phase group. Other associated diodes in that phase group that did not fail will not be affected by the diodes that did fail.

2.2.2 DIODE TESTING

1. Remove the bolt and unfasten diode lead. Check fuse continuity.

NOTE

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

2. Place continuity tester across negative bus and connecting rod, then switch the tester leads. This checks one of the diodes.
3. If the diode is good, the meter registers 10 to 20 ohms in one direction and above 30,000 ohms when leads are reversed.

NOTE

The 30,000-ohm value is for an individual diode isolated from the circuit. A diode not isolated from the circuit should register greater than the following values:

AR16 – 1250 ohms

AR10E2 – 2500 ohms

All others – 2000 ohms

4. Place continuity tester across positive bus and diode lead, then switch the tester leads. This checks the other diode.

Diode resistance depends, in a non-linear way, on applied voltage. The continuity tester applies very little voltage across the diodes. Therefore, if the above test is not conclusive, refer to Section 2.2.3 - Further Diode Tests.

2.2.3 FURTHER DIODE TESTS

Diode testing with a continuity tester may not prove conclusively whether a diode is good, shorted or open. To make a better determination, the following three tests can be used:

2.2.3.1 DC Megger Test

Use a hand-cranked or battery operated megohmmeter to test the diode. Connect one lead to diode pigtail and other lead to base of diode. If using a hand crank meter, it is important to crank slowly at first, then gradually increase the cranking speed to medium. Depending on polarity, the reading should be zero (blocking) when connected one way, then by reversing test leads, there should be a definite megger reading of at least one megohm or better.

NOTE

Remember, you are checking to see if the diode is blocking and/or carrying current. You are not taking insulation resistance readings, so a higher than one megohm is not important.

2.2.3.2 DC Voltage Test

Connect a 110-volt incandescent lamp in series with the suspected diode, and apply 64 vdc (from the locomotive batteries) to this series connected circuit, then, reverse diode leads and observe the lamp response.

- If the diode is good, a light turns ON when the diode is connected one way, and turns OFF when connected the other way.
- If the lamp turns ON both ways, the diode is shorted out.
- If the lamp remains OFF when the diode is connected both ways, the diode is open circuit.

2.2.3.3 AC Voltage Test

Connect a 60 to 100-watt, 110-volt incandescent lamp in series with the suspect diode. Apply 110-115 volts, 60-hertz shop power to the circuit, then reverse diode leads and observe the lamp response.

- If the diode is good, the lamp turns ON at about half of its normal light level (half wave rectification), when the diode is connected in one direction, and is OFF when connected the other way
- If the lamp is close to full light level, the diode is shorted.
- If the lamp does not light, the diode is open.

2.2.4 DIODE REPLACEMENT

1. Replace blown fuse with a good fuse.
2. Remove any defective diodes, using special diode socket 8361524 or 40045217 (AR20/TA20/TA22), Figure 17 and Figure 18.
3. Wipe the diode-mounting surface of the heat sink bus. Do not use abrasive material.
4. Replace defective diodes with good diodes of identical polarity and voltage class (or higher voltage class). Apply a thin coating of compound 8346481 to the base of the diode hex to cover the surface. Do not apply on threads.
5. With special diode socket and 0 – 50 ft.-lbs. Torque wrench, torque diodes to 45 to 47 Nm (33 to 35 ft.-lbs.). Make certain that the wrench is properly seated when torquing.
6. Reapply the insulating boot and sleeve. Replace if burnt, cracked or damaged.
7. Torque diode terminal lug bolts to between 15 to 18 Nm (11 to 13 ft.-lbs).
8. Replace and securely fasten all air box panels and inspection covers.

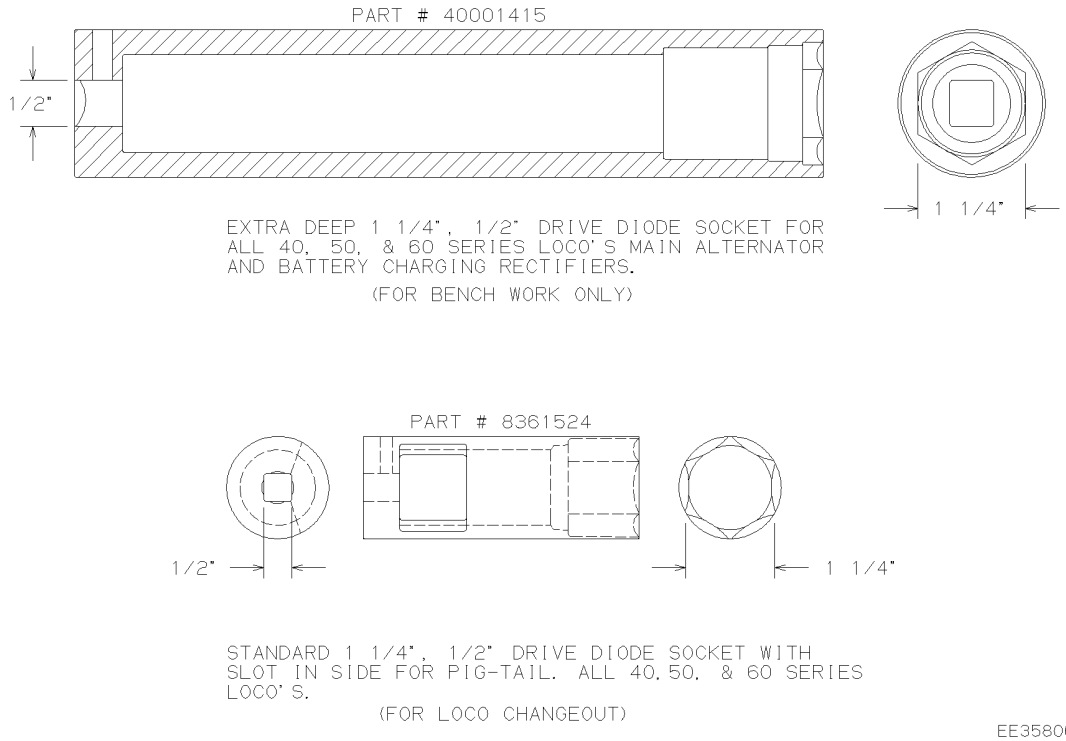


Figure 17 Diode Socket for Standard Alternators

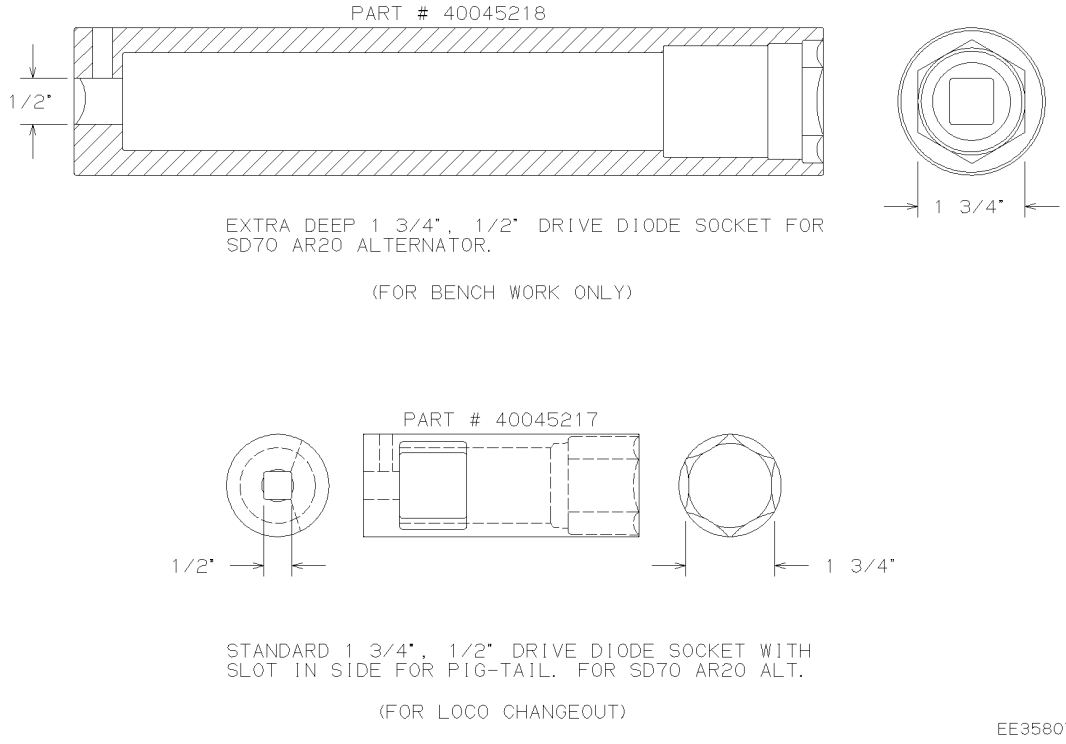


Figure 18 Diode Socket for AR20, TA20, and TA22 Alternators

2.3 DIODE CLASSIFICATION

For service purposes, the following classifications of generator diodes are significant.

- Polarity with respect to the diode base (threaded stud). A color code is used to assist in identification (See Diode Polarity – 2.3.1).
- Forward voltage drop (See Diode Types – 2.3.2)
- Voltage class in respect to repetitive and non-repetitive peak inverse voltage rating. Identification is assisted by color code (See Diode Voltage Classes – 2.3.3).

2.3.1 DIODE POLARITY

The direction in which conventional electrical current flows through a diode determines its polarity. The graphic arrow symbol, Figure 19, is oriented to indicate diode polarity.

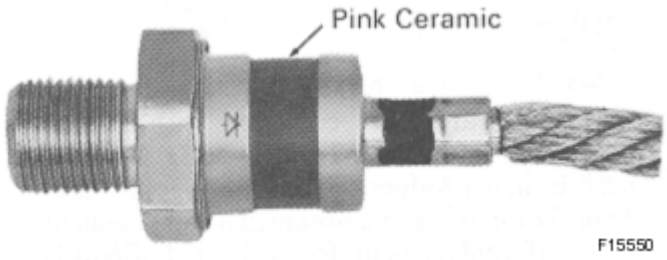


Figure 19 Diode Polarity Symbol – Negative Base Diode Shown

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

DIODE POLARITY	IDENTIFICATION
Positive Base Diode	White Ceramic or Plain Metallic Case
Negative Base Diode	Pink Ceramic or Color Band

Table 3 Diode Polarity Identification

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.

2.3.2 DIODE TYPES

Diodes are 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 generator diodes is accomplished by paralleling only diodes whose forward characteristics (forward voltage drops), are a near match.

NOTE

The universal-type diodes being used now, have the same forward characteristics, and no longer need to be matched.

In the past, diodes were segregated under specific test conditions, according to their forward characteristics, and were assigned a type number that was permanently impressed in the metal at the flat end of the threaded stud. In addition, a color-coded band was applied where the flexible lead is crimped to the diode body.

DIODE TYPE NUMBER	BODY CRIMP COLOR BAND
1	None
2	Red
3	Black

Table 4 Former Diode Types

NOTE

Only 3 Universal Diodes without type identification (with different voltage classes), available as replacement parts, are being used on current production of AR and TA-type main generators.

However, on main generators **NOT** equipped with universal type diodes, if diode(s) with a type # need to be changed within a matched group, the replacement diode(s) need to be of the same type as the others within the group. If this is not possible, **ALL** of the matched diodes will have to be replaced by universal type diodes.

NOTE

It is recommended that any former types diodes in any given model generator be replaced as the universal diode was introduced in 1991. All diodes should be replaced after “10 years” of service due to thermal/mechanical degradation

2.3.3 DIODE VOLTAGE CLASSES

Six voltage classes of diodes have been manufactured in the past and are now being replaced by three universal type diodes. The class identification is indicative of repetitive and non-repetitive transient peak, inverse voltage capabilities, under specific test conditions. Diodes used in the past had a color band around the barrel at the lug end of the flexible lead to indicate the diode voltage class. The universal diodes used today do not have a color band, and can only be identified by the part number impressed on the diode casing. Tables 4 and 5 will assist in diode identification.

COLOR BAND (AT LUG BARREL)	VOLTAGE CLASS
None	1600/2000
Orange	1800/2100
Green	2000/2400
Brown	2200/2600
Blue	2200/2800
White	2200/3000

Table 5 Diode Voltage Classes (on older equipment)

VOLTAGE CLASS	PART NUMBER	APPLICATION
2600 Volts	40032602 Pos. 40032603 Neg.	AR20
2800 Volts	40029132 Pos. 40029131 Neg.	All AR, TA12, TA17
4400 Volts	40053999 Pos. 40053998 Neg.	TA20, TA22

Table 6 Diode Voltage Classes (new type universal diodes)

The voltage class used in a specific generator is dependent upon the type of service in which the generator is employed, and upon specific characteristics of the control system that is used.

2.3.3.1 Manufacturer's Qualification Marks

The manufacturer has placed a variety of qualification marks upon diodes. Some of these qualification marks include: 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 the manufacturer's identification only. The only significant marks for service purposes are:

- The service part number printed on the cap of the diode body.
- The color of the ceramic insulator.

ALL OTHER COLOR SPOTS AND STAMPINGS ARE IRRELEVANT FOR SERVICE PURPOSES, AND ARE TO BE COMPLETELY DISREGARDED.

2.3.4 DIODE MATCHING

Figure 22 shows a typical AR10 rectifier assembly with the air box removed. The illustration shows how diodes and fuses are paralleled, in groups of five, by use of paralleling bars. Diodes used in the generator must be matched as follows:

Polarity

All diodes in any paralleled group must be of the same polarity (ceramic cases must be of the same color), and the diodes must be applied to the proper heat-sink 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.

Type (applicable to non-universal diodes only)

All diodes in any paralleled group 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.

NOTE

Only 3 Universal Diodes without type identification (with different voltage classes), available as replacement parts, are being used on current production of AR and TA-type main generators.

However, on main generators **NOT** equipped with universal type diodes, if diode(s) with a type # need to be changed within a matched group, the replacement diode(s) need to be of the same type as the others within the group. If this is not possible, **ALL** of the matched diodes will have to be replaced by universal type diodes.

Voltage Class

Diodes of different voltage classes may be mixed in a generator, but all diodes in any generator must equal to, or better than the inverse voltage ratings (voltage class) required for the particular application. For example, diodes of the 4400 volts voltage class may be mixed with diodes of the 2800 volts voltage class but not the reverse.

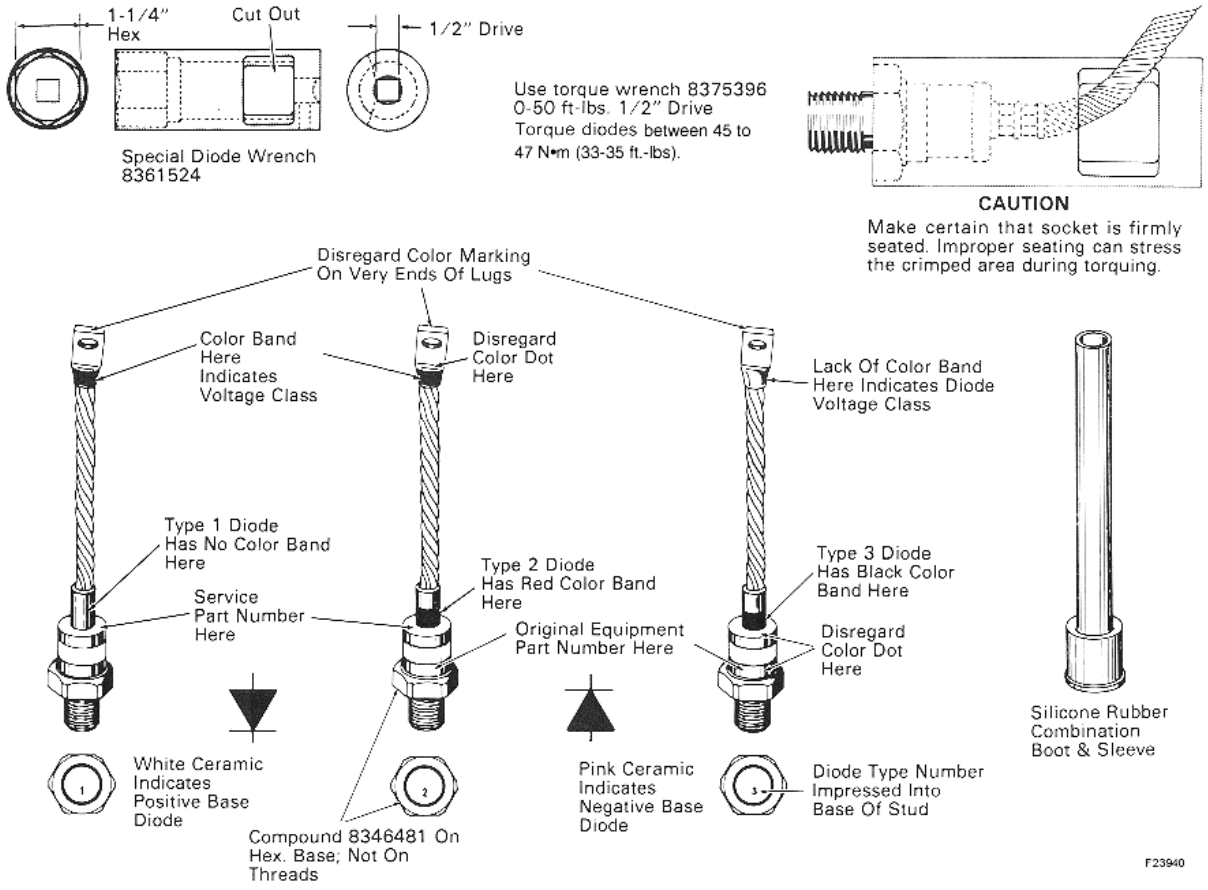


Figure 20 Non-Universal Diode Identification Markings

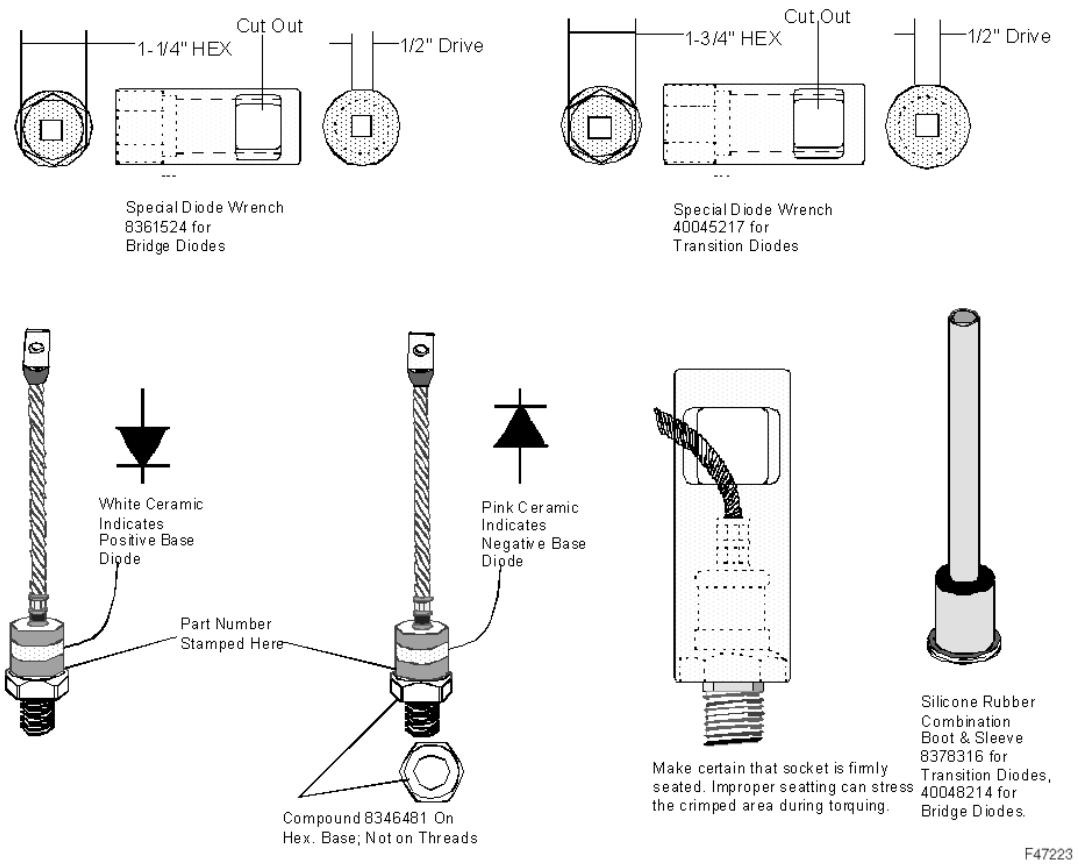


Figure 21 Universal Diodes Identification Markings

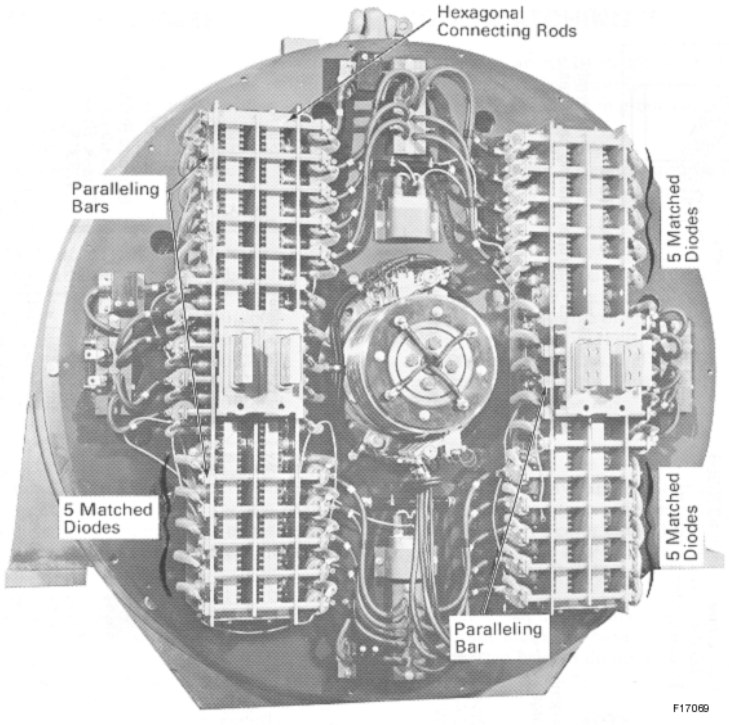


Figure 22 Diode Matching Within Groups (applicable to non-universal diodes only)

3.0 COMMUTATION TRANSIENT VOLTAGE SUPPRESSION

3.1 INTRODUCTION

The action of diodes switching from a conducting to a blocking state in the 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. After commutation, voltage transients are produced.

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.

With the exception of the TA20 and TA22 main generators, all of the other main generators discussed in this maintenance instruction, are actually equipped with a system for capacitive storage of energy from circuit inductance during commutation. The system is called the Commutation Transient Voltage Suppression System.

3.2 SUPPRESSION SYSTEM DESCRIPTION

Two different suppression systems have been applied to protect the rectifiers from commutation transients. They are the Bridge-Connected Suppression Circuit, and the Delta-Connected Suppression Circuit. Both provide equal reliability and protection when properly connected.

3.2.1 BRIDGE-CONNECTED SUPPRESSION CIRCUIT

The first of these systems, the Bridge-Connected Suppression Circuit, Figure 23, uses a 4 microfarad capacitor, and a 10 ohms resistor connected in series and parallel with each group of five diodes for suppression of commutation transients. Since the DC buses are paralleled, there are 12 series resistor-capacitor circuits connected in parallel with diodes.

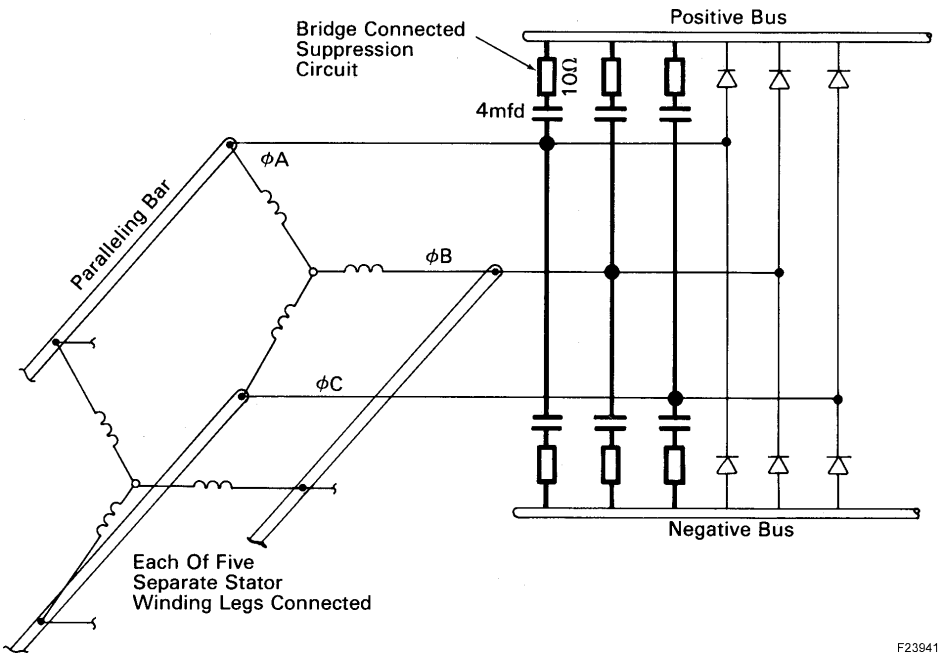


Figure 23 Bridge-Connected Suppression Circuit, Simplified Diagram

3.2.2 DELTA-CONNECTED SUPPRESSION CIRCUIT

The second system, the Delta-Connected Suppression Circuit, Figure 24, uses a 2 microfarad capacitor and a 5 ohms resistor connected in series for suppression of commutation transients. These in turn are connected between the “A”, “B”, and “C” phase paralleling bars on both the left and right banks of the generator.

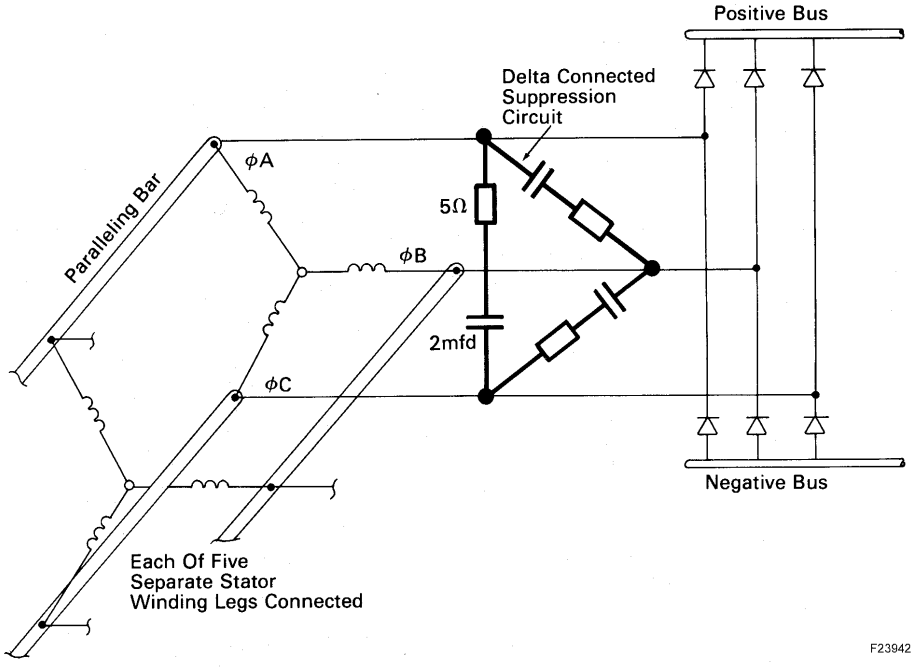


Figure 24 Delta-Connected Suppression Circuit, Simplified Diagram

3.2.3 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.
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).

3.3 TEST AND CORRECTIVE MEASURES

3.3.1 LOOSE OR IMPROPER CONNECTIONS

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

3.3.2 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.

3.3.3 DEFECTIVE CAPACITORS

If a capacitor is suspected faulty, it should be disconnected and checked in the following manner with a 500 or 1000 volt megger.

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 rotate the megger handle. The reading should be 25 megohms or more. Disconnect the megger and shorting jumper.

Connect one megger lead to one capacitor terminal, and connect the other megger lead to the other capacitor terminal, and rotate the megger 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 indicate zero when the megger handle is rotated. If the capacitor is open, it will indicate infinity immediately upon rotating the handle, and the reading will drop to zero when the rotation of the handle is stopped.

CAUTION

Carefully discharge the capacitor after the test, by using a screwdriver with an insulated handle to short across the capacitor terminals.

If a 500 volt megger check indicates a good capacitor, but the condition of the capacitor is still suspect (burn spots appear on resistors associated with the capacitor), repeat the test with a 1000 volt megger. If the 1000 volt megger is not available, use a 64 VDC input, 1200 VDC output MG set, as a high potential tester to induce possible flashover within the capacitor. Use the following procedure to perform the test:

1. 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 VDC meter to read MG set output voltage. Connect MG set input to a 64 or 74 VDC source.
2. Advance MG set output voltage The meter needle will advance as the MG set handle is rotated. If a flashover is induced in the capacitor, the meter needle 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 a screwdriver with an insulated handle to short across the capacitor terminals.

WARNING

Polychlorinated Biphenyl (PCB) capacitors contain a toxic environmental contaminant requiring special handling and disposal in accordance with U.S. Environmental Protection Agency Regulations 40 CFR 761. For disposal information, contact the nearest U.S. EPA Office.

PCB capacitors are no longer available as replacement parts.

'

ORIGINAL PCB CAPACITOR	NON-PCB REPLACEMENT CAPACITOR
8380921	9332014
8442069	*9332014 (*requires bracket 8391246)
8411555	9332016
8352261	9503808

Table 7 PCB Capacitor Replacement

4.0 GENERATOR MODELS

The particular model number assigned to a generator is determined by considering a variety of characteristics.

- The type of suppression circuit employed, and the rating of suppression circuit components.
- The use of, or lack of current transformers.
- The voltage class of the diodes employed.
- Configuration of air box.
- Type of coupling disc employed.
- Application of wedges at the rotor coils.

Refer to Figure 25 through Figure 37 for Physical Schematic Diagrams of Model AR6, AR10, AR12, AR16, AR17, TA12-8, TA17-6 , TA20 and TA 22 rectifier banks and suppression circuits.

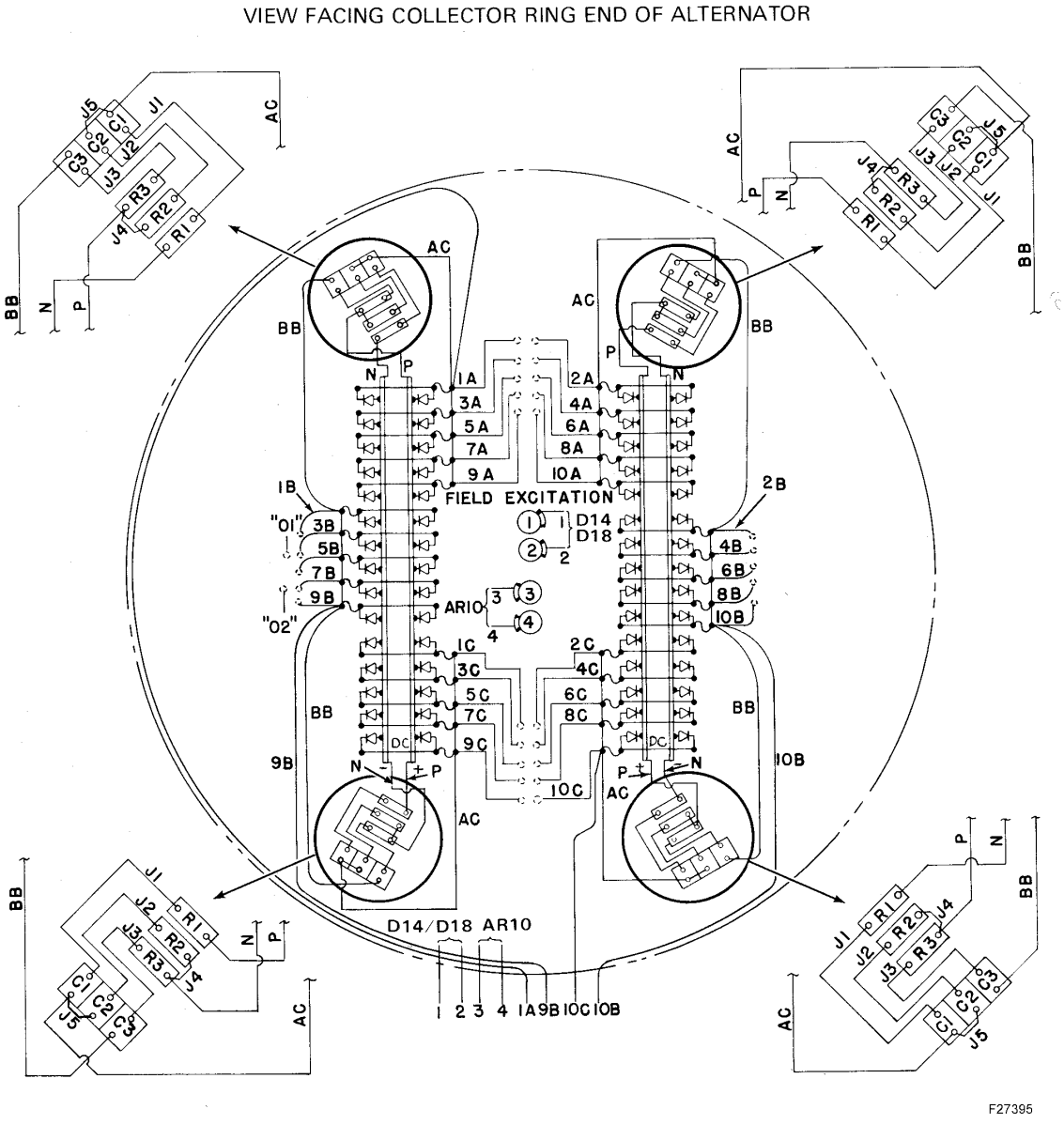


Figure 25 AR10A Physical Schematic

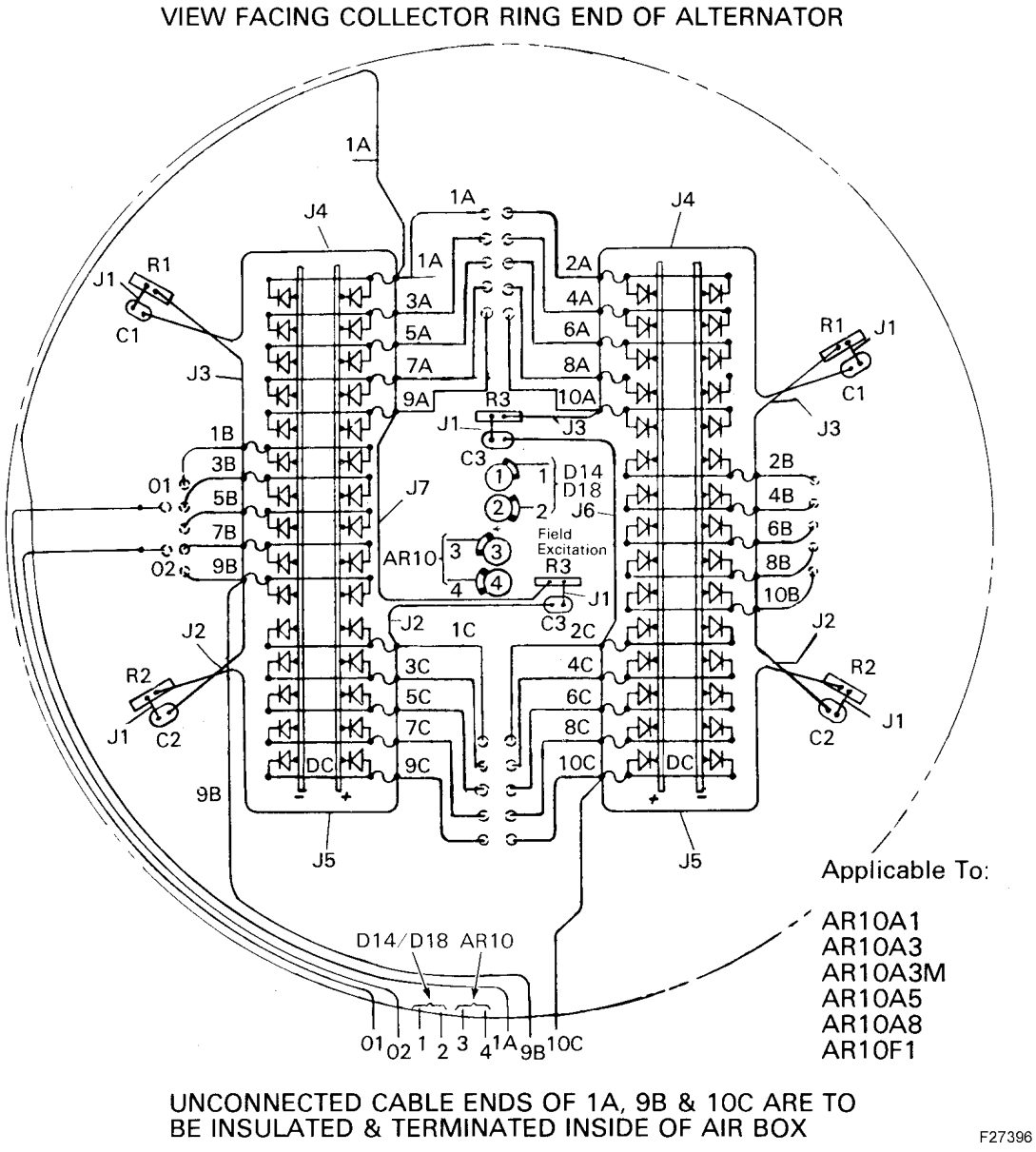


Figure 26 AR10 Physical Schematic (Various Models)

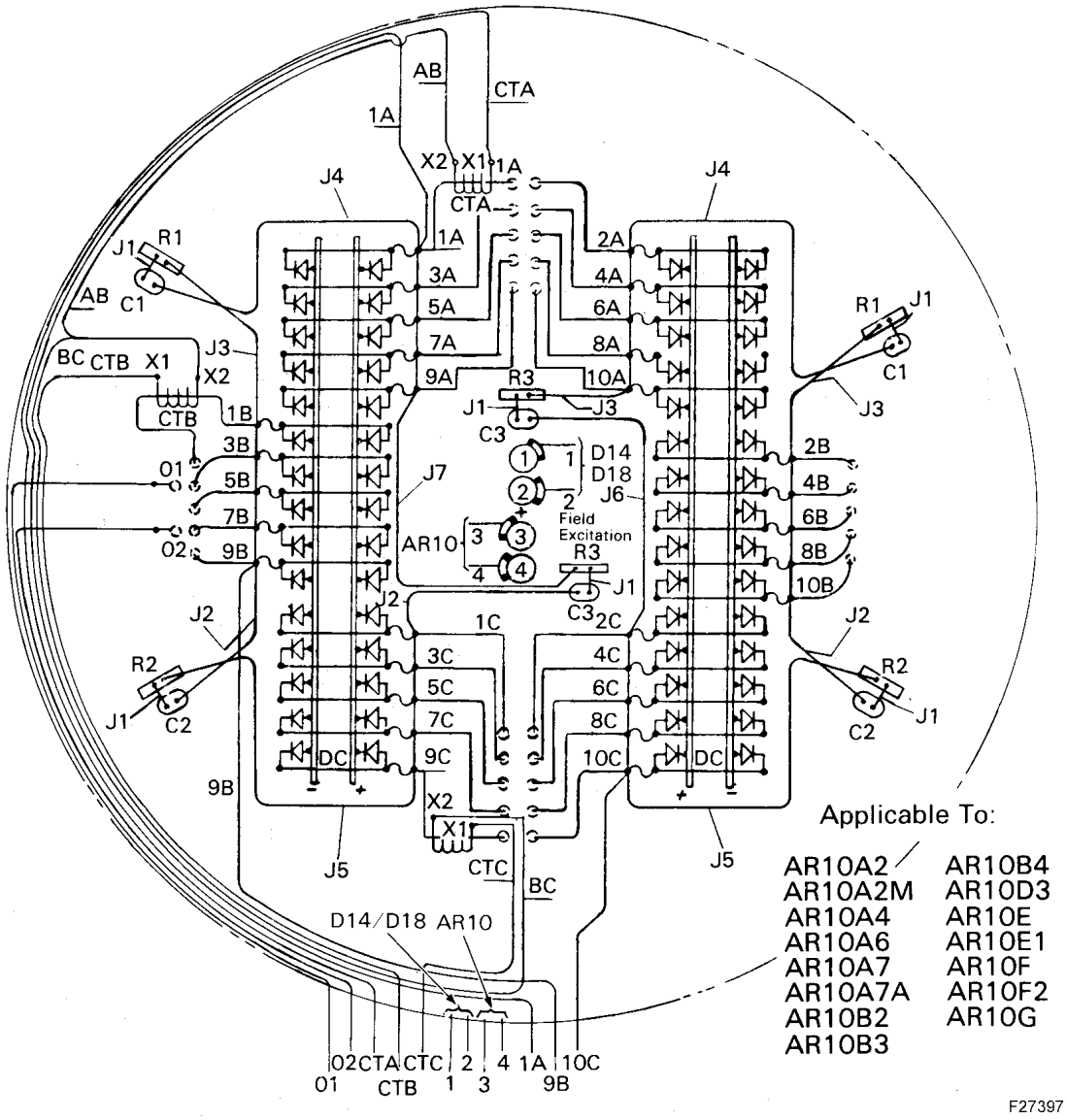


Figure 27 AR10 Physical Schematic (Various Models)

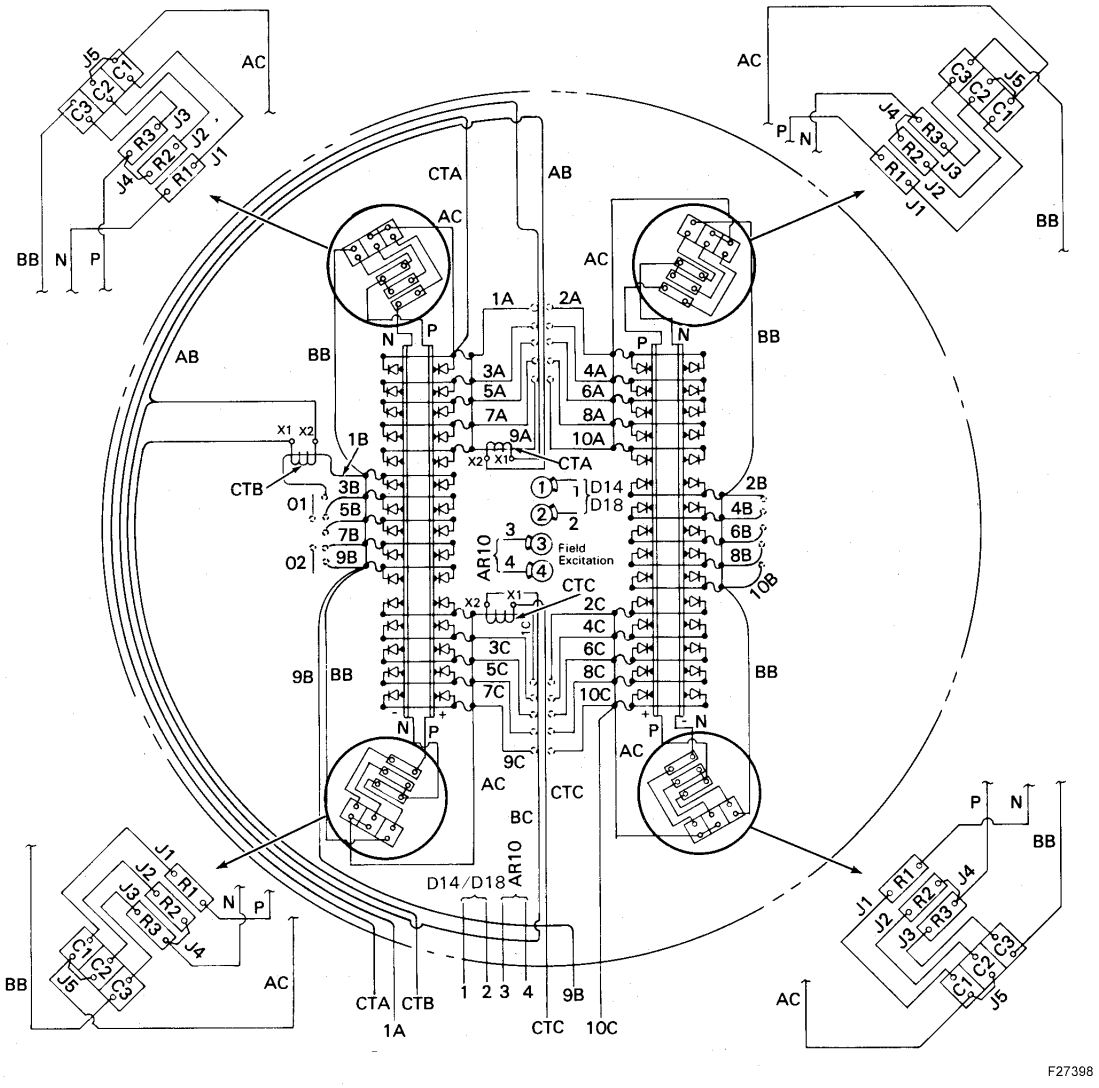


Figure 28 AR10B Physical Schematic

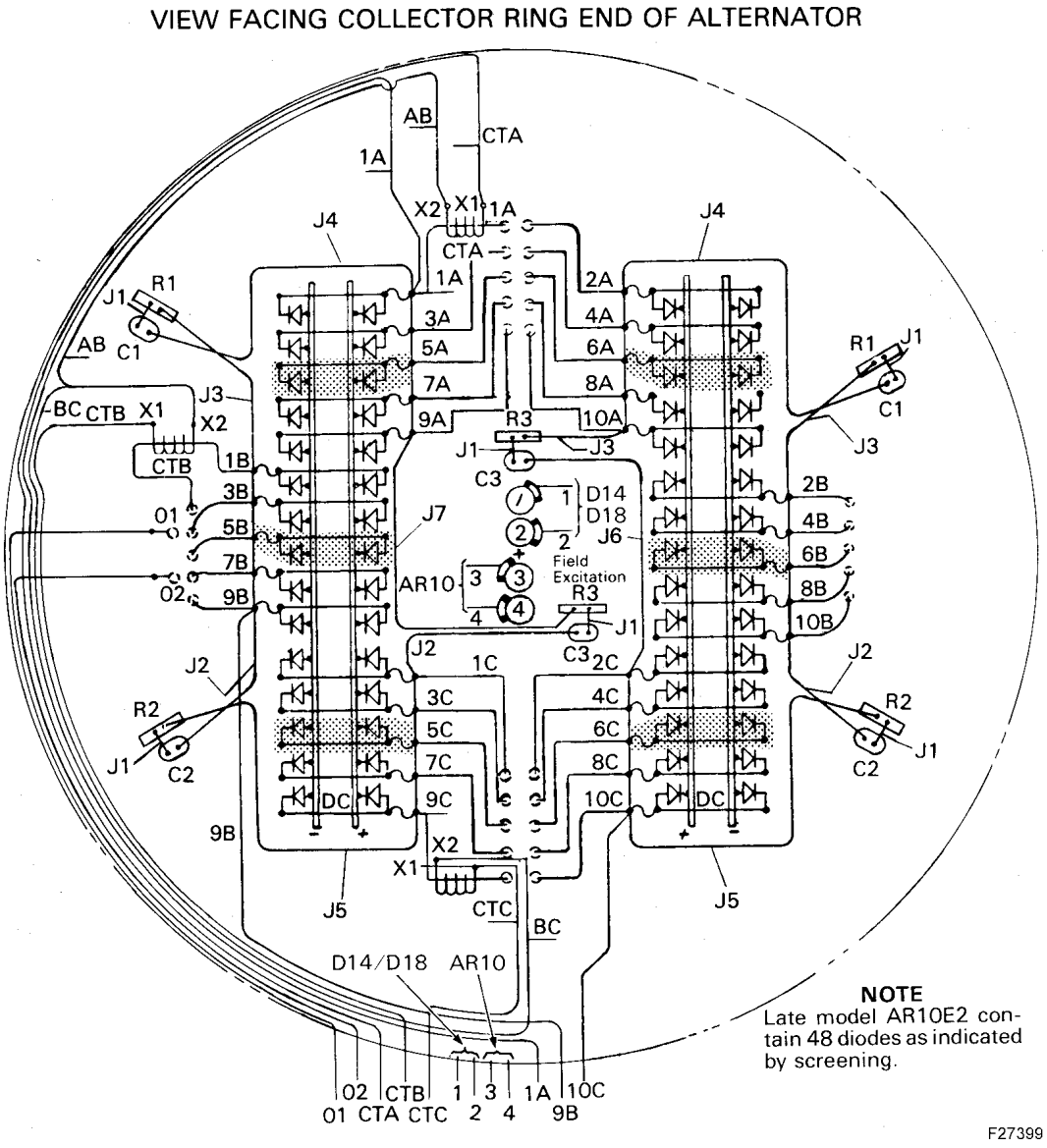


Figure 29 AR10E2 Physical Schematic

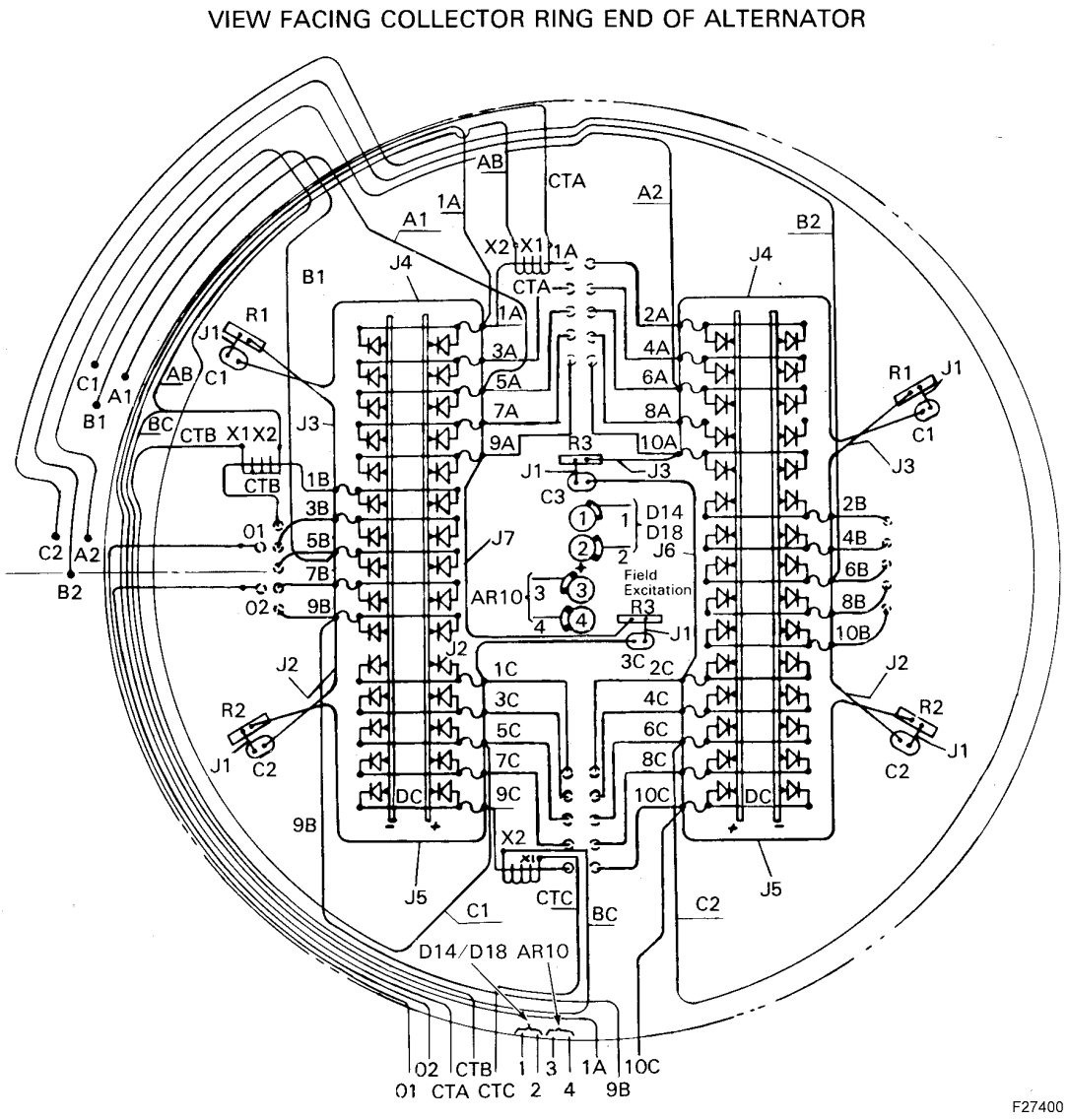


Figure 30 AR10A7B, AR10A9 Physical Schematic

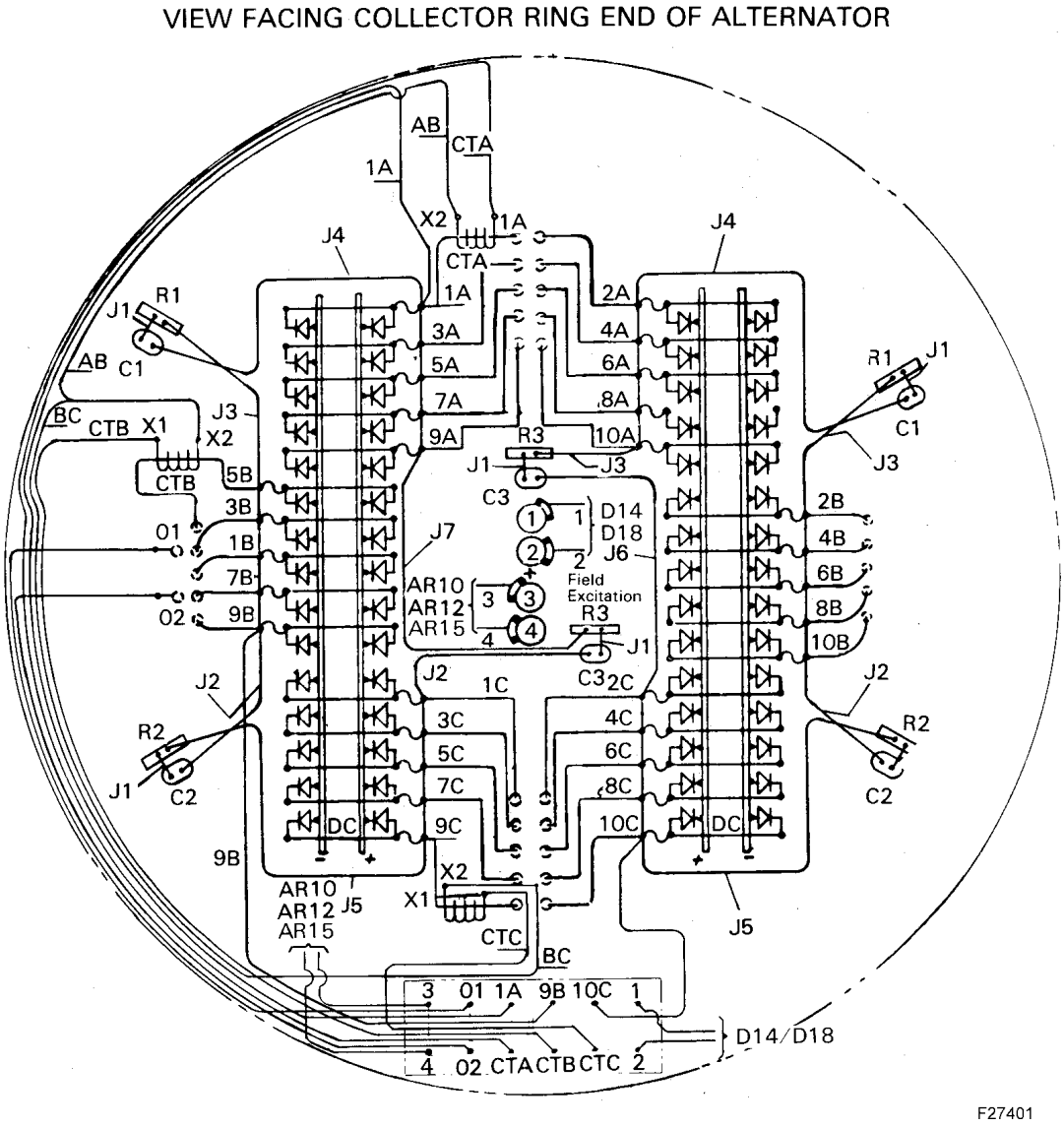


Figure 31 AR10X2, AR12, AR12A, AR15, AR15A, Physical Schematic

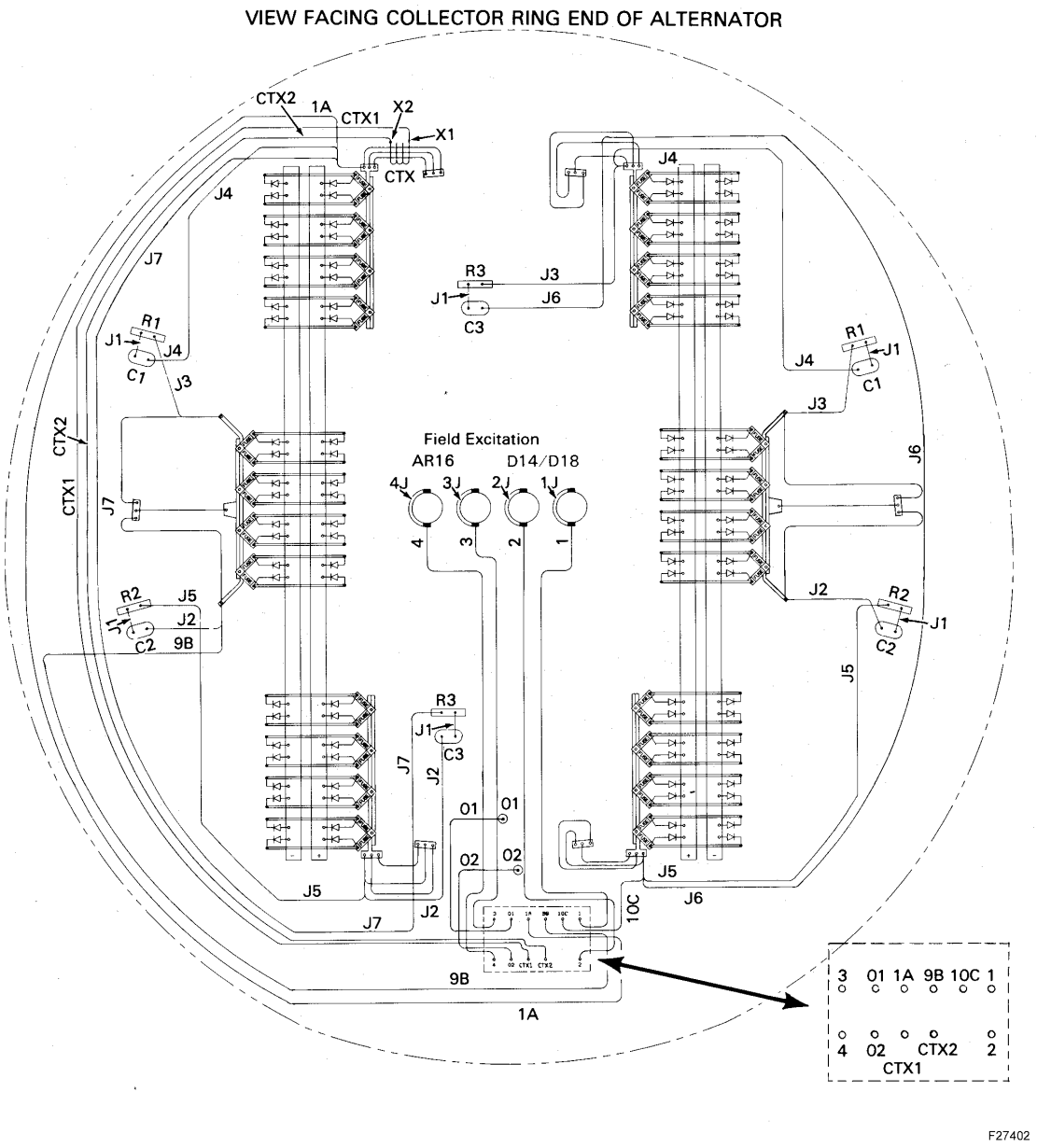


Figure 32 AR16 Physical Schematic

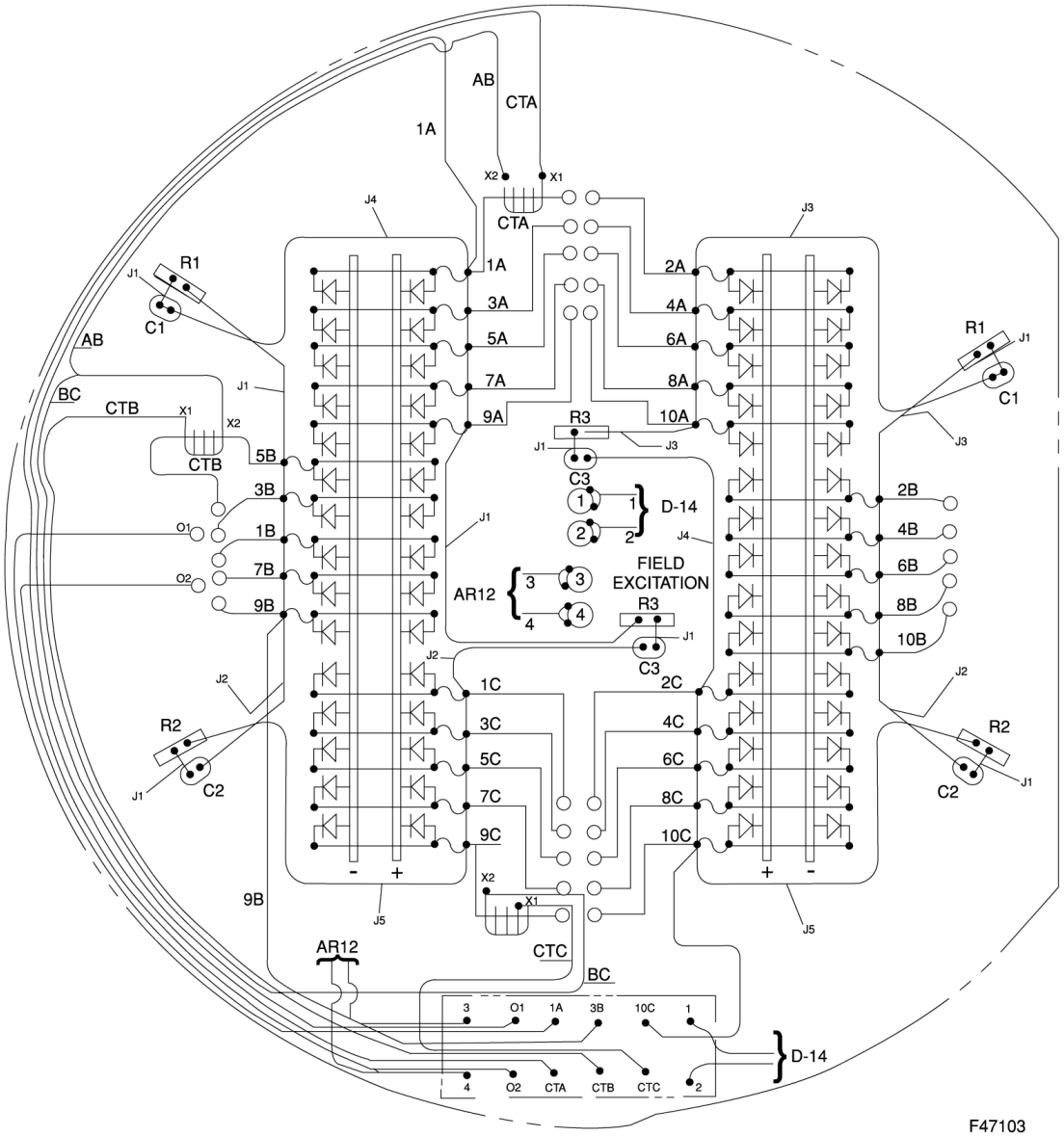


Figure 33 AR17 Physical Schematic

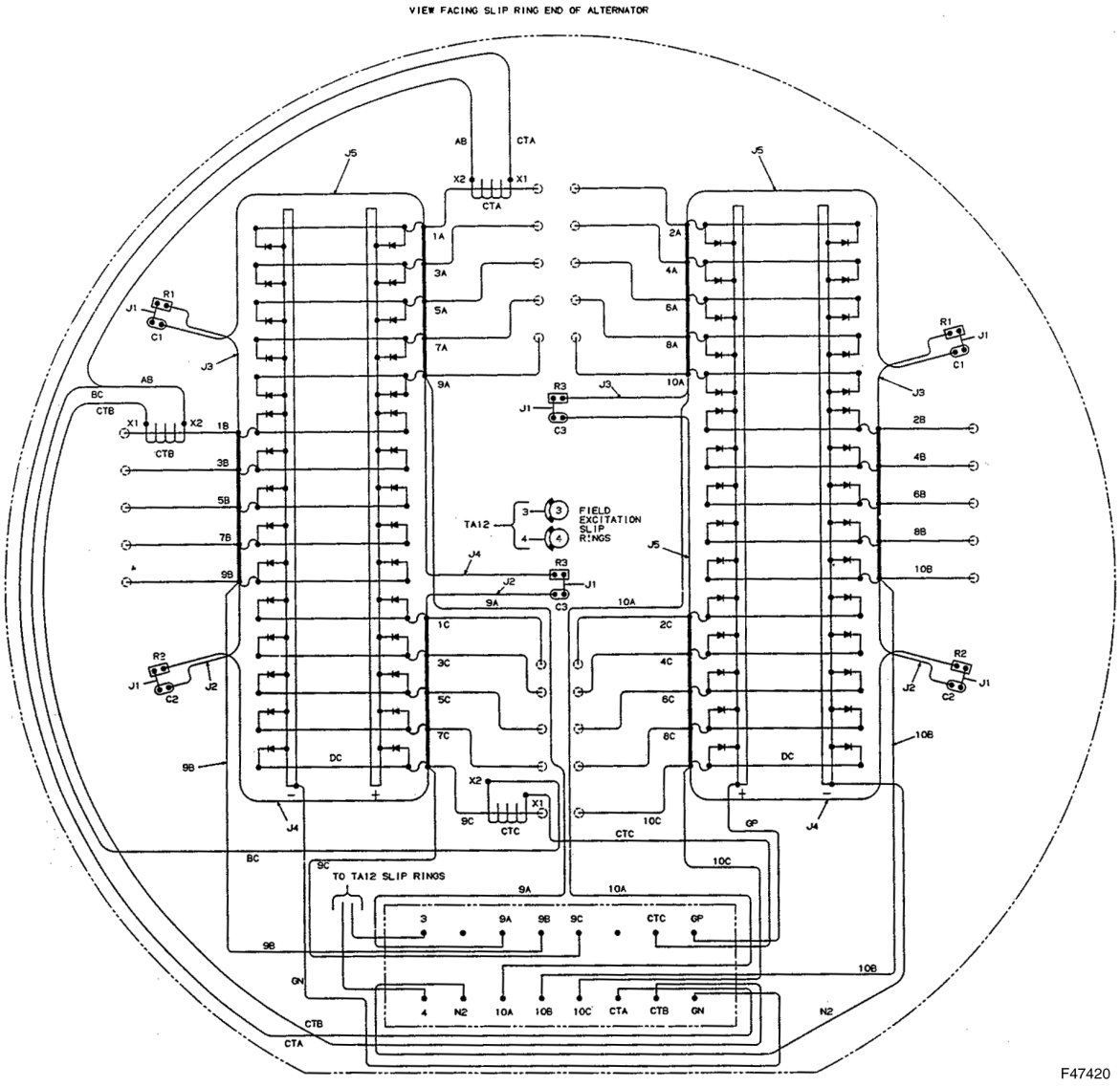


Figure 34 TA12-8 Physical Schematic

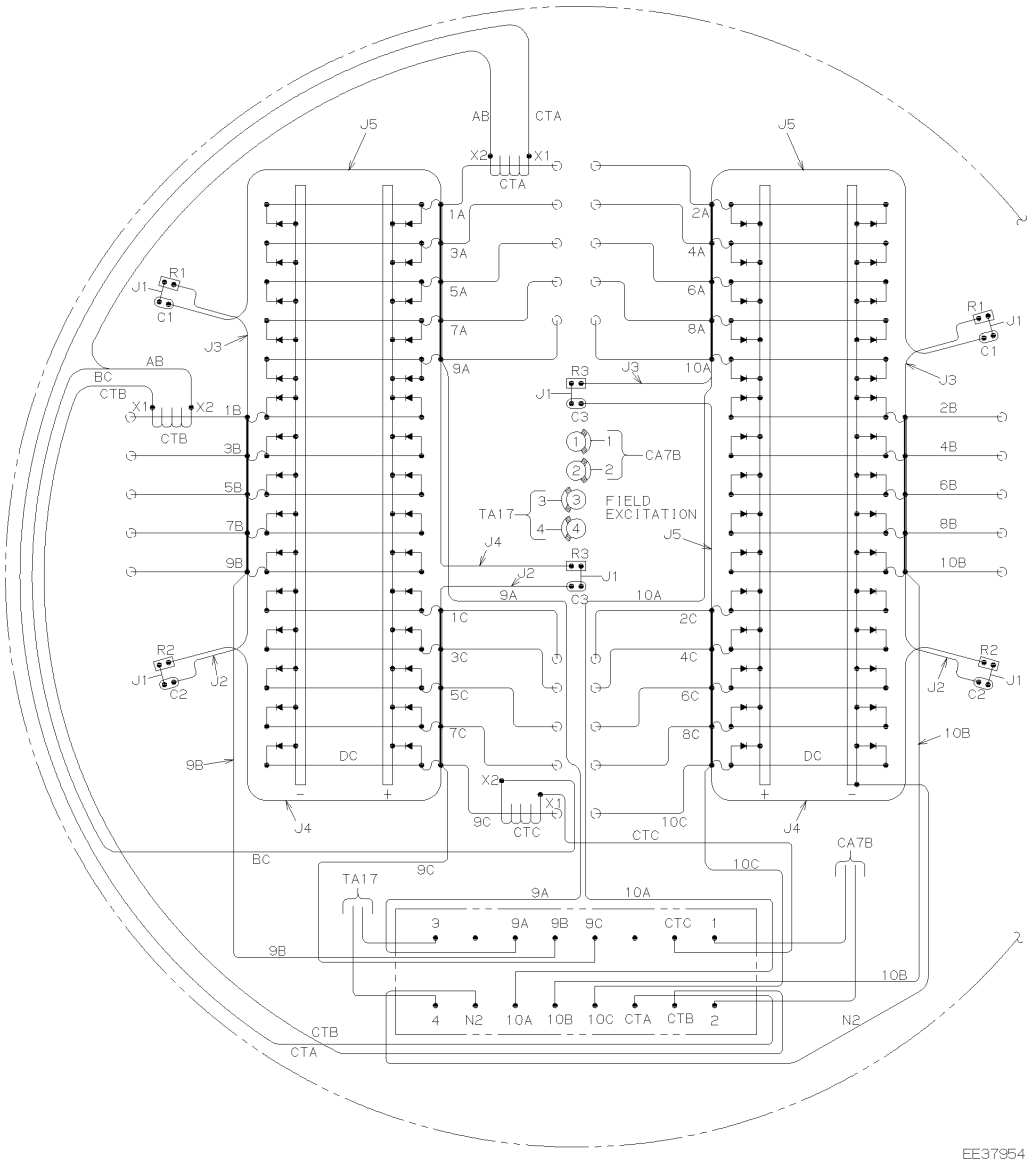


Figure 35 TA17-6 Physical Schematic

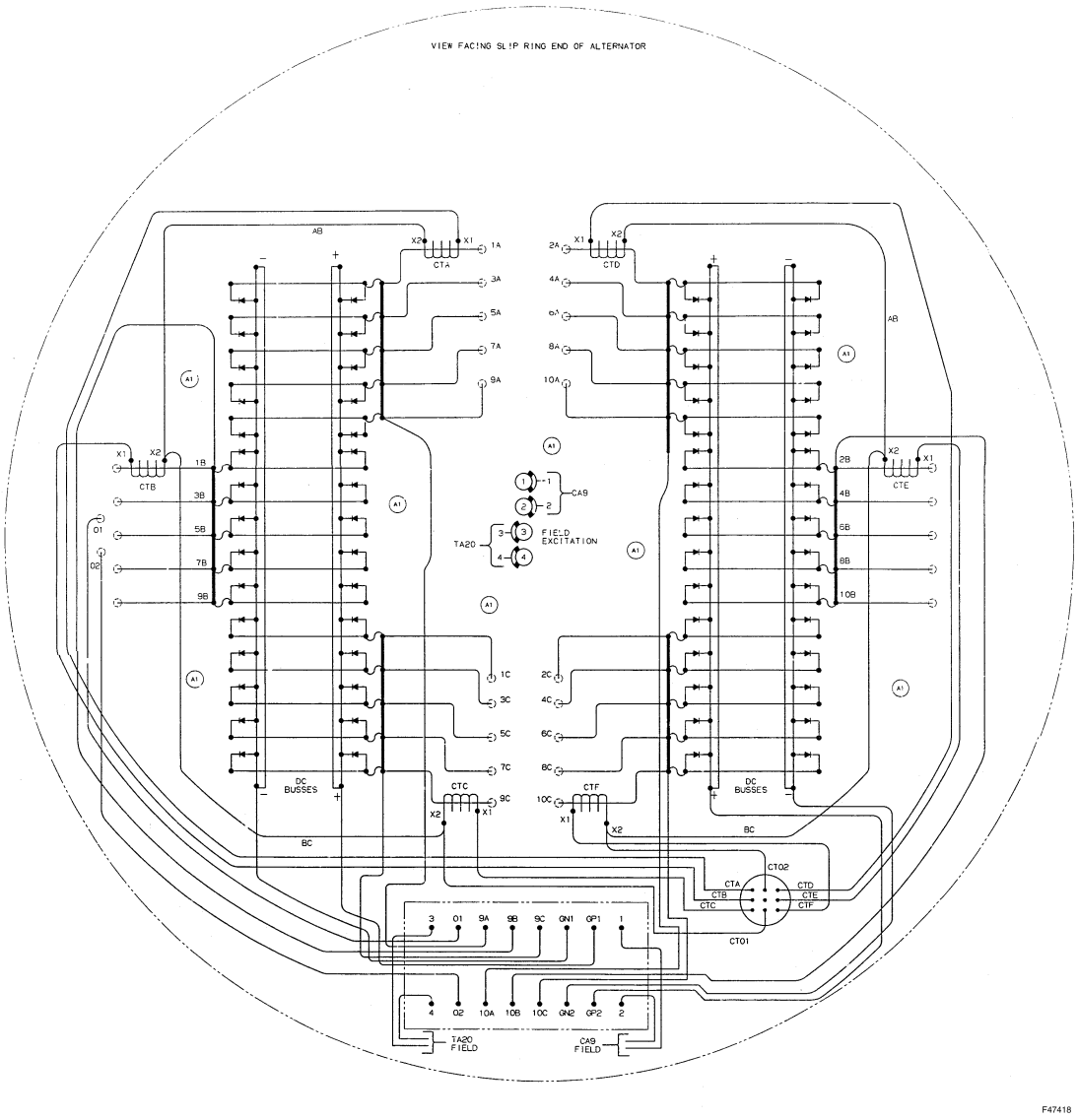
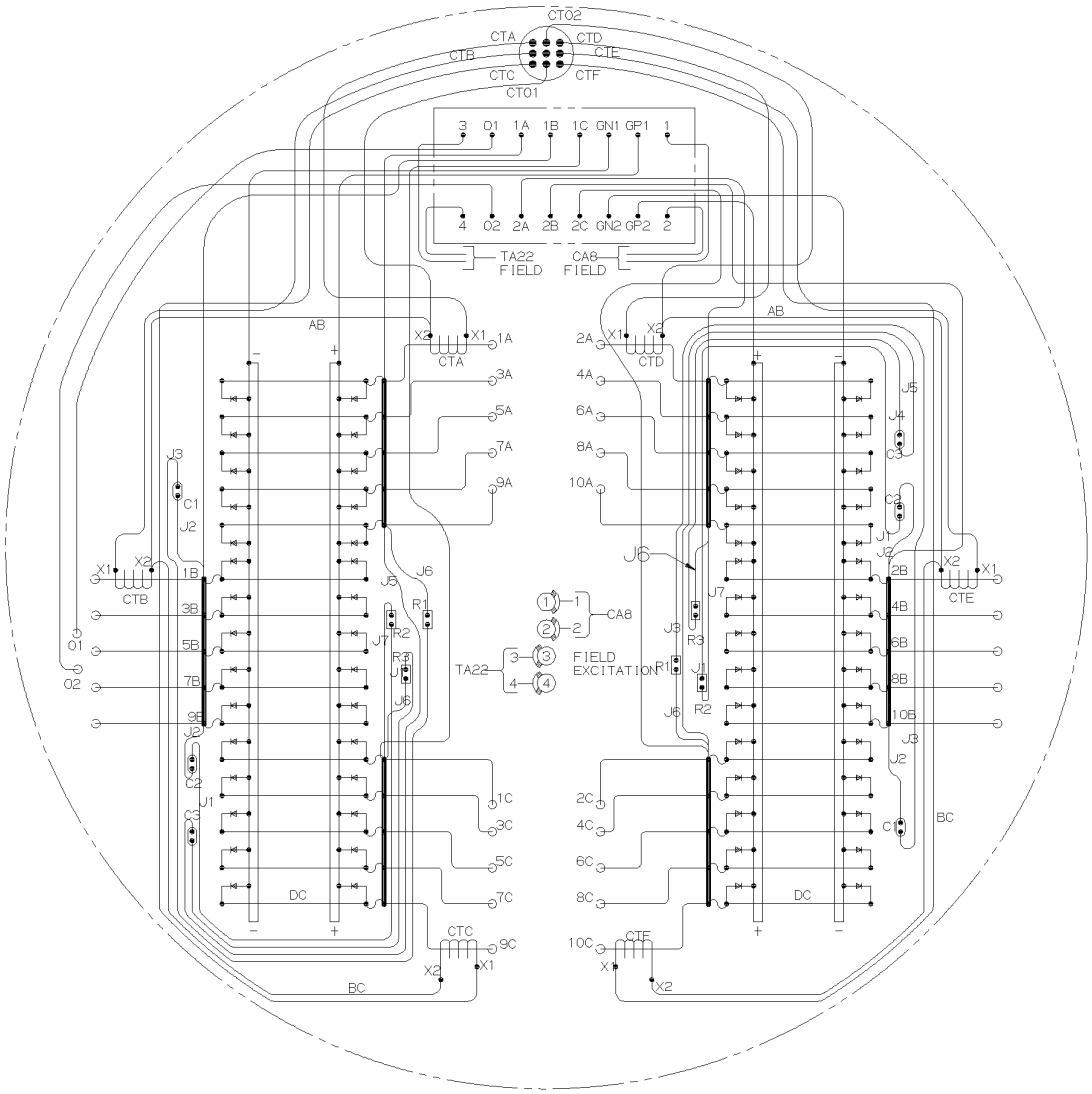


Figure 36 TA20 Physical Schematic



EE39646

Figure 37 TA22 Physical Schematic

5.0 SERVICE DATA

5.1 DIODE APPLICATION (Universal Diodes)

VOLTAGE CLASS	PART NUMBER	APPLICATION
2600 Volts	40032602 Pos. 40032603 Neg.	AR20
2800 Volts	40029132 Pos. 40029131 Neg.	All AR, TA12, TA17
4400 Volts	40053999 Pos. 40053998 Neg.	TA20, TA22

5.2 CURRENT LIMITING FUSE APPLICATION

PART #	CURRENT RATING	GENERATOR MODEL	NOTES
8346478	350 Amps	AR6, AR7, AR10, AR 12	Original Equipment
8407729	400 Amps	AR15, AR17, TA12, TA17	Original Equipment
40054000	315 Amps	TA20, TA22	Original Equipment
40080476	600 Amps	AR6, AR7, AR10, AR12 AR15, AR17, TA12, TA17	Replaces Fuses 8346478 and 8407729

5.3 CURRENT LIMITING FUSE RESISTANCE VALUES (@75°F/23°C)

PART #	CURRENT RATING	GENERATOR MODEL	RESISTANCE VALUES
8346478	350 Amps	AR6, AR7, AR10, AR 12	.000195 + - .000010
8407729	400 Amps	AR15, AR17, TA12, TA17	.000195 + - .000010
40054000	315 Amps	TA20, TA22	.000368 + - .000010
40080476	600 Amps	AR6, AR7, AR10, AR12 AR15, AR17, TA12, TA17	.000195 + - .000010

5.4 REFERENCES

AR8, AR11 and AR20 Traction Generator Rectifier Bank Assemblies and Suppression Circuit ..... MI 3317-3
Traction Alternators with Head End Power ..... MI 3319
AR5 Traction Generator ..... MI 3318
AR6 Traction Generator ..... MI 3323

5.5 SPECIFICATIONS

Weight of Rectifier Bank Assembly (Approximate)
AR10, AR12, AR15, AR6 ..... 45 kg. (100 lbs)
AR16 ..... 82 kg. (180 lbs)
AR17 ..... 45 kg (100 lbs)
TA12-8 ..... 45 kg (100 lbs)
TA17-6 ..... 45 kg (100 lbs)
TA20 ..... 64 kg (140 lbs)
TA22 ..... 64 kg (140 lbs)

5.6 EQUIPMENT LIST

	Part No.
Special Diode Socket 1 – ¼" Hex (all standard AR)	8361524
Special Diode Socket 1 – ¾" Hex (AR20/TA20/TA22)	40045217
Torque Wrench 0 – 50 ft/lbs. – 1/2" Drive	8375396
Compound – Joint	8346481
Multimeter	8276478
Megger Tester, 0 – 200 megohms at 500 VDC	8174880
Leads, 3.7 m (12 ft.)	8174878
Carrying Case	8174879
Dynamotor (MG Set) 1200 VDC Output – 64 VDC Input	8233558
Digital Low Ohm Resistance Tester Kit (Range 0 to 1.999 miliohms) (Includes AC – DC Power Supply and 6 foot test leads)	9322573

Document Number MM001001 (DE-LP)

Electro-Motive Division of General Motors Corporation
La Grange, Illinois 60525 USA
Telephone: 708-387-6000
Website: www.gmemd.com